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"WATER SCARCITY – STRATEGIC APPROACH"

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PAKISTAN ENGINEERING CONGRESS

MID TERM SYMPOSIUM ON 23RD FEBRUARY 2019 ON THE TOPIC OF

"WATER SCARCITY: STRATEGIC APPROACH"

KEYNOTE ADDRESS

By

ENGR. CH. GHULAM HUSSAIN

CONVENER

The Honorable Chief Guest

Engr. Mahmood ul Hasan Siddiqui

Advisor irrigation Department, Punjab.

Congress Members,

Fellow Engineers, Ladies and Gentlemen!

Assalam-o-Alaikum

It gives me great pride to inform that, as a norm, Pakistan Engineering Congress convenes mid-term symposia during the incumbency tenure of various managements to address the technical issues of national importance. Not only this, but the papers presented and discussed and recommendations resulting from the events, are published and disseminated complimentarily by the Congress to all concerned, particularly Federal and Provincial Government Agencies and various autonomous technical entities.

Ladies and Gentlemen!

Since 1957, 38 such symposia have been convened so far and this is 39th.of the series. Though of global magnitude it has grave implications for Pakistan and is titled:

"Water Scarcity: Strategic Approach"

You are aware that in 1951 Pakistan had per capita surface water availability of about 5300 m^3/s which by now (2018) has dwindled to under 900. According to international criteria, this has placed Pakistan in 'Water Scarce Category'. Unfortunately, on the other hand, the country has hardly 30 days surface water storage capacity, and that too, reducing rapidly due to sedimentation of existing reservoirs and non-construction of any new major dam over the last 40 years. Against this, India has already created storage capacity of about 120 days and and is enhancing it further. Most of the developed countries have constructed storage capacities even upto 220 days.

Ladies and Gentlemen!

Though water is a free gift of nature, human beings are required to realize its immense value and make all out efforts to conserve and use it for socio-economic development in a judicious manner to maximize its benefits. In this context, Pakistan should have also visualized the importance of water for ensuring sustainable economic development, prosperity and food security for the fast growing population.

Indus Waters Treaty of 1960 ceded to India three (3) eastern rivers of Ravi, Beas and Sutlej. Notwithstanding this, construction of Indus Basin Project (IBP) not only replaced this water loss but also established a firm base for further development and management of the available surface water resources. To our bad luck, subsequent planners and policy decision makers failed to capitalize on the opportunity provided by IBP. Consequently, Pakistan is now faced with acute water scarcity along with its dire consequences.

After full commissioning of Mangla and Tarbela Dams under IBP in 1977, the country miserably failed to construct any major reservoir. As per World Bank “Study on Water and Power Resources of West Pakistan-1968” Pakistan should have constructed at least one major water reservoir every decade. Fully engineered Kalabagh Dam, which could be made operational by mid 1990s, was not constructed under the utopian plea of absence of “Provincial Consensus”. Thus a purely technical issue, to be resolved through domestic / international expertise, was politicized. Furthermore, aside from Kalabagh Dam, construction of no other major dam could be started due to one reason or another. Simultaneously, about 30 MAF surface water continued to flow into the sea without being utilized for: generating cheaper energy from a renewable source; and development of agriculture and industry.

It is fortunate that due to acute water scarcity of threatening proportions, a national awareness has been sparked through recent decision of our honorable Chief Guest, the Chief Justice, of Pakistan to immediately take up construction of Diamer Basha and Mohmand Dam Projects. Their completion, even on fast track basis, is going to take between 6 to 10 years.

The country has not only plundered surface water, but played havoc with groundwater exploitation. Presently, about 50 MAF is being pumped to provide for: critical surface water shortage to crops; and municipal and industrial uses. This indiscriminate pumping, mostly through 1.2 million private tubewells, has caused excessive mining of freshwater aquifers accumulated through a recharge from the vast irrigation network established over the last 150 years or so. Besides suffering from inadequate recharge for sustainability, these aquifers are threatened by serious quality deterioration due to intrusion from the adjacent saline aquifers. In the absence of urgent regulatory and management measures by public and private sectors sustainability of these aquifers is perilous.

Rainfall is another precious natural water resource, which can be beneficially harvested for: potable water supplies; domestic and industrial supplies; and groundwater recharge. So far, this potential water resource has received scant attention both in public and private sectors.

Hill torrents in Pakistan drain approximately 65% of catchment area of the country. Amongst these are 16 large Hill Torrents generating about 18 MAF annually. Through a number of hill torrent related studies carried out during the past 3-4 decades, over 1200 sites have been identified where about 13 MAF water can be conserved for effective flood control and regulated irrigation development over an area of about 1.5 million acres. Alas, little efforts have been made so far to tap this valuable potential also.

Ladies and Gentlemen!

Aside from the aforementioned dismal situation on the water supply side, the management and effective utilization picture is also quite disturbing. In this regard, the following particular areas need priority attention:-

i. About 95% of present water use is for agriculture through the largest contiguous irrigated system in the world. The infrastructure being used for this purpose is in a state of disrepair and requires substantial revamping.

ii. Out of average annual canal head diversion of 105 MAF, more than half is wasted in conveying the water to farms through mostly unlined and ill maintained network. For salvaging and conservation of these losses, the following interventions have been tried in the past: -

   a. On-farm water management projects were executed over the last 4-5 decades covering a part of over 1 million water course commands in the Indus Basin, through improvements of farmer's ditches including selective lining and provision of 'Pacca Naccas". Though providing significant initial relief, the benefits of these projects frittered due to lack of sustained O & M by the concerned Water Users Organizations (WUAs) established through the farmers.

   b. Lining of distributaries and minors was undertaken to salvage losses in the secondary irrigation system. In this case also, much progress could not be made due to financial and institutional constraints. Furthermore, their proper maintenance including periodic silt clearance suffered due to the basic reason that water charges hardly covered about 25% of O & M charges.

   c. To salvage sizeable on-farm water losses:

      - Farmers were subsidized to adopt rough and precise land levelling but with very limited success including lack of follow up.
      - Farmers were advised to discard age old wasteful flood irrigation practice and adopt furrow irrigation, but in this case also limited success was achieved.

   d. To significantly reduce crop water requirement, attempt was made to introduce higher efficiency irrigation systems (HEIS) including sprinkler and drip irrigation system. Here also, the effort has not gone beyond pilot stage.

Though the present non-agricultural municipal and industrial water use is not significant, it is progressively increasing to cope with the requirements of our burgeoning population. Management and utilization aspects in this regard are also alarming as is evident from:-

i. Highly wasteful use of municipal water and its untreated disposal into natural water bodies causing extreme pollution and environmental hazards. If treated, this water could be recycled for agricultural and other non-consumptive uses.

ii. Uncontrolled and extravagant use of water by industries and its untreated disposal into nullahs / rivers causing also extreme pollution and environmental hazards.

iii. Seepage of untreated municipal and industrial waste water into fresh aquifers causing biological and chemical contamination with endangered sustainability.

Ladies and Gentlemen!

It can be appreciated from the foregoing that strategy to cope with looming water scarcity demands holistic approach. The instrument to accomplish this is adoption of Integrated Water Resource Management (IWRM) covering:-

i. Water resources development and management.

ii. Efficient water utilization backed by synergic public and private sector efforts in the areas of irrigation, agriculture, municipal water supplies and industrial use.

Ladies and Gentlemenk!

In this Symposium, 11 papers are going to presented by eminent experts and professionals. These will invariably cover various aspects highlighted in my address and hopefully help in recommending an appropriate way forward.

Thank you

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STRATEGIC APPROACH TO ALLEVIATE WATER SCARCITY THROUGH RESERVOIRS INCLUDING IMPACT OF BHASHA DAM PROJECT

Riaz Nazir Tarar

STRATEGIC APPROACH TO ALLEVIATE WATER SCARCITY THROUGH RESERVOIRS INCLUDING IMPACT OF BHASHA DAM PROJECT

By

Riaz Nazir Tarar[1]

A. ABSTRACT

Indus Basin of Pakistan possesses world's largest contiguous irrigation system. This was developed on the basis of run-of-river concept, over 100 years or so during the British Colonial Rule. Some further extension of the System on similar basis was also continued over the first 15 or so years after Independence. Under 1960 Indus Waters Treaty three eastern rivers (Sutlej, Beas and Ravi) were ceded to India. However, Indus Basin Replacement Works in Pakistan introduced for the first time the concept of storages (Mangla and Tarbela). This important intervention provided a substantial boost to canal withdrawals of Indus Basin Irrigation System (IBIS). This can be judged from the fact that IBIS average annual withdrawals were: 67 MAF soon after independence (1950); 88 MAF (1960-67) in pre-Mangla period; 95 MAF (1967-77) post-Mangla period; and 105 MAF (1977-82) in post-Tarbela period.

Post-Tarbela developed average canal withdrawals of 105 MAF provided the basis for provincial allocations under 1991 Water Apportionment Accord (WAA). Accordingly, the provinces were given 12 MAF additional allocations over and above 105 MAF post-Tarbela developed canal uses. However, this additionality could be only achieved through new storage(s), which has not been accomplished so far. On the other hand, due to rapid sedimentation of on-line storages it has not been possible to maintain even post-Tarbela developed uses and in the post-Accord period of 20 years (1994-2013) IBIS faced an average shortage of over 10%. To good fortune of the country, it is now proposed to implement Diamer Basha and Mohmand Dam Projects on fast track basis under directions of the Supreme Court of Pakistan.

While approving the original PC-I Proforma of Diamer Basha Dam Project (DBDP) in 2009, ECNEC constituted a committee to determine utilization pattern of increased water storage capacity as well as additional power generation at the existing downstream facilities. Consequently, a case study was carried out for the Committee by WAPDA. It targeted to meet an overall provincial demand of 121.2 MAF and 3.6 MAF minimum ecological flows downstream Kotri based on derivations from WAA provisions. It assumed integrated operation of Indus River System including the reservoirs.

The case study brought out that significant relief, between 8% to 15%, would be provided by DBDP to IBIS in Rabi season. It will also enable between 4% to 8% increase in minimum ecological flows below Kotri. Additionally, extra generation of about 11%

[1] Riaz Nazir Tarar, Associate NDC, Lahore.

would become available from the downstream existing facilities of Tarbela, Ghazi-Barotha and Chashma. Further estimated power generation increase at the future downstream cascade projects (Dasu, Pattan and Thakot) would be over 50% of generation at the dam site.

It is therefore, imperative that priority implementation, of DBDP as per direction of the Chief Justice of Pakistan be taken up without by further delay.

B. Text

1. INDUS BASIN

Indus Basin fed by Indus (including Kabul), Jhelum, Chenab, Ravi, Beas and Sutlej rivers is source of water utilised for development of world's largest contiguous irrigation system. Under Indus Waters Treaty 1960, three Eastern Rivers, Ravi, Beas and Sutlej were ceded to India while three Western Rivers, Indus, Jhelum and Chenab, were allocated for exclusive use by Pakistan.

To replace the Eastern River water loss to irrigation system, during 1960-74 Pakistan constructed Indus Basin Project (IBP), which represented the largest peace time civil construction activity of the world. IBP comprised: three storage reservoirs at Mangla, Tarbela and Chashma; eight inter-river link canals; five new barrages and a syphon; and remodelling of three existing link canals and one barrage.

Development of irrigated agriculture under British Colonial Rule started during 19th century. By the time of independence in 1947, it had been transformed into the gigantic Indus Basin Irrigation system (IBIS). Despite division of Indus River System under 1960 Indus Waters Treaty and construction of IBP, Pakistan continued developing some additional irrigation infrastructure.

Schematic 'Diagram of Indus River Irrigation System' is shown in Annex-01.

At present, IBIS of Pakistan consists of a vast infrastructure as listed in Annex-02. It comprises: three storage reservoirs with initial aggregate live capacity of 15.7 MAF; 23 barrages including one syphon; 45 main irrigation canals and their distribution network over a length of 38000 miles to command 35 million acres; and 90,000 watercourses with an aggregate length of about 1 million miles.

2. INDUS BASIN WATER AVAILABILITY

Starting from early 20th century in 1922-23, Indus River System has a record of very long historic inflow data at the rim-stations, where these debouch into plains. However, water availability for irrigation diversion / development is now basically confined to three Western Rivers (Indus, Jhelum and Chenab) as a consequence of 1960 Indus Waters Treaty.

'Inflow Variability at Rim-Stations of Western Rivers Over Discharge Availability Period From 1923 – 2013' is shown in Annex-03. It can be seen from Annex-03 that mean inflow under various scenarios over the record period of 1923 – 2013 is about 138 MAF with a variation between maximum and minimum values of 187 and 97 MAF, respectively.

'Seasonal Distribution of Water in Western Rivers of Pakistan' is shown in Annex-04. Regarding flow contribution the share of Indus (including Kabul) is about 60% while the remainder comes from Jhelum, Chenab and uncontrolled flood from the Eastern Rivers. Over 80% flow occurs during summer (April to September) with remaining 20% in winter (October to March).

For the purpose irrigation planning and development in Indus Basin, water availability has been based on the long term average river flows. In the current context, post-Tarbela average can be considered realistic (refer Annex-03). Correspondingly computed 'Surface Water Availability For Indus River System' is shown in Annex-05. This shows an overall average availability of about 148 MAF.

3. CANAL HEAD WITHDRAWALS

Historic IBIS development was based on run-of-river concept till induction of storage reservoirs under IBP. These three storages helped in seasonal carry-over from high flow period of Kharif to low flow period of Rabi. This impact is shown in Annex-06. It may be noticed that under pre-Mangla era the ratio between Kharif and Rabi flows was 88:12. After full commissioning of Mangla, Tarbela and Chashma this ratio got raised into 81:19. Resultantly, it provided a substantial boost to canal head withdrawals of IBIS as shown in Annex-07. It can be seen that the System canal head withdrawals increased from 88 to 105 MAF (about 19%) soon after full commissioning of Tarbela. However, due to sedimentation of on-line storages, and non-addition of another storage for the las 40 years or so, it has not been possible to sustain even post-Tarbela developed canal uses. After turn of the century, shortage between 5% to 21% is being experienced in sustaining post-Tarbela developed canal uses of 105MAF.

4. WATER APPORTIONMENT ACCORD ALLOCATIONS

A Water Apportionment Accord (WAA) was agreed between the provinces in 1991. Besides protecting post-Tarbela canal withdrawals of 105 MAF, under Para 2 it allocated additional 12 MAF to provinces for development through construction of new storage(s). Some further supplies from flood flow were also allocated to provinces through an agreed sharing formula under Para-4. A tentative provision subject to confirmation through subsequent study was also made to check sea water intrusion downstream of Kotri.

Considering various provisions of WAA 1991, it has been estimated that 'Targeted Annual Irrigation Demands of Indus Basin Irrigation System' will aggregate to about 125 MAF as per break-up shown in Annex-08.

5. NEED FOR STORAGES AND PROJECTED AVAILABILITY THROUGH 2030

As already mentioned, the targeted irrigation demand as per WAA has been estimated around 125 MAF. Not to speak of this target, it has not been possible to sustain even post-Tarbela canal withdrawals due to rapid sedimentation of on-line and non-construction of any new storage project since. 1977. It is, therefore, imperative that sizeable additional storage capacity be created in the Indus Basin on priority basis.

It is fortunate that the Chief Justice of Pakistan has taken cognizance of impending acute water shortage and ordered priority implementation of Diamer Basha (6.4 MAF) and Mohmand (0.7MAF) dams. It taken up immediately in real earnest, Mohmand Dam could be completed by 2023 followed by Diamer Basha Dam in 2027.

Additional storage requirement to meet the targeted irrigation demand of 125 MAF is estimated as 18 MAF as detailed in Annex-09.

The above target is achievable if Diamer Basha and Mohmand Dams are implemented according to instructions of Chief Justice of Pakistan. This can be appreciated from 'Projected Sedimentation and Live Storage Capacity Though 2030' as depicted in Annex-10.

6. CASE STUDY FOR CONTRIBUTION OF DIAMER BASHA DAM TOWARDS MEETING PROJECTED IRRIGATION DEMANDS AND ADDITIONAL HYDROPOWER GENERATION

6.1 AUTHORIZATION

While approving the original PC-I Proforma of Diamer Basha Dam Project in 2009, ECNEC constituted a committee to determine utilisation pattern of increased water storage capacity as well as additional power generation at the existing / upcoming downstream facilities.

6.2 CONDUCTION OF STUDY AND BASIS

Related case study was carried by WAPDA for the Committee. Basic assumptions of this hydrological study were: -

i. Targeted annual overall provincial demand of 121.2 MAF and 3.6 MAF minimum ecological flows downstream of Kotri based on derivations from WAA allocations (refer Annex-08).

ii. Annual Western Rivers rim-station inflows of 137 MAF over record period of 1962-63 to 2003-04) including maximum of 177.2 (1972-73) and minimum of 98.2 MAF (2000-01) and graphically presented in Annex-11.

iii. Pre-Diamer Basha availability of on-line storages of Raised Mangla, Tarbela and Chashma.

iv. Conjunctive operation of on-line storages (both for pre and post-Diamer Basha scenarios) and integrated operation of IBIS to meet the targeted demand of 125 MAF (refer Annex-08) under the following inflow conditions: -

    a. Wet year (1991-92)

    b. Average year (1980-81)

    c. Dry year (1979-80)

6.3 CASE STUDY RESULTS

6.3.1 Water

Study results corresponding to the selected wet, average and dry river inflow years were as below:-

i. Overall Projected Canal Diversions Under Pre and Post-Diamer Scenarios:

   a. System Irrigation Service (refer Annex-12):-

      - Rabi withdrawals ranging from 78-92% for pre-Diamer Basha condition would increase between 91-100% under post-Diamer Basha condition.

        Annual withdrawals ranging from 92-97% for pre-Diamer Basha condition would increase between 96-100% for post-Diamer Basha condition.

   b. Provincial / Regional Canal Service (refer Annex-13):-

      - Rabi canal head service for Upper Indus System (Punjab, Khyber Pakhtunkhwa and Part Balochistan under Taunsa command) for post-Diamer Basha condition would increase to 92-100% as compared to 79-91% for pre-Diamer Basha condition. In Lower Indus System (Sindh and Balochistan) it would also increase to 92-100% in post-Diamer Basha as compared to 78-92% of pre-Diamer Basha condition.

      - On annual basis, there would be an increase to 96-100% in post-Diamer Basha condition as compared to 92-97% in pre-Diamer Basha condition in the Upper Indus System. In the Lower Indus System the increase would also be from 96-100% for post-Diamer Basha condition as compared to 93-98% in pre-Diamer Basha condition.

ii. Ecological Release Below Kotri (refer Annex-12): -

   Ecological Releases Below Kotri in Rabi season would increase to 90-100% in post-Diamer Basha condition as compared to 79-93% in pre-Diamer Basha condition. On annual basis, the service of 88-96% in pre-Diamer Basha condition would increase to 94-100% in post-Diamer Basha condition.

iii. Surplus water downstream Kotri Barrage for future development, excluding, ecological releases, would be basically available during the flood period. On annual basis, surplus availability would be: 18.3 MAF for wet year, 5.7 MAF for average year and 2.7 MAF for dry year (refer Annex-14).

6.3.2 Power Generation

Mean annual power generation under post-Diamer Basha condition, including the project itself, would be about 43900 Gwh representing an increase of about 96% over pre-Diamer Basha condition (refer Annex-15). Net additional generation at the three existing

downstream stations of Tarbela, Ghazi-Barotha and Chashma would be over 2400 Gwh representing an increase of about 11% (refer Annex-15).

It is further estimated that future impact of power generation increase at the forthcoming downstream locations of Dasu, Pattan and Thahkot, would be of about 10500 Gwh representing an increase of about 25% (refer Annex-16).

It is estimated that future aggregate additional generation at existing / proposed downstream power facilities due to cascading effect of Diamer Basha Dam Project, would be about 13000 Gwh (refer Annex-16). This would represent about 70% of annual at site generation.

6.3.3 Enhanced Life of Downstream Reservoirs

Due to trapping of heavy sediment in Diamer Basha Dam, useful life of Tarbela reservoir will be enhanced by about 35 years.

Under construction Dasu Hydropower Project will only have a re-regulatory storage of 0.7 MAF. In the absence of Diamer Basha Dam, it will get depleted due to sedimentation with a short period of 15 years. Similarly, Diamer Basha Dam will significantly reduce rapid sedimentation of small re-regulatory storages at the forthcoming hydropower projects of Pattan and Thakot

7. CONCLUSION

Foregoing case study demonstrated that 6.4 MAF live storage capacity and 4500 MW power installation at Diamer Basha would substantially contribute towards improved water supplies in IBIS and hydropower generation at the downstream facilities as below: -

i. Providing 96 to 100% irrigation service under varying river inflow conditions to meet the targeted demand of 125 MAF against post-Tarbela development of 105 MAF.

ii. Besides at site annual generation of 19000 Gwh, hydropower generation due to cascading effect at the downstream facilities would comprise: -

   a. 2400 Gwh (about 11%) at the existing Tarbela, Ghazi-Barotha and Chashma power facilities.

   b. 10500 Gwh at the upcoming / proposed facilities of Dasu, Pattan and Thahkot.

   c. Above aggregate additionality of about 13000 Gwh would represent about 70% of annual at site generation.

Above figures demonstrate that induction of DBDP will not only contribute towards alleviation of irrigation water scarcity but substantially boost hydropower generation. Therefore, as per direction of the Chief Justice of Pakistan, priority implementation of DBDP should be taken up without any further delay.

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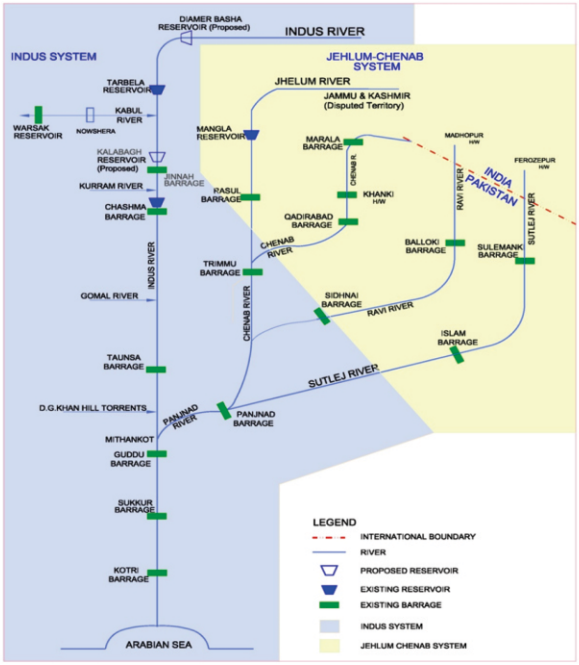
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Annex-01

SCHEMATIC DIAGRAM - INDUS RIVER IRRIGATION SYSTEM



Annex-02

INDUS BASIN IRRIGATION SYSTEM PAKISTAN

Sr. No.	Infrastructure	Quantum
1	**Storage Reservoirs:**	
	a. Number	3
	b. Live Capacity (Designed)	15.7 MAF (19.4 BCM)
2	**Barrages / Headworks / Syphons (Including IBP)**	23
3	**Main Irrigation Canals:**	
	a. Number	45
	b. Command Area	35 MA (14.2 Mha)
	c. Length Including Distribution System	38,000 miles (60,800 km)
4	**Water Courses:**	
	a. Number (Approximate)	90,000
	b. Length (Approximate)	1 million miles (1.6 million km)

Source: WAPDA

Annex-03

INFLOW VARIABILITY AT RIM-STATIONS OF WESTERN RIVERS OVER DISCHARGE AVAILABILITY PERIOD FROM 1923 -2013

Sr. No.	Period	Years	Inflows (MAF		
			Average	Maximum	Minimum
1	1922-23 to 1993-94	72	138.69	186.79 *(1959-60)*	109.81 *(1962-63)*
2	1922-23 to 1966-67 (Pre-Mangla)	45	138.95	186.79 *(1959-60)*	109.81 *(1962-63)*
3	1922-23 to 1975-76 (Pre-Tarbela)	54	131.21	186.79 *(1959-60)*	97.74 *(1974-75)*
4	1936-37 to 1945-46 (Water Treaty)	10	135.00	167.09 *(1942-43)*	120.09 *(1940-41)*
5	1940-41 to 1969-70 (Fazle Akbar Committee)	30	142.50	186.79 *(1959-60)*	109.81 *(1962-63)*
6	1940-41 to 1993-94 (Pre-Water Accord)	54	140.50	186.79 (1959-60)	97.74 *(1974-75)*
7	1976-77 to 1993-94 (Post-Tarbela, Pre-Water Accord)	18	149.11	172.1 *(1991-92)*	117.69 *(1985-86)*
8	1997-77 to 5012-13 (Post-Tarbela / Post-Water Accord)	37	138.33	172.1 *(1991-92)*	97.16 *(2001-02)*
9	1994-95 to 2012-13 (Post-Accord)	19	132.71	165.81 *(1994-95)*	97.16 *(2001-02)*
10	1922-23 to 2012-13 (Total Period)	91	134.10	186.79 (1959-60)	97.16 *(2001-02)*
11	**Mean (1 to 10)**		**138.11**		

Annex-04

SEASONAL DISTRIBUTION OF WATER IN WESTERN RIVERS OF PAKISTAN

River	Flow Contribution (%)	Seasonal Distribution (%)		Dominant Source of Water	
		Summer (Apr-Sep)	Winter (Oct-Mar)	Summer	Winter
Indus	44	86	14	Snow/Glacier melt	Winter Rainfall + Baseflow
Kabul	16	82	18	Snow/Glacier melt	Winter Rainfall + Baseflow
Jhelum	16	78	22	Mainly Snow melt + Monsoon	Winter Rainfall + Baseflow
Chenab	19	83	17	Snow/Glacier melt +Monsoon	Winter Rainfall + Baseflow
Others	5*	100	0		

* Unaccountedflows including uncontrolled floods from Eastern Rivers of Ravi and Sutlej

Annex-05

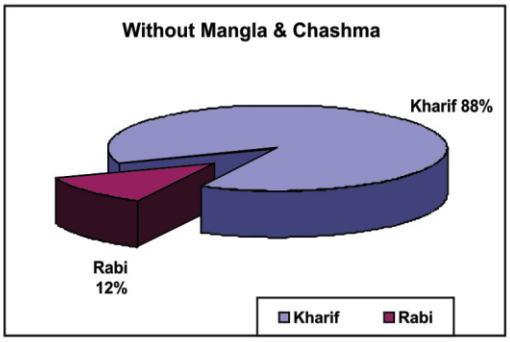
SURFACE WATER AVAILABILITY FROM INDUS RIVER SYSTEM

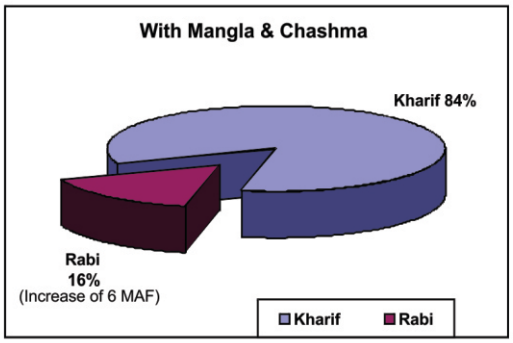
Sr. No.	Source	Post-Tarbela * Availability (MAF)
I	**Western Rivers**	
1.	Indus at Kalabagh	90.3
2.	Jhelum at Mangla	22.8
3.	Chenab at Marala	26.5
4.	**Sub-total (1+2+3)**	**139.6**
5.	NWFP Diversions Above Kalabagh	5.0
6.	**Total (I)**	**144.6**
II	**Eastern Rivers Run-off Within Pakistan**	**3.8**
III	**Total (I+II)**	**148.1**

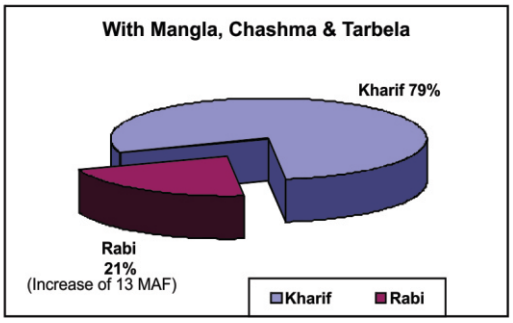
*** Average from 1976-77 to 2012-13**

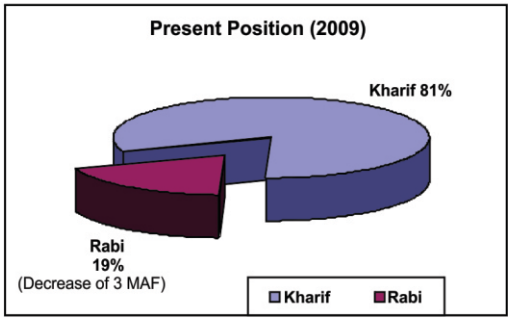
Annex-06

SEASONAL CARRY OVER FROM KHARIF TO RABI THROUGH ON-LINE STORAGES









Annex-07

INDUS BASIN AVERAGE CANAL WITHDRAWALS AND CORRESPONDING ON-LINE STORAGE AVAILABILITY TILL COMPLETION OF INDUS BASIN PROJECT

Period	Average System Canal Withdrawals (MAF)	Average Storage Availability (MAF)	Remarks
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

Annex-08

TARGETED INDUS BASIN IRRIGATION SYSTEM DEMANDS AS PER PROVISIONS OF 1991 WATER APPORTIONMENT ACCORD

Sr. No.	Province / Project	Annual Irrigation Demand (MAF)
I.	**BELOW RIM-STATIONS**	
	PARA 2 (WAA)	
1	**Punjab**	55.94
2	**Sindh**	48.76
3	**NWFP (Khyber Pakhtunkhwa):**	
	i. CRBC (Gravity)	1.53
	ii. Additional for [CRBC(L+G)]	0.72
	Sub-Total (3)	2.25
4	**Balochistan**	3.87
5	**Sub-Total Para 2**	110.82
	PARA 4 (WAA)	
6	**Punjab:** (G. Thal)	0.62
7	**Balochistan:**	
	i. Kachhi Canal (Flow)	1.21
	ii. Kachhi Canal (Raised Mangla)	0.36
	iii. Pat Feeder Extension	0.10
	Sub-Total (7)	1.67
8	**Sindh:**	
	Rainee	1.09
9	**NWFP:**	
	CRBC (L+G)	0.47
10	**Sub- Total Para 4**	3.85
11	**Grand Total (Para 2 + Para 4) PARA 7 (WAA)**	114.67
12	**Kotri Below for Seawater Intrusion and Environment**	3.62 [d]
13	**TOTAL BELOW RIM-STATIONS (I)**	
	i. MAF	118.29
	ii. BCM	145.97
II.	**ABOVE RIM-STATION**	
	NWFP (Khyber Pakhtunkhwa) Under Para-2	6.56 [e]
III.	**GRAND TOTAL (I + II)**	
	i. MAF	124.85
	ii. BCM	154.07

a. Total Pat Feeder para 2 allocations are 3.01 MAF (3.72 BCM); 0.45 MAF (0.56 BCM) for Kachhi canal will be utilized at Taunsa Barrage, while balance at Guddu Barrage will be 2.56 MAF (3.16 BCM).

b. Total CRBC (L+G) allocations are 1.19 MAF (1.47 BCM), out of which para 2 and para 4 allocations are 0.72 MAF (0.89 BCM) and 0.467 MAF (0.58 BCM), respectively.

c. Total includes: Trimmu 3.33 MAF (4.10 BCM); Panjnad 4.92 MAF (6.07 BCM); and SVCL 4.65 MAF (5.74 BCM).

d. As per Federal Government Consultant's Report duly reviewed by International Panel of Experts (IPoE) on Water Escapages Below Kotri Barrage, dated 20-11-2005.

e. NWFP above rim-station para 2 allocations are for Swat Canals; Kabul River Canals; Pehur Canals (high and low level); Lower Siran; Marwat; III Lora, Muqam nala; small irrigation; and Civil Canals.

Note: - Allocations of new projects i.e. Greater Thal Canal, Kachhi Canal, Pat Feeder Extension, Rainee Canal and Raised Mangla are as per approval of IRSA, conveyed by Chief Engineer (H&WM), WAPDA vide No. : CE (H&WM) / 3-W/ 7720, dated 08-11-2005.

Annex-09

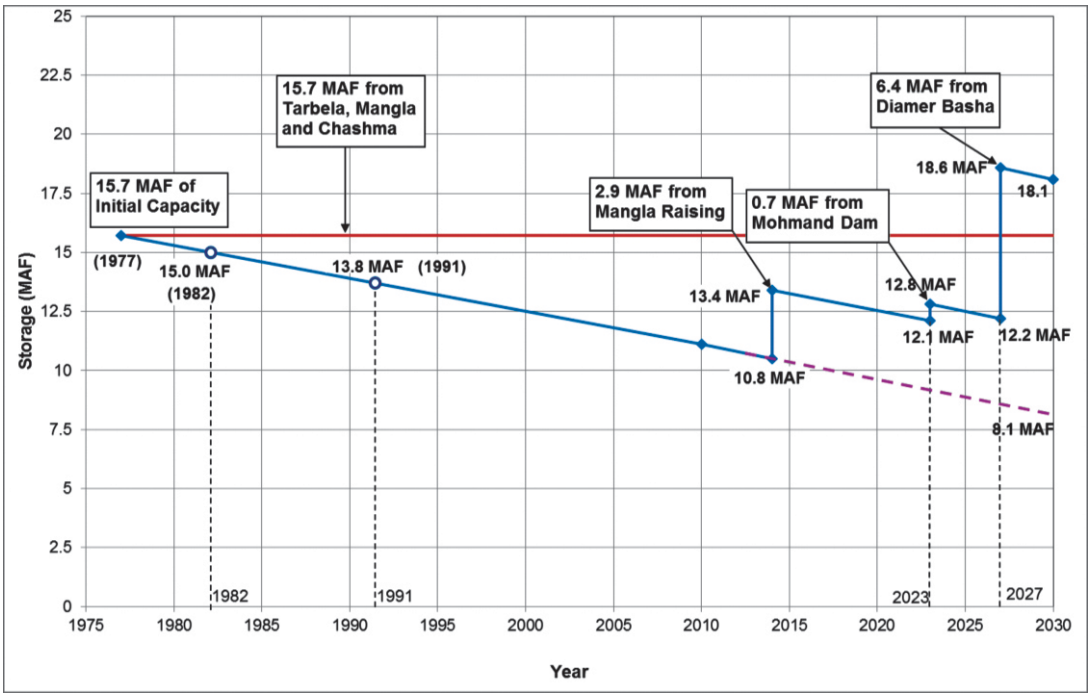
ESTIMATED MINIMUM ADDITIONAL STORAGE REQUIREMENT [a] BY 2030

		MAF
1.	Replacement of On-line Storage Loss	6
2.	Meeting shortfall between projected demand and anticipated withdrawals of 2030:-	
	i. Minimum Demand	125
	ii. Anticipated Withdrawals Without Additional Storage	105
	iii. Corresponding Storage Requirement @ 60% of 20 MAF Shortfall	12
3.	Total Storage Requirement [1+2(iii)]	18

a) Corresponding to WAPDA's Vision 2025 Programme and ADB's Water Strategy Study

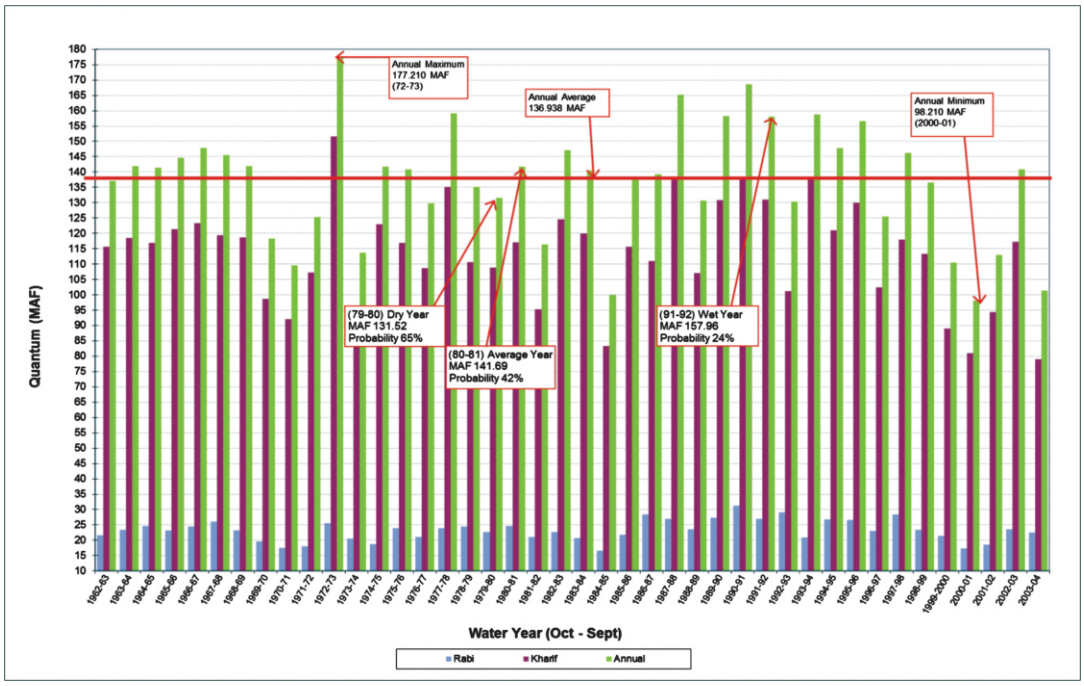
Annex-10

PROJECTED SEDIMENTATION AND LIVE STORAGE CAPACITY THROUGH 2030



Annex-11

WATER AVAILABILITY UNDER POST -DIAMER BASHA SCENARIO AT RIM-STATIONS OF WESTERN RIVERS



Annex-12

SYSTEM IRRIGATION SERVICE UNDER PRE AND POST -DIAMER BASHA SCENARIOS

Sr. No.	Context	Inflow Condition	Canal System [a] Service (%)		Service for Ecology Releases Below Kotri (%)	
			Pre-DBD	Post-DBD	Pre-DBD	Post-DBD
1	Rabi	i. Wet (1991-92)	92	100	93	100
		ii. Average (1980-81)	83	98	83	100
		iii. Dry (1979-80)	78	91	79	90
2	Kharif	i. Wet (1991-92)	100	100	100	100
		ii. Average (1980-81)	100	100	100	100
		iii. Dry (1979-80)	98	98	98	98
3	Annual	i. Wet (1991-92)	97	100	96	100
		ii. Average (1980-81)	96	100	92	100
		iii. Dry (1979-80)	92	96	88	94

a) Excluding NWFP (Khyber Pakhtunkhwa) canals above Kalabagh with entitlement of 6.6 MAF.

Annex-13

PROVINCIAL / REGIONAL CANAL SERVICE AND SHORTAGE UNDER PRE AND POST -DIAMER BASHA SCENARIOS

Sr. No.	Context/Inflow Condition	Canal System Service (%)			
		Pre-Diamer Basha		Post-Diamer Basha	
		Upper Indus	Lower Indus	Upper Indus	Lower Indus
1	**Rabi Context**				
	i. Wet Year (1991-92):				
	a. Irrigation Service (%)	91	92	100	100
	b. Shortage (%)	9	8	0	0
	ii. Average Year (1980-81):				
	a. Irrigation Service (%)	83	83	99	99
	b. Shortage (%)	17	17	1	1
	iii. Dry Year (1979-80):				
	a. Irrigation Service (%)	79	78	92	92
	b. Shortage (%)	21	22	8	8
2	**Kharif Context**				
	i. Wet Year (1991-92):				
	a. Irrigation Service (%)	100	100	100	100
	b. Shortage (%)	0	0	0	0
	ii. Average Year (1980-81):				
	a. Irrigation Service (%)	100	100	100	100
	b. Shortage (%)	0	0	0	0
	iii. Dry Year (1979-80):				
	a. Irrigation Service (%)	98	98	98	98
	b. Shortage (%)	2	2	2	2
3	**Annual Context**				
	i. Wet Year (1991-92):				
	a. Irrigation Service (%)	97	98	100	100
	b. Shortage (%)	3	2	0	0
	ii. Average Year (1980-81):				
	a. Irrigation Service (%)	95	96	100	100
	b. Shortage (%)	5	4	0	0
	iii. Dry Year (1979-80):				
	a. Irrigation Service (%)	92	93	96	96
	b. Shortage (%)	8	7	4	4

Annex-14

SURPLUS WATER DOWNSTREAM OF KOTRI BARRAGE FOR FUTURE DEVELOPMENT IN WET, AVERAGE AND DRY YEARS UNDER PRE AND POST-DBD SCENARIOS

Sr. No.	Context / Inflow Condition	Surplus Water [a] for Future Development Downstream of Kotri Barrage					
		Pre-DBD Scenario (MAF)			Post-DBD Scenario(MAF)		
		Indus	Jhelum-Chenab	Total	Indus	Jhelum-Chenab	Total
1.	Rabi Context						
	i. Wet Year (1991-92)	0.1	0	0.1	0.1	0	0.1
	ii. Average Year (1980-81)	0.2	0	0.2	0	0	0
	iii. Dry Year (1979-80)	0	0	0	0	0	0
2.	Kharif Context						
	i. Wet Year (1991-92)	11.0	7.6	18.6	10.6	7.6	18.2
	ii. Average Year (1980-81)	5.8	4.8	10.6	0.8	4.9	5.7
	iii. Dry Year (1979-80)	5.8	2.4	8.2	0	2.7	2.7
3.	Annual Context						
	i. Wet Year (1991-92)	11.1	7.6	18.7	10.7	7.6	18.3
	ii. Average Year (1980-81)	6.0	4.8	10.8	0.8	4.9	5.7
	iii. Dry Year (1979-80)	5.8	2.4	8.2	0	2.7	2.7

a) Excluding ecological releases for seawater intrusion and environment

Annex-15

SUMMARY OF MEAN ANNUAL GENERATION AND ADDITIONALITY UNDER PRE AND POST-DIAMER BASHA SCENARIOS

Sr. No.	Power Station	Mean Annual Generation [a] (Gwh)								Mean Additionallity	
		Pre-Diamer Basha				Post-Diamer Basha				Gwh	%
		Wet	Average	Dry	Mean	Wet	Average	Dry	Mean		
1	Diamer Basha	0	0	0	0	20329	18921	18026	19092	19092	100.0
2	Tarbela	15453	15397	14485	15112	17276	16602	15306	16395	1283	8.5
3	Ghazi-Barotha	6378	6312	6202	6298	7268	7472	7356	7366	1068	17.0
4	Chashma	1023	976	908	969	1142	1020	991	1051	82	8.5
5	**Total**	**22854**	**22685**	**21595**	**22379**	**46015**	**44015**	**41679**	**43904**	**21525**	**96.2**

a) Mean of wet (1991-92), average (1980-81) and dry (1979-80) years

Annex-16

CASCADING EFFECT OF DIAMER BASHA DAM PROJECT ON DOWNSTREAM HYDROPOWER PROJECTS

Sr. No.	Location	Installed Capacity (MW)	Status	Cascading Effect of Annual Additional Generation (GWh)	Remarks
I.	**Existing Projects**				
1.	Tarbela	3478	In operation	1300	With enhancement of installed capacity to 6298 MW through 4th and 5th extensions, additional generation between 15-20% may become possible
2.	Ghazi-Barotha	1450		1100	
3.	Jinnah	96		40	Estimated @ 10% of annual generation with 50% plant factor
4.	Chashma	184		80	
5.	**Sub-Total I (1 to 4)**	**5208**		**2520**	
II.	**Upcoming Projects**				
1.	Dasu	4320	Under Two Stage Implementation	5400	At about 25% of estimated total annual generation of 21500 GWh
2.	Pattan	2380	Feasibility Completed	1900	Based on 2015 Feasibility Study
3.	Thahkot	3900	Feasibility in hand	3200	15% of estimated total annual generation of 21,300 GWh
4.	**Sub-Total II (1 to 3)**	**10,600**		**10500**	
III.	**Total Cascading Effect of Diamer Basha Dam Project (I + II)**	**15,808**		**13,020**	**Over 70% of annual at site generation of 18100 GWh**

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NATIONAL WATER POLICY – A MILESTONE TO ADDRESS WATER SCARCITY IN PAKISTAN

Dr. Qazi Tallat, M. Siddiqui

NATIONAL WATER POLICY – A MILESTONE TO ADDRESS WATER SCARCITY IN PAKISTAN

BY

DR. QAZI TALLAT, M. SIDDIQUI

Deputy Engineering Adviser, Ministry of Water Resources

Pakistan has one of the largest contiguous irrigated systems in the World. The snow-clad peaks of the mountain ranges in the North continuously re-charge the system. The descending snow-melt and monsoon waters flow into the country's Indus River System and its tributaries. Passing through the plateau and the great plains across the Indus Valley, the rivers join up to form the Indus that eventually drains into the Arabian Sea in the South. Irrigated agriculture is the backbone of the country's economy, and consumes around 95 percent of the nation's water resources, the balance is used for domestic and industrial requirements. With rapidly growing population, Pakistan is heading towards a situation of water shortage and by corollary, a threat of food insecurity. Per capita surface water availability has declined from 5,260 cubic meters per year in 1951 to around 1,000 cubic meters in 2016. This quantity is likely to further drop to about 860 cubic meters by 2025 marking our transition from a "*water stressed"* to a *"water scarce"* country .The situation calls for rapid development and management of the country's water resources on a war footing.

Water resources are inextricably linked with climate and the impending climate change scenario has serious implications for Pakistan's water resources. The continuing increase in population at an annual rate of over 2% combined with rapid and un-regulated urbanization has already pushed Pakistan into the category of water stressed countries. The changing and unpredictable precipitation patterns may have serious consequences, including flash floods in the north and increasingly prolonged droughts in the south. As the glaciers retreat, more glacial lakes will form, increasing the risk of Glacial Lake Outburst Floods (GLOF), which are already becoming increasingly common and hazardous in the Northern parts of the country. Only by devising and implementing appropriate adaptation measures will it be possible to ensure water, food and energy security for the country as well as minimize the impact of natural disasters.

The objective of the National Water Policy is to take cognizance of the emerging water crisis and provide an overall policy framework and guidelines for a comprehensive plan of action. Pakistan has a federal system of government and the provinces enjoy a considerable degree of autonomy under the 18thAmendment to the Constitution. Thus, this policy is a national framework within which the provinces can develop their master plans for sustainable development and management of water resources. The water resource is a national responsibility but irrigation and agriculture, as well as rural and urban water supply, environment and other water related sub-sectors are provincial

subjects. NWP is an enabling document and provides comprehensive guidelines for water resources management and development as per international practice. It also contains a development action plan till 2030. NWP will pave way for improved, sustainable and integrated water resources management in the country to combat the water scarcity in the future.

NATIONAL WATER POLICY –A MILESTONE TO ADDRESS WATER SCARCITY IN PAKISTAN

1. INTRODUCTION

The development and management of water resources in Pakistan has received considerable attention in many national and international studies and reports in the past three decades. These include:

i. The Report of the National Commission on Agriculture, Chapters 6,17,18(1988).

ii. Report of the Inter-Provincial Committee on the Apportionment of the Indus Waters (1991).

iii. Water Sector Strategy by the Asian Development Bank (2002).

iv. WAPDA's Vision 2025 Report (2003)

v. Pakistan's Water Economy Running Dry by John Brisco (2005).

vi. Development of Integrated River Basin Management for Indus Basin: World Wildlife Fund (2012).

vii. A Productive and Water Secure Pakistan: Report by Friends of Democratic Pakistan (2012).

viii. Pakistan Vision 2025: Pillar IV: Energy, Water and Food Security; Planning Commission, Government of Pakistan (2014)

ix. A Region at Risk – the Human Dimension of Climate Change in Asia and the Pacific: Report by Asian Development Bank and Potsdam Institute for Climate Impact Research: (2017).

These useful Reports and Studies stimulated considerable debate in professional circles and may have led to some useful projects and initiatives but the overriding objective of evolving an integrated Water Resources Management Strategy which can promote the coordinated development and management of water and land resources in a sustainable and equitable manner, has not yet been achieved. This is partly because any crisis that is creeping slowly does not normally attract high level political attention. But in Pakistan, concerns about future water shortages have been moderated at the farm level, by expanding abstraction of ground water in Punjab and Sindh. Currently 1 million tube wells are pumping about 55 million acre feet of underground water for irrigation, which is 20% more than that available from the canals. While the continuing increase in population at an annual rate of over 2% combined with rapid and un-regulated urbanization has already pushed Pakistan into the category of water stressed countries, the phenomenon of climate change is causing faster melting of the high altitude glaciers, on which the Indus Basin system is dependent and is also increasing sea levels.

Pakistan is located in one of the three most vulnerable regions in the world in terms of climate change threats of increasing frequency and intensity of floods, prolonged droughts and the frightening possibility of the melting of the Himalayan Ice cap.

This National Water Policy can provide a major response to the emerging water crisis if:

i. It receives high level political support, as a national imperative.

ii. It provides a set of agreed national targets for water conservation, water storage, water treatment and clean drinking water.

iii. It leads to a sustained national commitment to substantially increase public and private resources for the water sector.

iv. It creates an institutional framework that can address present deficiencies in project management and cost effective maintenance on a war footing to revive the technical capacity and efficiency of the system that achieved such remarkable progress between 1950 and 1990.

It has become a national imperative to ensure water security for the people of Pakistan, through a National Water Policy (NWP) laying down the outlines of an integrated water management strategy that can optimize the economic, social and environmental returns on water resources, ensure equitable allocation among its competing demands as well as its judicious use by consumers and safe disposal of post-use effluents.

2. MAJOR ISSUES IN PAKISTAN WATER SECTOR

Some of the specific issues concerning the water sector are:

i. Fresh water being a finite resource is progressively becoming more scarce due to persistent increases in its competing demands;

ii. Water scarcity can adversely affect the health and well-being of the people of Pakistan and must be resolutely addressed especially since it has serious implications for the nation's food and energy security;

iii. The geographic location of Pakistan places the country in the heat surplus zone on Earth, putting it high on the vulnerability scale of climate change with considerable increase in frequency and intensity of extreme weather events and erratic monsoon rains (as demonstrated by the unprecedented floods of 2010)

iv. Existing and planned trans-boundary developments on the Western Rivers could further impact water availability to the disadvantage of Pakistan;

v. The "Indus Basin Replacement works" (dams in particular) are approaching the end of their designed life span due to siltation. requiring replacement storages;

vi. Different regions in the country are endowed differently with water in terms of precipitation, surface flow and ground water and there is increased stress on the sharing of water resources;

vii. Lack of equity in water allowances of various canal commands is causing water and salt imbalances at a regional level;

viii. Salt balances in irrigated lands are already negative and with the passage of time the soil quality will deteriorate resulting in reduced yields.

ix. Bulk of drinking water requirement is met by groundwater which is depleting and its quality is deteriorating;

x. It is necessary to avoid growing conflicts and social unrest in the country due to water scarcity;

xi. The mandate and roles of the federal and provincial water related agencies need to be reviewed in view of the 18th Amendment to the Constitution;

xii. Concentrated efforts are needed to re-use treated sewage water in order to reduce sweet water demand;

xiii. There is lack of awareness amongst the general public about the impending threat of water scarcity and the huge wastage of sweet water; excessive watering of crops is endemic with total disregard for efficiency and conservation;

xiv. Desalinization of Sea water is a significant source of water, however, no effort has been made for desalinization in the light of technology advances and international best practices;

xv. Irrigated agriculture is indispensable for Pakistan's agriculture and low irrigation efficiency vis-à-vis water productivity is a major factor leading to lower growth of the sector;

3. OBJECTIVES OF NWP

The National Water Policy lays down a broad policy framework and set of principles for water security on the basis of which the Provincial Governments can formulate their respective Master Plans and projects for water conservation, water development and water management. The National Water Policy is based on the concept of Integrated Water Resources Management primarily aimed at the following policy objectives:

i. Promoting sustainable consumption and production patterns throughout the water sector from exploitation to utilization;

ii. Augmentation of the available water resources of the country through judicious and equitable utilization via reservoirs, conservation and efficient use;

iii. Improving availability, reliability and quality of fresh water resources to meet critical municipal, agricultural, energy, security and environmental needs;

iv. Improving urban water management by increasing system efficiency and reducing non revenue water through adequate investments to address drinking water demand, sewage disposal, handling of wastewater and industrial effluents;

v. Promoting behavioral change to reduce wastage of water by raising public awareness through media campaigns and incorporating water conservation lessons in syllabi/curricula at primary, secondary and tertiary levels;

vi. Hydropower development to increase the share of renewable energy;

vii. Providing food security and expanding water availability to help adapt to climate change, population and other large-scale stresses;

viii. Treatment and possible reuse of waste water - domestic, agricultural and industrial;

ix. Upgrading water sector information systems for improved asset management and to derive evidence and data driven decision making;

x. Improving watershed management through extensive soil conservation, catchment area treatment, preservation of forests and increasing forest cover;

xi. Restoring and maintaining the health of the environment and water related eco systems;

xii. Flood management to mitigate floods and minimize their damages;

xiii. Drought management with emphasis on long term vulnerability reduction;

xiv. Guarantee Socio-Economic Benefits of the water related infrastructure for relevant stake-holders to ensure sustained utilization;

xv. Promoting appropriate technologies for rain water harvesting in rural as well as urban areas;

xvi. Regulating groundwater withdrawals for curbing over-abstraction and promoting aquifer recharge;

xvii. Adequate water pricing (Abiana) for irrigation and proper operation and maintenance of the irrigation system as well as other user sectors;

xviii. Promoting measures for long term sustainability of the Irrigation System;

xix. Encouraging beneficiary participation and public private partnerships;

xx. Strengthening and Capacity building of water sector institutions;

xxi. Profitable use of flood water towards promotion of local irrigation practices;

xxii. Exploitation of vast potential of water generated through hill torrents;

xxiii. Protection of wet lands and Ramsar Sites for the prevention of wild life, flora and fauna;

xxiv. Stoppage of further sea water intrusion into Sindh (upstream from coastline) for the sustainability of coastal environment, flora and fauna and mangrove growth including the use of skimming dug- wells in coastal areas ;

xxv. Establishment of Hydro-meteorological disaster risk reduction complied integrated water resources management regime;

xxvi. Enhancing water productivity through infrastructure development and adoption of improved technologies in a sustainable manner;

xxvii. Climate change impact assessment and adaptation for sustainable water resources development and management;

xxviii. Promoting research on water resources related issues of national importance and building capacity/delineating roles and responsibilities of Federal research institutions and promoting coordination among them;

xxix. Setting major national targets for the water sector including those for water conservation, water storage, Irrigation, water treatment and drinking water. These targets can be firmed up in consultation with the Provincial Governments and reviewed periodically for inclusion in the 12th and 13th Five Year Plans and future plans;

xxx. Secure Katcha areas and economy thereof;

xxxi. Preserve delta area by providing sufficient supplies regularly;

xxxii. Rainwater management in plains where it cannot be disposed of or diverted to the river;

xxxiii. Effective implementation of the 1991 Water Apportionment Accord in letter and spirit.

4. PRIORITY OF WATER USES

The priorities set in NWP for the consumptive and non-consumptive uses of water shall be as follows:

i. Drinking and Sanitation (WASH)

ii. Irrigation including land reclamation

iii. Livestock, fisheries and wildlife

iv. Hydropower

v. Industry and mining

vi. Environment, river system, wetlands, aquatic life

vii. Forestry including social forestry

viii. Recreation and sports

ix. Navigation

5. STRATEGIC AREAS OF NWP

National Water Policy (NWP) is based on a set of principles aimed at promoting greater national interest and the welfare of the people of Pakistan. In NWP seven strategic areas have been identified that will be taken up at the Federal and Provincial levels, since they are of critical importance to the water, energy and food security of Pakistan. These include,

5.1 Conservation and Efficiency:

More than 50 per cent of canal water diverted from the Indus system does not reach the farm level. While the main canals cannot and should not be lined, a crash programme for lining the water courses can reduce the seepage by at least one third. Similarly conservation measures can be adopted for ground water by regulating its extraction and

use. Both conservation and efficiency must be highlighted for Demand Side Management (DSM) of water resources. The current policies have a supply side bias. It is important to make the distinction between efficiency, which means reducing waste and doing more with less and conservation, which refers to restricting use.

5.2 Storage:

The most important instrument of mitigation against the impact of climate change on water resources is storage. If the pattern of rainfall becomes erratic with more than average rain in one year and a drastic reduction in the next years' rainfall, the only way to conserve the surplus rainwater in wet years is to store it and release it in dry years, when required. For storage and new irrigation projects a national master plan must be developed which must cater for storage, floods, arid areas, irrigation, urban water and tariff rationalization. In addition there are vast possibilities of small and medium size dams, enhancing the life of existing storages and remodeling and rehabilitation of existing infrastructure in the country. Expansion of water storage will expand irrigation and also increase the proportion of hydro-power in the energy mix, reducing the need for thermal power.

5.3 Leveraging Technology:

Adoption of new technologies is urgently needed for (i) sea water utilization and water recycling (ii) preparation of an inventory of water resources through remote sensing and GIS technologies (iii) accurate monitoring of irrigation water delivery. Home grown innovation in the water sector should be encouraged as much as possible, including investments aimed at start-up companies that promote remote sensing, demand side management and agricultural productivity.

5.4 Renewable Energy:

Sustainable water resources development has a close nexus with renewable energy. Large, medium and small dams not only generate cheap and clean energy but also provide reliable source of water for agriculture and other human needs. With appropriate policies and subsidies, a large percentage of tube wells in Pakistan, can be converted to solar energy especially in areas where water table is not very low, to provide additional water at lower cost. Solar energy can also be used for day-time de-salinization of sea water, particularly in the coastal areas of Baluchistan.

5.5 Integrated Water Resource Management:

The management of water resources is shifting from sectoral to a more integrated approach in different parts of the world. Under IWRM, (i) the interests of all upstream and downstream stakeholders can be protected against mining and contamination. (ii) Watershed and catchment areas can be protected to prolong the life of water storage facilities. This revolutionary IWRM concept will however require strengthening institutional and management capacity at all levels.

5.6 Comprehensive Regulatory Framework:

The Federal government must play a leading role in facilitating regulations to ensure the efficient and sustainable utilization of ground water, industrial uses, and waste water management. Food security, water security and energy security being inextricably

linked, so the regulatory framework must address all the associated issues comprehensively, including ground water contamination, waste treatment, open defecation (WASH).

5.7 Planning Principles:

The process of planning, development and management of water resources at the Federal and Provincial level, including the development of this policy will be guided by the following set of principles:

i. Equity and participatory decision-making; Water sector activities shall be participatory and consultative at each level and decisions will be taken by consensus

ii. Water is a strategic resource and access to affordable and safe drinking water is a fundamental human right of all citizens

iii. Efficiency and conservation will be promoted at all levels

iv. Environmental Sustainability must be ensured

v. Practicability and Innovation will be encouraged and ensured

vi. Command area development shall be the responsibility of farmers with government support in respect of small land-holdings

Within these broad parameters of water security, the provincial governments can formulate more detailed policies and guidelines on other subjects like (i) water pricing (ii) drinking water, (iii) water quality and (iv) water treatment, keeping in view the national environment policy 2005, the national sanitation policy 2006andthe national drinking water policy 2009 and the overall agricultural priorities.

6. SALIENT PROVISIONS OF NWP

Salient features of NWP include; Water Uses and Allocation of Priorities, Integrated Planning for Development and use of Water Resources, Environmental Integrity of Basin, Impact of Climate Change, Trans-boundary Water Sharing, Irrigated as well as Rain-fed Agriculture, Drinking Water and Sanitation, Hydropower, Industry, Ground Water, Water Rights/Obligations, Stakeholder's Participation, Sustainable Water Infrastructure, Water-Related Hazards, Quality Management, Information Management, Research, Economic and Financial Sustainability, Demand Management, Conservation of Water, Legal Framework and Capacity Building of Water Sector Institutions.

7. TARGETS OF NWP

Our river flows are heavily dependent on glacial melt (41%), snowmelt (22%) and rainfall (27%). The Indus River System receives an annual influx of about 138.4 Million Acre Feet (MAF) of water. Pakistan receives snowfall only in the Northern Areas of the country during winter. Rainfall is markedly erratic in magnitude, time of occurrence and aerial distribution. The mean annual precipitation ranges from less than 100 mm in parts of the Lower Indus Plain to over 750 mm near the foothills in the Upper Indus Plain.

Pakistan is mainly dependent on the three western rivers of the Indus (including Kabul, Jhelum and Chenab). Post-Tarbela (1976-2008) flows (Indus at Kalabagh, Jhelum at

Mangla and Chenab at Marala) were 137 MAF. The three eastern tributaries of the Indus – Ravi, Sutlej and Beas – were allocated to India for its exclusive use. Currently about 1.4 MAF of water flows from India to Pakistan through these eastern rivers. Pakistan is extracting 50 MAF from the aquifers and already crossed the sustainable limit of safe yield. This over-mining and pollution of aquifers has resulted in secondary salinization and the presence of fluorides and arsenic in water, which in turn is degrading the quality of agricultural lands.The Indus Waters Treaty led to the construction of multiple hydraulic structures. These enabled Pakistan to enhance water availability at canal head works to about 104.0 MAF. However, this has now started decreasing because of the lack of surface water development since construction of Tarbela dam and the significant loss of on-line storage capacity through sedimentation. Of the 104.0 MAF of annual canal diversion, only 58.3 MAF reaches the farm-gate, while remaining 46.7 MAF seeps into the ground water.

Water Availability can be enhanced through reduction in water loss, additional water storage through large, medium and small dams, cycling used waters, desalinization of sea water and more efficient water use. An important aim of the National Water Policy is to fix quantifiable targets in each of these sub-sector with a timeline and estimated resources required over the next twelve years i.e. by 2030.

Main Targets proposed for 2018-2030 can be summarized as follows:

i. Reduction of 33 percent in the 46 MAF river flows that are lost in conveyance, through accelerated programme of water course lining specially in saline or semi saline areas.

ii. In order to augment the dwindling irrigation deliveries into the existing canal systems on account of ever decreasing existing storage capacity of Mangla and Tarbela due to sedimentation and to develop new cultivated area on canal irrigated water, the existing water storage capacity of 14 MAF shall be increased by immediately starting construction of the Diamer-Basha Dam Project having 6.4 MAF live storage on which consensus of all the federating units has already been achieved in 2009 at CCI level. The existing water storage capacity will be increased up to 10 MAF including Diamer-Basha Dam.

iii. Increase of at least 30 percent in the efficiency of water use by producing “more crop per drop”. This will require use of new technologies like drip and sprinkler irrigation and more realistic water pricing policy. The present average rate of water charges per acre is only one fourth of what the farmer pays for tube well water in the ground water market.

iv. Gradual replacement and refurbishing of decades old irrigation infrastructure in accordance with an adequate asset management plan.

v. Real-time monitoring of river flows by IRSA is to be ensured through telemetric gauging to support transparent water accounting system and to check the increasing trend of unaccounted-for water in the Indus System of Rivers. This task should be completed before the end of 2021.

vi. In order to establish and maintain a reliable assessment of water resources in the country, federal and provincial water sector organizations would develop a standardized and uniform mechanism for data collection of various parameters of water resources including but not limited to rivers/canals gauge and discharge, rainfall/snowfall, depth to groundwater table, surface/ subsurface water quality parameters, river/canal and reservoirs sedimentation.

The tentative targets proposed in this policy will be firmed up in consultation with the Provinces and incorporated in the 12th Five Year Plan (2018-2023) and 13th Five Year Plan (2023-2028).In addition to these over all national targets, the Provincial Governments can formulate their own targets for watershed management, aquifer recharge, ground water extraction and drainage as a part of their respective Master Plan for Water.

8. INVESTMENT REQUIREMENTS

The root cause for the current water crisis is lack of adequate allocations in the Public Sector Development Programme for the Water Sector. As a result there has been virtually no increase in the total cropped area of 55 MA in the past two decades. National Water Policy recognizes the need to ensure that water sector receives at least 10 percent of Federal PSDP allocation in 2018-19, gradually increasing to 20 percent by 2030. Correspondingly the Provincial Governments may also increase their development expenditure for this sector. Sub-sector wise estimates of investment needed by 2030 are given in the table below:

(Rs. Billion)

Sub Sector	Investment	Major Projects
Storage	1,600	Diamer-Basha Dam, Mohmand Dam
Conservation	800	HEIS Projects, lining of distributaries and minors, telemetric monitoring, improvement of conveyance efficiency
Drainage	150	RBOD-I, RBOD-II and RBOD-III, new reclamation projects
Flood Control	186	National Flood Protection Plan-IV (NFPP-IV)
Rehabilitation of Irrigation System	300	Rehabilitation of barrages, head-works and canals
Research 1% of total	30	IWASRI Research Program, GMRC, Hi-AWARE

Apart from that, sectors that can benefit from PPP modalities and private sector participation (like urban water and sewage for example) should immediately be opened up for investment through appropriate policies. The introduction of private capital and discipline in project execution will not only introduce cost savings and efficiency during implementation but will also save time and create a competitive environment. However,

it will have to be ensured that a public utility like water is not exploited for profit and the strictest regulatory standards are maintained. Fortunately, Pakistan has successfully undertaken private investment in the power sector so there is a readily available model that can be emulated.

9. IMPLEMENTATION MECHANISM

The integrated management of water resources requires the highest level of skills and knowledge to effectively address the looming water crisis. In fact, the real challenge is not just listing "what" needs to be done, because that is well known, but "how" to do it and "who" will do it, with a clear time lines. This is exactly what this policy has aimed to achieve.

Capacity Building of all water related Public Sector Organizations at Federal and Provincial level shall be given high priority to equip and improve their performance in order to generate capacity for:

i. Design, develop, upgrade, maintain and manage the water resources infrastructure according to national needs and optimum standards.

ii. Meet future challenges of increased demand and finite water resources.

iii. Meet challenges of climate change and demographic constraints;

iv. Ensure Integrated Water Resources Planning, Development and Management.

It is of paramount importance that an effective and responsive institutional structure is decentralized for implementation of this Policy that supports linkages between policy, practice, science and decision making, so as to facilitate at various levels, the sustainable solutions for water resources planning, development and management. The new priorities for the water sector that will be spelled out in the proposed increase in financial allocations for the water sector will be of limited value unless and until the institutional capacity for policy formulation and management capacity for project implementation is upgraded in a holistic manner. It is recognized that an effective institution is one that has a clear mandate, a legal framework, a well-structured organization with clear responsibilities and accountability at various levels, professionally competent engineers and other professionals with a clear mandate and operational autonomy. New and vibrant institutions are required at four levels i.e. planning, regulation, development coordination and management. The following institutional framework will be adopted and gradually strengthened:

9.1 National Water Council:

A national body named as "National Water Council" (NWC) shall be established with the following composition:

1.	Prime Minister of Pakistan	Chairman
2.	Federal Minister for Water Resources	Member
3.	Federal Minister for Power	Member
4.	Federal Minister for Finance	Member

5.	Federal Minister for Planning, Development & Reform	Member
6.	Chief Ministers of Provinces and one Provincial Minister nominated by the CMs	Members
7.	5 Private sector members from water related disciplines	Members
8.	Secretary, Ministry of Water Resources	Secretary

(Note**:** The Prime Minister AJK and Chief Minister G.B. will be invited to the meetings of NWC.)

The National Water Council shall meet at least once a year and perform the following functions:

i. Review and coordinate implementation of the National Water Policy and National Water Sector Strategy in the country and periodic updating of the same;

ii. Recommend legislation, policies and strategies for water resources development and management in the country;

iii. National planning and coordination for water resources development and management activities among concerned organizations at federal as well as provincial government level to achieve objectives of NWP;

iv. Review all major interprovincial water-related projects and activities in the fields of irrigation, drainage, flood control and hydropower where federal funding is involved to ensure optimal and economical use of water resources;

v. Create an enabling environment that shall promote broader multi-stakeholders' participation and integrated water resources management with due consideration for environment and ecology;

vi. Review in consultation with concerned organizations the progress in controlling pollution of water bodies including rivers, streams, lakes and groundwater;

vii. Coordinating water resources database service at different level;

viii. Any other functions, which the CCI may assign to the Council.

9.2 **A <u>Policy Steering Committee</u>** on water will assist the NWC by ensuring inter-provincial coordination and reviewing policy papers and monitoring reports before submission to NWC. The composition of the Steering Committee will be as follows:

(i)	Federal Minister for Water Resources	Chairman
(ii)	Secretary, Ministry of Water Resources	Member
(iii)	Secretary, Ministry of Power	Member
(iv)	Secretary, Ministry of PD & Reform	Member
(v)	Secretary, Ministry of Finance	Member
(vi)	Chairman WAPDA	Member

(vii)	Chief Engineering Advisor	Member/ Secretary
(viii)	Chairman NDMA	Member
(ix)	Surveyor General of Pakistan	Member
(x)	Chairman Pakistan Engineering Council	Member
(xi)	Provincial Irrigation Secretaries	Members
(xii)	Secretary (Works), PWD, Govt. of Gilgit-Baltistan	Member
(xiii)	ACS Fata Secretariat	Member
(xiv)	Secretary, (Irrigation & Small Dams), Govt. of AJ&K	Member

(Note: Depending upon the agenda other stakeholders can be invited)

The Steering Committee shall meet twice in a year or more, frequently whenever deemed necessary.

10. WAY FORWARD

Subsequent to approval of NWP, a national body named as “National Water Council” (NWC) has been established under chairmanship of the Prime Minister of Pakistan with Federal Minister for Water Resources, Federal Minister for Finance, Federal Minister for Power, Federal Minister for Planning, Development & Reform and Provincial Chief Ministers as members. The prime function of the NWC shall be to oversee the implementation of the Policy and issue directions where appropriate. A Steering Committee has also been notified to oversee and monitor the policy implementation guidelines given by the NWC through Policy Implementation Cell. The Steering Committee shall be headed by the Federal Minister for Water Resources with representatives from federal and provincial governments and concerned organizations. The Steering Committee shall have its meeting twice in a year or whenever deemed necessary .The draft NWP is an enabling document and provides comprehensive guidelines for water resources management and development as per international practice. It also contains a development action plan till 2030. It is strongly believed that NWP will pave way for improved sustainable and integrated water resources management in the country.

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STRATEGIC APPROACHES TO DEAL WATER SCARCITY IN PAKISTAN

M. Munir Ch., M. S. Qureshi, Dr. A. B Sufi, S. Laraib Zaidi

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By:

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ABSTRACT

With the increase in population of our country and changing geo-political landscape, the available water resources are fast depleting. We also understand that without water, there can be no life as we see in this physical world. The solution lies in judicious usage of water and realization to preserve, which ultimately leads to superior management of this essential resource. This paper addresses the issues pertaining to water required for agriculture, drinking as well as for other purposes. The measures recommended for preservation of irrigation water include cost effective maintenance of water channels under an integrated mechanism of public-private partnership and ownership through community participation. Similarly to resolve the issues related to drinking and general purpose water, a distinction between the two categories has been proposed for putting in practice under an integrated approach. For the purpose of enhancing storage capacity, instead of fighting on the construction of much awaited mega dams, the paper suggests construction of small dams and run of the water channels auto-spillover bunds are short term solutions. However, construction of mega reservoirs is also necessary to cope with water needs. These measures, apart from being cost effective (i.e. affordable) shall have no political controversies. The concept is storage of water through spread over river beds and storage sites. The paper also suggests measures for creating awareness among our people to make judicious use of water.

However, due to some controversial issues and short funds availability of required funding, it has not been possible to undertake construction new storage dam, to meet with the urgent national need for additional storage capacity, especially on river Indus is to be taken on fast track. The construction of additional dams would not only augment irrigation supplies, but also mitigate floods, besides increase in power generation, employment opportunities and economic boost. Our underground water resources are being over exploited. Increase in sustainable water resources in the country can be achieved through a combination of exploring valuable groundwater aquifers and constructing potential large, medium and small surface water storages and through water conservation strategies. This combination will be critical in meeting the water needs of the 21st century in the country.

1. INTRODUCTION

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Our country would be critically water stressed by the year 2025. In recent days, this prediction has generated headlines and stimulated social media users across the country. It's not the first time we've heard about this phenomenon. The UN, Pakistan's Met department and the Pakistan Council of Research in Water Resources have all pointed out this aspect in recent years. The fact that the projection didn't attract much attention previously is surprising. For years, Pakistan's water researchers have showed deep concerns about water insecurity. Most of the people couldn't be concerned to look up to see water scarcity. But perhaps because of the debate on the Kishanganga dispute, Pakistan's water distresses are getting attention. That's a good thing, when the planner's attention was invited towards the situation, when India untimely stopped water for a certain period during Rabi crop season, the seriousness of the situation. The water scarcity has reached a crucial stage in Pakistan, and it is considered as one of the water-stressed countries in the World. It is apprehended that country has become water scarce due to high population, estimated over 210 million in 2018. The water storage capacity has been reducing due to continuous sedimentation of its existing reservoirs. It is apprehended that by the end of year 2018, storage capacity of reservoirs would be reduced by **28%**. Under this scenario, construction of mega multi-purpose storage dams is assuming highest priority to sustain irrigated agriculture which is the backbone of Pakistan's economy and to meet the growing water needs of all water utilizing sectors. For meeting these requirements, a number of dams are planned on River Indus including under construction Dasu Hydropower Project. However, due to some controversial issues and non-availability of required funding, it has now been possible to undertake construction of storage dams, despite urgent national need for additional storage capacity, especially on river Indus. The construction of additional dams would not only augment irrigation supplies, but also mitigate floods, besides increase in power generation, employment opportunities and economic boost?

These dams would store billions cubic meters of water that presently is going unutilized into the sea during floods in summer months. Confidence building measures among provinces, to address the related controversial issues for building new dams, is a real national need. Additional water will be needed to meet requirements of irrigated agriculture and anticipated improvements in the standard of living through greater economic activity. Increase in industrial activity will also require additional water. Our underground water resources are already being over exploited. Increase in sustainable water resources in the country can be achieved through a combination of exploring valuable groundwater aquifers and constructing potential large, medium and small surface water storages and through water conservation strategies. This combination will be critical in meeting the water needs of the 21st century in the country. Per capita water availability is quite less than around 1,700 cubic meters, the scarcity threshold. In some areas, the water indx has been reduced, bringing misery to farmers and an agricultural sector that dominates the economy. Drought conditions are prevailing in Balochistan. According to officials in Karachi, residents receive less than 500 million gallons of water per day which is well below 50 per cent of daily needs. Meanwhile, groundwater tables are reducing. According to the World Wide Fund for Nature in Pakistan, the water table has fallen below 130 feet (39.6 meters) in central Lahore. The Indus basin aquifer, as revealed by NASA Satellite data, is the most stressed in the world. Groundwater is water security's safety factor, in Pakistan, this safety factor is distressing rapidly. The

groundwater is also increasingly being contaminated. Let's be clear that Pakistan is rapidly running short of water, and much of what's left is unfit groundwater for human consumption.

Over 53,000 children die every year from waterborne disease, according to UNICEF, pick up this in the most tragic way. More than two-thirds of Pakistan's households drink contaminated water, according to UNICEF. Research in Science Advances journal finds that, based on about 1,200 groundwater samples, up to 60 million people, more than a quarter of the population, are at risk of consuming arsenic. An enormous, 91pc of Karachi's water, according to a Pakistani judicial commission report, contains sewage and industrial waste. Water pollution isn't just a public health hazard and it's also detrimental to the economy. According to the World Bank, it costs Pakistan nearly 4pc of GDP. With scarcity having arrived, there's only so much that can be done. Indeed, the what-should-be-done, can-anything-be-done?

Fortunately, the answer is yes. The first step is to develop a national consensus, with buy-in from the entire political class, for addressing a long-neglected crisis. A new national water policy, approved, is a good start. It needs a strong implementing framework and should be formed by inputs from Pakistan's water experts. A preference for wasteful flood irrigation and water consuming crops, and lack of maintaining and repairing ageing, leaky water infrastructure; a paucity of wastewater treatment facilities, and a distorted water-pricing regime that gives way to losses. For Pakistan, the alternative is glaring where some, equipped with electric tube wells, desperately search for the last drops of groundwater. Today, with the existential threat posed by water stress is coming into sharp focus to be attended on a fast track as quick as possible. Water is a natural commodity which sustains life on our planet, may it be in the shape of plants, animals or human beings. In fact without water there can be no life as we see in this physical world. At the same time we find that fresh water does not exist in unlimited quantity, rather its storage has certain limits within which it recycles under a natural system. The living beings and plants require certain quantity of water, if deficiency occurs beyond the desired limits, the life is threatened. This simply implies "No water No life". Allah has created every living being on the earth surface out of water.

Verily in the creation of heavens and the earth, and in the alternation of night and day, and the ships which sail through the sea with that which is of use to mankind, and the water (rain) which Allah sends down from the sky and makes the earth alive therewith after its death and moving (living) creatures of all kinds that He has scattered therein, and in the turning of winds and clouds which are held between the sky and the earth, are indeed Ayahs (proofs, evidences, signs) for people of understanding. We opened the gates of the heaven with water pouring forth. With the increase in population and ongoing rapid industrialization – urbanization, consumption of water has increased manifold. This has resulted into a situation of water scarcity, leading to water crisis, particularly in countries like Pakistan. Water here means the 'usable water' not its overall availability as it exist like the sea water which cannot be used for living beings till the time it is processed to make it usable. As referred above, our Earth has a finite supply of fresh water, stored in aquifers, some as surface waters and some in the atmosphere.

Where deficiency of water may slowly lead to economic crisis and consequently elimination of living beings, its availability - flow in excess to our capacity of storage and drainage into the sea becomes disastrous for the living beings like we see the situation of floods in Pakistan in the past and the one occurred in August 2010. The recent floods just washed away the human settlements - large number of our towns, cities and villages apart from the destruction of crops at large scale and deaths of human beings as well as animals. It has incurred colossal loss to our economy which may take decades to recover. Therefore, it is disastrous in either way (i.e. the deficiency of water as well as its excess beyond certain limits). At the same time, in its polluted form, water leads to the outbreak of numerous diseases and consequently large scale deaths. According to a survey, at any given time, almost half of the hospital beds are occupied by the patients suffering from waterborne diseases worldwide. In that, 88 per cent of all waterborne diseases are caused by unsafe drinking water which also results into inadequate sanitation and poor standard of hygiene.

When we have meager resources and increasing demands, solution has to be sought in the effective management of available means. Here management of water implies that every living being gets the due share to survive. Management of water is to reduce its wastage to the bare minimum. At the same time, management also implies storage of water and its effective regulation through various channels for controlled and useful flows. It is the imprudent actions of humans that result into water scarcity and devastation of droughts. United Nations report on water issues focuses on governance as the core of water crisis, maintaining "There is enough water for everyone and water insufficiency is due to mismanagement, corruption, lack of appropriate institutions, bureaucratic inertia and shortage of investment in both human capacity and physical infrastructure".

2. AVAILABILITY OF WATER AND OUR NEEDS

Out of the total available water on the planet, 97% is saltish, thus not suitable for human beings, animals as well as plants. Only 3% freshwater available is useful for the living beings. Out of this 3%, almost 66% is frozen in glaciers and 33% is available on the surface, underground and some part in the air. Nature has its own system of recharging these resources through precipitation. The storage of fresh water depends upon the capacity of lakes, wetlands and artificial reservoirs. Seepage, run off rivers into the sea and evaporation incur loss of water. Therefore the quantity of water available at a given time is dependent upon the storage capacity of a country in the shape of reservoirs. Desalination is an artificial process of converting saline water into its usable form which is expensive compared to most of the alternative sources of water available. In Pakistan, it is in its preliminary stage where Pakistan Navy has developed a limited quantity plants for desalination.

Looking at the issue from agricultural point of view, which is the backbone of national economies in most of the developing countries, Pakistan has a total geographical area of 196 million acres out of which 77.1 million acres is suitable for agriculture. A total of 54.5 million acres (71 per cent) out of the total Arable land is already cultivated either by irrigation or through rain. The remaining 22.6 million acres of land which constitutes 29 per cent of the total area suitable for agriculture can become productive if water is made

available for irrigation. It means that a little less than one third of the agricultural potential of Pakistan remains untapped because of non-development of water resources and associated infrastructure as well as its poor management.

Pakistan's water needs can be categorized as those for agriculture, industrial and domestic uses. In Pakistan's predominantly agrarian economy, irrigation consumes about 97% of the total quantity available and contributes 25% in our GDP. This means that out of total available potable water, 3% is available for industrial and domestic use. Based on the data of year 2009/2018, total water needs of Pakistan and its availability are as given below:

- Water available - 125.56 MAF
- Water required - 164.48 MAF
- Shortage - 38.92 MAF (31%)

The shortfall of about 39 MAF of water in the present year 2018 is to be met through creating storage facilities and diverting additional 30.4 MAF to canals which at present is flowing to sea after allowing 8.6 MAF for environmental flows below Kotri. The irrigation system of Pakistan is one of the largest in the world. The irrigation network is maintained through three main storage reservoirs / dams, eighty small dams, nineteen barrages, twelve link canals and forty five canals. This network is to regulate 97% of the total fresh water solely for irrigation purpose. The left-over 3% is used for domestic and industrial purpose with mutually interchanging percentages. Whereas, the industrial sector meets its requirement adequately, clean drinking water is not available to the entire population of Pakistan. The drinkable water is not available in greater part of Sind, Balochistan and southern Punjab. Therefore, the population of these two provinces in particular and some other parts of the country in general is dependent on rain water accumulated in natural and manmade ponds.

The problem of drinkable water is compounded in cities where population has increased out of proportion to the availability of water like Karachi, Lahore, Faisalabad and Rawalpindi / Islamabad. According to various sectors, the water requirements of Pakistan are as given below:

Irrigation	159.54 MAF	likely to increase to 12.1 MAF by 2025
Domestic sector uses	3.82 MAF	
Industrial use	1.1 MAF	

Further escapages below Kotri below Kotri are estimated as 8.6 MAF.

As per United Nations Water Needs Report, 1700 m³ per capita availability of water is the threshold. Therefore, by international standards, in 1991, Pakistan at 1610 cubic meter per capita availability of water was 'a water scarce country'. Now at about 900 m³ per capita, we are a water stress country. The situation is going to further deteriorate in years to come as shown in the data tabulated above. This implies that we need to find a solution to the problem at priority. With the increase in population, shortage is going to increase in years to come. Since 1951, per capita availability of water is decreasing as shown below:

Year	Population (million)	Water Availability (m^3)
1951	34	5260
1961	45	3950
1971	65	2700
1981	84	2100
1991	115	1600
2000	148	1200
2001	172	1078
2013	207	850
2025	221	659

3. WATER SECTOR ISSUES

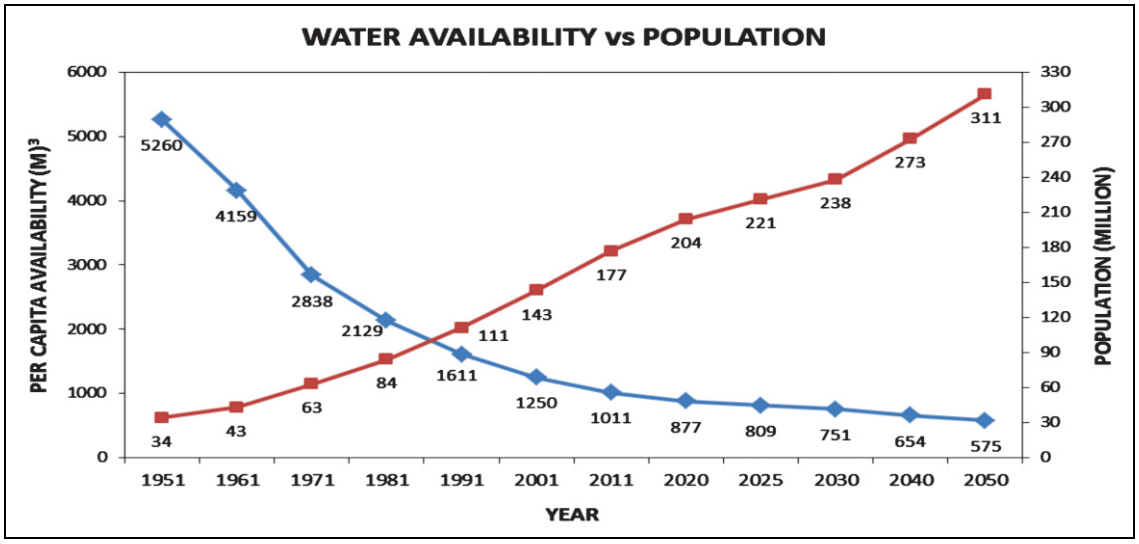
There are many water sector issues faced by the country and major ones are as follows:

Pakistan is one of the world's arid countries, with an average rainfall of under 240 mm a year. According to the benchmark water scarcity indicator (Faulken Mark Indicators-FAO), Pakistan's estimated per capita water availability of around 800 m^3 in 2018 and places the country in the "high water stress" category.

Water Scarcity (Faulken Mark Indicators, FAO – 1992)

>1700 m^3/Capita	Water Scarcity Rare
<1700 m^3/Capita	Country faces seasonal or regular water-stressed conditions
<1000 m^3/Capita	Water shortages hamper the health and wellbeing of the human economic activities are affected
<500 m^3/Capita	Shortages are severe constraints to human life

The water shortage scenario in Pakistan is further aggravated with high variability of rainfall. The climate change and global warming is likely to severely affect the availability of water. After the loss of 3 major rivers, Ravi, Sutlej and Beas, to India under the Indus Waters Treaty 1960, India's construction of water storage infrastructure at Baghlihar and Kishanganga, is threatening the uninterrupted flow of water downstream into Pakistan. The per capita water availability v/s population is shown below:



3.1 Low Water Productivity

Whatever water is available is utilized in an inefficient manner. A comparison of wheat yields in California (USA), the Indian Punjab and the Pakistan Punjab shows that productivity of Pakistan in relative proportion to India and California is about 3:6:10 per unit of land and about 5:8:10 per unit of water. The same proportion is shown in tabular form below for explicit indication.

Per unit of Land/Water	Yield Ratio		
	Pakistan	India	California
Land	3	6	10
Water	5	8	10

3.2 Aging and Outdated Infrastructure

Pakistan is blessed with one of the largest contiguous irrigation infrastructure. However, it was designed for water requirements of the 20th century and not for the 21st century. The design of system was for 60% cropping intensity and now the cropping intensity has crossed over 120%. Further the cropping pattern on which water demands and withdrawals were worked out was not supposed to cater for crops like sugarcane and rice which require high water use.

3.3 Low Water Charges

The water charges are very low and cover only 19% of O&M cost of irrigation network. The system maintenance requires a lot more attention due to deferred maintenance over

the Past 100 years. The adequate water costing could offset O&M cost and could generate finances for new water sector development projects.

3.4 Innovative Knowledge Based Management

Challenges of the 21st century require the frontiers of knowledge and innovative approaches rather than historic practices. The institutions need redefining of their roles and to develop their capacities according to new responsibilities to cope with water scarcity scenario.

3.5 Ownership, Reforms and Joint Management

The irrigation infrastructure operation and on farm practices, need ownership of the stakeholders such as farmers, professionals and revenue collectors. A joint management mode needs to be devised as Area Water Boards and Farmer's Organizations under PIDA Act 1997.

3.6 Equity

Water provides prosperity and jobs, and acts as an incremental factor as multiplier in the national economy. However, serious concerns exist with respect to spending common pool money to the benefit of selected groups in the absence of policy on equity.

3.7 Reservoir Sedimentation

Pakistan has three major reservoirs, which had as built storage capacity of 18.64 MAF. The storage capacity of Tarbela, Mangla and Chashma reservoirs has depleted by 4.99 MAF or 27% by the year 2017 due to sedimentation. It is estimated that the gross storage capacity would be reduced by 6.00 MAF or 32% by the year 2025 as shown below. Due to loss of storage, agriculture of Pakistan is facing water shortage during low flow season.

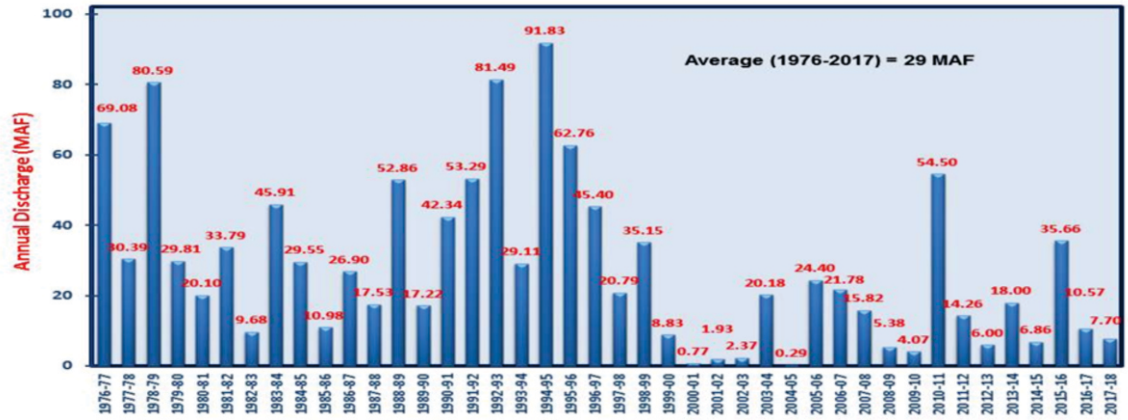
Storage Loss Due To Sedimentation

Reservoir (Commissioning Year)	Storage capacity			Storage loss	
	Original	Year 2017	Year 2025	Year 2017	Year 2025
	MAF	MAF (%)	MAF (%)	MAF (%)	MAF (%)
Tarbela (1976)	9.68	6.06 (63%)	5.37 (56%)	3.62 (37%)	4.3 (44%)
Mangla (1967)	5.34	4.35 (82%)	4.19 (79%)	0.99 (18%)	1.15 (21%)
Chashma (1971)	0.72	0.38 (53%)	0.27 (38%)	0.34 (47%)	0.45 (62%)
Sub-Total	**15.74**	**10.79 (69%)**	**9.83 (63%)**	**4.95 (31%)**	**5.91 (37%)**
Addition of Raised Mangla (2012)	2.90	2.86 (99%)	2.81 (97%)	0.04 (1%)	0.09 (3%)
Total	**18.64**	**13.65 (73%)**	**12.64 (68%)**	**4.99 (27%)**	**6.00 (32%)**

Source: WRM Directorate, WAPDA

3.8 Un-captured Water

Despite acute water shortage in the system, data shows that a substantial amount of water escapes below Kotri to the Arabian Sea. Post-construction of Tarbela (1976-2018) average annual escapages below Kotri are 29 MAF, with a maximum of 91.83 MAF in 1994-95 and minimum of 0.77 MAF in 2000-01. Most of the flow to the sea occurred during Kharif season and very little during Rabi season. For better water management, storage capacity should be equivalent to at least 40 percent of total river flows but Pakistan's live storage capacity is about 7 percent of its overall river flows.



Source: WRMD WAPDA based on data supplied by Govt. of Sind

Water Escapages below Kotri (MAF)

3.9 Rainwater Harvesting

Rainwater harvesting in Pothohar areas can be a reasonable source of water for raising crops. With this technique about 5 to 6 % GDP earnings are generated. It is a good source of income and livelihood of uphill areas in the country and it is about 12.85 million acres contributing towards uplift of the peoples of such areas. The water harvesting provides about 3 MAF water.

4. FUTURE STRATEGIC AREAS FOR WATER MANAGEMENT ENSURING SUSTAINABILITY

The following core areas require immediate attention while formulating contingency action plan and management/policy plans:

Implementation of the corrective measures made above requires a detailed, long-term planning and execution strategy through a phased program. In our views there are three ways to do it; i) Planning and its execution through government machinery ii) Leaving it to the private sector where users to plan and undertake the work and iii) a combination of the above mentioned i) & ii).

The government machinery being sluggish and reputed as corrupt may not be able to develop consensus, gather necessary funds and undertake the work as envisaged. The private sector needs leadership, historically dependent on official way of implementation, therefore will not be able to develop mutual understandings and vision to undertake such a gigantic work. Therefore, the solution lies in combination of public and private sectors -

a joint approach for planning and execution of water vision for our future generations. Salient aspects of this public – private integrated approach (PPIA) are as given below:

Government to constitute a body of experts and administers to undertake planning and developing resources to finance the envisaged 'Water Vision'. It should be constituted at the federal as well as provincial levels, to be known as Federal Water Management Authority (FWMA) and Provincial Water Management Authority (PWMA) respectively. FWMA be mandated to plan management - conservation and regulation of water of the rivers. It should include building storage capacity in the shape of reservoirs and dams, regulating water in the rivers through existing barrages and link canals, equitable distribution of water to all the stakeholders and maintaining river beds to sustain requisite flow - capacity in view of extra / unusual rains.

PWMA be mandated to manage the water in irrigation canals within the jurisdiction of their respective provincial boundaries. PWMA to deal with the canals up to their tail ends and also build seasonal canals as well as their maintenance to drain out the excess water - a safety valve to deal with an unforeseen / eventuality. Maintenance of water channels from the water connection point at the canal ends up to the field should be the responsibility of respective district administration / governments' to be known as DWMA (District Water Management Authority).

The water management authorities at all levels i.e. federal, provincial and district should have representatives from the users. Execution of work, especially at district and below levels should be undertaken through user's participation like town and village committees. At the federal and provincial levels, we already, have public representatives in the shape of members of National and Provincial assemblies. The bottom line philosophy is to inculcate sense of belonging / ownership to make every user realize that every drop of water matters for life, the loss of which is like his personal loss. That is possible only when one pays the price for every drop of water. Otherwise it has become our second nature to expect everything from the government to do, not realizing that governments run on the public money. The joint and collaborated efforts can make our system better through self and public accountability.

Water availability is diminishing with a growing population and increasing urbanization. The need for better water demand management is well established. The following represent some areas of immediate attention are; i) Promoting efficient use of water by all sectors of life ii) Pricing water to an appropriate level and iii) Better optimizing cropping pattern. Pakistan has been cited amongst the most vulnerable countries facing extreme weather changes in temperature and rainfall.

To mitigate risks & impacts of climatic change, the following actions are required:

- Need for additional dams by adopting cascade approach (Basha, Kalabagh and Akhori)
- Confidence building among provinces needed for national harmony.

The core areas require immediate attention while formulating contingency action plan and management / policy plans to keep the country ever green is described in the proceeding paragraphs.

4.1 Water Demand Management

Water availability is diminishing with a growing population and increasing urbanization. The need for better water demand management is well established. The following strategy represents some areas of immediate attention:

- Promoting efficient water use
- Rationalizing water price
- Optimizing cropping pattern to save water
- Integrated use and recycling of water
- Ground water regulation to avoid over mining
- Climate Change Impact on Water Resources and Agriculture

Global weather changes and water resources are deeply inter-related. The largest source of freshwater is rain. Global climatic changes will have major effects on precipitation and runoff. In the relatively arid and semi-arid regions, modest changes in precipitation have large impacts on water supplies. In mountainous watersheds, higher temperatures will increase the ratio of rain to snow, accelerate the rate of spring snowmelt, and shorten the overall snowfall season, leading to more spring runoff. Because the temperature projections of climate models calculate less than the projections of precipitation, temperature-induced shifts in the relative amounts of rain and snow and in the timing of snowmelt in mountainous areas are considered likely. Climate-induced changes in hydrology will affect the magnitude, frequency, and costs of extreme events, which produce the greatest economic and social costs to human beings. Flooding could become more frequent and extreme. Recent reports of the Intergovernmental Panel on Climate Change (IPCC) suggest that a greenhouse warming is likely to increase the number of intense precipitation days as well as flood-frequencies in northern latitudes and snowmelt-driven basins. These reports also suggest that the frequency and severity of droughts could increase in some areas, as a result of a decrease in total rainfall and more frequent dry spells.

A macro-scale hydrological model for river-flow suggests that the runoff of the Indus will decrease significantly by the year 2050 (IPCC, A4-WG-II). This implies that the availability of fresh water in Pakistan is highly vulnerable to climate change. A reduction in average flow of snow-fed rivers, coupled with an increase in peak flows and sediment-yield would have major impacts on hydropower generation and agriculture. Availability of water from snow-fed rivers may increase in the short term, but decrease in the long-run. Runoff from rain-fed rivers may also change in the future. A reduction in snowmelt water will put the dry-season flow of these rivers under more stress than is the case now, especially in Pakistan where one major snow fed river, the Indus, accounts for as much as 80 % of the normal water flow. Increased population and increasing demand for the agricultural, industrial and hydropower sectors will put additional stress on water resources.

4.2 Water Management Problems of Urban Areas

Our urban areas have grown out of proportion to the availability of services, especially the supply of fresh water. Even within the cosmopolitan cities like Karachi, Lahore, Islamabad etc. there are certain pockets which are over populated than adjacent colonies. To manage water supply to such a large population, all put together at one place, is a huge task which needs enormous resources and superior management and administration. Their maintenance is even difficult through heavy traffic and population, especially in narrow streets and apartments. Secondly, we do not have distinction between drinking water and the water required for gardening and vegetation. Water supply system is the same from where consumers take water for drinking, bathing / washing as well as for gardening etc. Furthermore to the wastage of fresh drinkable water, we do not have the accountability mechanism of water consumption. With negligible water tax, our consumer has unlimited supply of water at his disposal according to his status / approach to the concerned departments. In the same colony / street, one may find people without water even for drinking purpose and certain privileged ones having overflowing water in excess to their lawns and gardens.

4.3 Water Management Problems of Rural Areas

Our Rural Areas have also expanded over larger areas with new settlements, particularly of those who migrate from village to village in search of livelihood. Wherever they find a suitable place, get settled, may it the river bed or under a bridge. Thereafter these settlements start growing in size and turn into villages and towns. Most of the settlements and villages washed away in the recent floods which have been constructed in the river beds and, low lying areas. There are basically two issues with the availability of water in rural areas. One is the increase in population exerting more demands of water supplies and shrinking water sources closer to populated areas. Secondly, over pumping has lowered the water table in certain areas and now it is getting deeper and deeper, making it almost impossible to get more water even with better technologies. The water available on the surface of the earth is either the rain water accumulated in natural and manmade ponds or river water which flows in various canals. None is drinkable till the time it is cleaned, treated and made usable.

In order to resolve these issues of rural or urban areas, water management is required to be understood and applied in letter and spirit. Since urban and rural areas have their distinct problems so their resolution requires separate approaches as well.

4.4 Resolving Urban Areas' Water Problems

The bigger cities like Karachi, Lahore, Faisalabad, Hyderabad, Peshawar and Rawalpindi - Islamabad have become unmanageable under the management cum administration of a district. Since at this stage it is not possible to undo their varied size, we need to do two things. Firstly stop their further growth and organize the existing population to make it manageable. Secondly divide these cities into distinct manageable units which should be autonomous and accountable for the availability of essential services including water. Management of water should be devolved to the level of District Government / Administration self-sustenance mechanism. We would need to get out of the mindset of free water supply. It should be a community based transparent water supply system where one has to pay for the quantity of water one desires to

consume. The culture of free supply of water even to the government departments should be stopped forthwith. Rather all government offices be authorized certain scales for which the money should actually be paid to the Districts' Domestic and Industrial Water Management Authority (DD&IWMA). The system would work effectively only when there is no discretion and no free supply of water.

DD & IWMA would offer two types of connections to the consumers i.e. one, water connection for drinking, cooking, bathing, washing and second for gardening, vegetation, cleaning the toilets etcetera. Both the water supply connections would have different rates for payment of water service charges. The consumer would be billed at the end of every month according to his usage of water. At the same time we would need to improve the water supply system including repair of the water supply lines to reduce wastage. Improvement of services through an efficient management mechanism would encourage the consumers to pay for water services.

4.5 Resolving Rural Areas' Water Problems

In rural areas, the situation is slightly different. In rural areas of the Punjab baring some parts of southern Punjab and Khyber Pakhtun Khwa sufficient quantity of underground drinking water is available. Therefore, the problem is how to extract the water and subsequently make its supply to the consumer's end. Its implication is the requirements of pumping motors and water supply lines. In terms of expenditures, it is not an expensive issue. It requires only the division of areas into manageable units and provision of underground fresh water to the consumers. In order to conserve the underground resource of fresh water, its pumping by the individual consumers need to be stopped. It should rather be organized on area basis under the community based government mechanism as that of urban areas. We have a more pronounced problem of water scarcity in most of the rural areas of Sind and Balochistan, where underground drinkable water is seldom available. In parts of Sind, especially adjoining areas of Arabian Sea, the underground water is available but it is brackish. In its desert part, the underground drinkable water is not available at the extractable depths. In both the cases canal / rain water is required to be stored in ponds, clean it to make it drinkable and then supply to the population scattered over larger areas in the form of hamlets and villages.

In Balochistan, the situation is different. There the groundwater is mostly not available therefore majority of the population is dependent on natural springs and underground water tunnels known as Karez. The Karez is an ancient type of water supply system developed in earlier times and still in use in arid regions of the world. In Karez, underground water sources are channelled downhill through a series of tunnels to the places where it is needed. From here the water is either taken to the fields and villages through vertical shafts which are sunk underground or it is drawn out at the foot of the hill where it had been gathered. In order to keep the underground channels unclogged, two men and a draught animal work as a team where one man is lowered down to clear the channel who fills the buckets with mud which is then taken out by the animal. This is an age old system, which is a human effort but intensive and difficult in transportation of water. Like other parts of the country, people of Balochistan also deserve drinking water through a well laid out water supply system. In both the cases, the solution lies in developing the water sources and handing them over to the community based water

management mechanism of administration to maintain it on self-sustaining principles. In underdeveloped areas like most part of Balochistan, the water supply has to be subsidized to make it affordable to the population. The solution is not cost prohibitive, it is affordable and requires only management. However, it should not be free of cost in any case otherwise no supply system can sustain for longer without storages.

4.6 Enhancing Storage Capacity

In order to have sustained and continuous supply of water for agriculture, industrial as well as domestic uses, it is necessary to enhance our storage capacity, may it be in any shape i.e. dams, ponds, river beds etc. Some of the cost is affordable / sustainable and less controversial options are as given in the succeeding paragraphs.

Construction of New Mega Dams has been an issue over the last many years. It is the reason that after late 1960s, there has been no worthwhile breakthrough in construction of new mega dams. At the same time, the bigger dams have become cost oriented, especially initial investment and rehabilitation / resettlements required. The construction of large and small dams in suitable areas all over the country at suitable sites already planned for mega dams like Kala Bagh may require to be redesigned for early construction Mass Public Awareness about Water Management is essentially required to take the people along with the campaign at the government levels. The most effective instruments are television and radio for the general - comparatively less educated population and print media focusing on the educated segment of the society. Awareness and motivation at the national level is one aspect of the issue, the other segment of the campaign is equally important and that pertains to making the masses realize through their contribution / payment for the services, they avail / utilize. What has been observed in our mass public perception is that they become careful when they know that whatever one consumes, he would require paying for that, may it be a small amount.

Creating a Self Sustaining Water Sector is need of the time. Water is an important natural commodity and unfortunately in Pakistan, it does not have its own resources to make any development. If we look at its consumption (i.e. relationship of demand and supply) we find that it is the most essential commodity. We need a water sector development strategy (WSDS) over a longer period of time - a "Water Vision", which needs resources. We would require creating a broad based water sector at all tiers of the government machinery and making it economically viable and sustainable. For that purpose there is a need to undertake constitutional reforms. We need water management mechanism as a joint venture of public and private sectors at the federal, provincial and district government levels, some of them have been explained in the earlier parts of this paper. Controlled exploitation of water is essentially required for sustained supply of water in areas where water level is going deeper and deeper due to unchecked pumping through powerful electric, diesel and petrol motors / engines. At the moment, there is no check on any individual to bore the earth and install tube wells. This has resulted into scarcity of water in certain areas due to over pumping, particularly in central Punjab. With better technology, the consumers are going deeper and deeper to extract water but soon a stage is approaching where it will remain no more possible to get any further water even with the more powerful motors/ pumps.

Inequitable Distribution and Inefficient Use of water leads to socio - political disorder and unacceptable wastage of water respectively. This is particularly so in the case of irrigation water, where its inequitable / unjust distribution creates feelings of deprivation and dissatisfaction in certain segments of society and at the same time, its inefficient use adds to the wastage of water. There is a need to take stock of the whole situation and ensure equitable distribution amongst all water users. 2ndly, we need to educate our farmers for the efficient use of water in the light of modern technology utilizing appropriate crop patterns, efficient irrigation techniques and proper water management at the fields level.

5. CONCLUSIONS

- We need efficient and integrated management of water in view of its increasing demands and depleting reserves. Allah has created this commodity according to the requirements of mankind. However, without management, it is not sustainable.
- The shortfall of about 39 MAF of water in the present year 2018 is to be met through creating storage facilities and diverting additional 30.4 MAF to canals which at present is flowing to sea after allowing 8.6 MAF for environmental flows below Kotri.
- Water plays a pivotal role in development of all sectors of life such as agriculture, domestic, industrial and environmental aspects keeping in view aesthetic approach.

6. RECOMMENDATION

- Campaign on efficient use of water in domestic, industrial and agricultural sectors have been launched to disseminate knowledge and information to the water users especially farmers by Planning Commission through Chief Engineering Advisor provincial OFWM Departments.
- Rain water harvesting of 3 MAF to irrigate 12.85 million acres and use of treated water is also being adopted at small scale. Water is key factor for agro-socio-economic uplift in the country.
- Additional storages and other relevant developments of efficient water use in the country would not only be able to sustain food security but also would enable the country to export more agricultural products to sustain the economy, besides flood management.

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WATER CRISIS, IMPACTS AND MANAGEMENT: PAKISTAN'S PERSPECTIVE

Romana Khan, Imran Hashmi

WATER CRISIS, IMPACTS AND MANAGEMENT: PAKISTAN'S PERSPECTIVE

By:

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Abstract

Amid the current scenario of water crisis globally, it becomes an indisputable fact that improving the current detrimental impacts of its scarcity and providing solutions along with the management of left over resource has become the need of an hour. Pakistan which stands third among countries facing acute water shortage is already bearing the impacts of its scarcity. Demand for water resources is increasing greatly in Pakistan, however; per person water availability has fallen below the 1000 cubic meter. This alarming figure is going to be more deleterious in the coming days as Pakistan is predicted to be on its way to becoming the most water-stressed country in the region by the year 2040. Therefore, Water crisis is becoming an evident factor by every passing day whilst an emerging issue of concern at present. Noticeably in Pakistan no less than 38.5 million Pakistani's lack access to safe drinking water the figure has been quoted by the Pakistan Institute of Development Economics. Besides humans, the perforating impacts of water crisis on the plants, animals, soil and weather will obliterate the whole economy. Reports by the United Nations Development Programme (UNDP) and the Pakistan Council of Research in Water Resources (PCRWR) also warn the authorities that the South Asian country will reach absolute water scarcity by 2025. Pakistan's major water consumption sector is agriculture with approximately 96 % water demand. Given the growing concerns about water availability in Pakistan now it's time to think about solutions that will help to reduce water shortages other than constructing huge dams and reservoirs that appear ineffective in current social and political context. For the beneficial management of the resource the country ought to show more dependency on the technology it should move towards the reuse of its resource through proper planning so that the impacts can be eradicated out for the welfare of the nation. Moreover, numerous steps need to be taken at the international as well as national level in collaboration with the grass root personnel's to reduce the impacts of water crisis.

Keywords: Water crisis, Water scarcity causes, Water management, Pakistan water scenario

Highlights

- Introduction
- Current scenario of water crisis
- Water Scarcity: Causes
- Impacts of water crisis on human life and environment

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- Management of water crisis
- Case study: Water Crisis scenario in Pakistan
- Conclusions

Introduction

Water is essential for life and livelihoods whilst it is a key to sustainable development. It allows the natural environment to flourish, and businesses, agriculture and the economy to grow and prosper. Successful water management will serve as a foundation for the achievement of the Sustainable Development Goal 6 (SDG 6), which is to *'Ensure availability and sustainable management of water and sanitation for all'* (Lisa Guppy and Kelsey Anderson, 2017).

Save every drop of water these cliché phrases are sounded everywhere to augment the sanctity of water but there is no one who pay attention to these voices in order to protect the future generation from the detrimental effects of water crisis. No one pays attention to the fact that every action has a reaction. Newton's third law of motion has full application on the water crisis. As humans exploit this natural resource that's why nature is taking its revenge by shrinking the water resources. Globally per capita water availability is reduced by three to four percent and it obliterate the whole environmental structure. Plants and animals are depending on the water for their survival, humans have stringent dependency on the water and any kind of water scarcity is proving to be detrimental for the whole ecosystem. Moreover; the management of water crisis is also facing the malfunctioning. Water scarcity is not considered as the crucial factor by the developing states as they have umpteen number of problems to deal. Moving ahead; the measurements standards for water saving were not met by the developing countries previously and there are not seen to be met by 2030. Therefore; numerous steps need to be taken at the international as well as national level in collaboration with the grass root personnel's to reduce the impacts of water crisis. In the coming paragraphs current scenario of water crisis, its impacts and management would be discussed in detail.

1. Current scenario of water crisis: Global Outlook

To begin with; the current scenario of water crisis has an aggravation situation globally. Water crisis is becoming an evident factor by every passing day whilst an emerging issue of concern at present. Figures 1 and 2 demonstrates the water stressed countries currently in the world and future projections respectively.

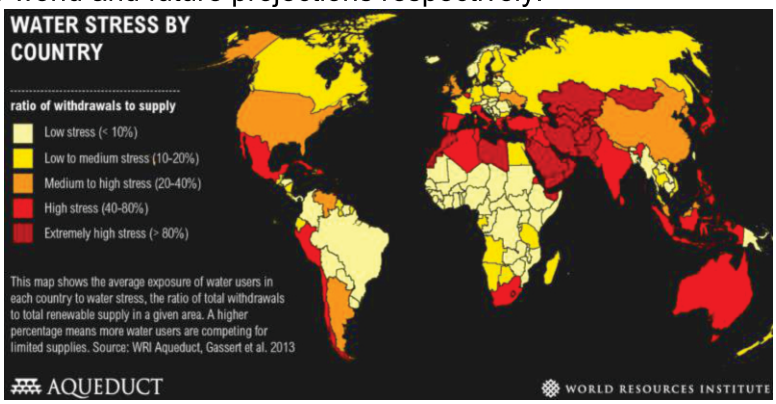


Figure 1: Water Stressed countries globally (Source: World Resources Institute, 2017)

Figure 2. Water Stress projections by country to 2040
(Source: World Resources Institute, 2017)

According to a McKinsey & Co. report (2009), global water demand is expected to further raise at an accelerated rate from 4,500 billion meters cubed to 6,900 billion cubed by 2030, thus increasing the water gap. If this water crisis scenario continues without reform or regulation over the next 20 years, 40 % of global demand will not be met. Currently more than one billion people globally still don't have access to clean water. The report warns that governments must now act to evade severe socio-economic and health consequences.

Figure 3. Global water demand by sector to 2040

According to a study by Lisa Guppy and Kelsey Anderson (2017), water is a critical concern while becoming a pressing societal and geopolitical issue in some regions of the world. It is expected that the world will lag behind in water-related SDGs by a wide margin; while up to 40% of the world's population will be living in seriously water-stressed areas by 2035; moreover, the ability of ecosystems to provide fresh water supplies will become progressively compromised. 60% of fresh water comes from river basins that cross national borders. Therefore, transboundary water agreements need to be robust enough to deal with increasingly uncertain environmental and climatic conditions. Where, the social and demographic changes will elevate global population to 9.7 billion by 2050 and twice the number of people living in urban settings.

Overuse of water is also evident and a huge issue that a lot of people are dealing with beside over population. The global population in the 20th century become three times, however water consumption increased six-fold (FAO, 2009). It is now expected that in 2050, water demands will increase by 400% from manufacturing, and by 130% from household use (OECD, 2012).

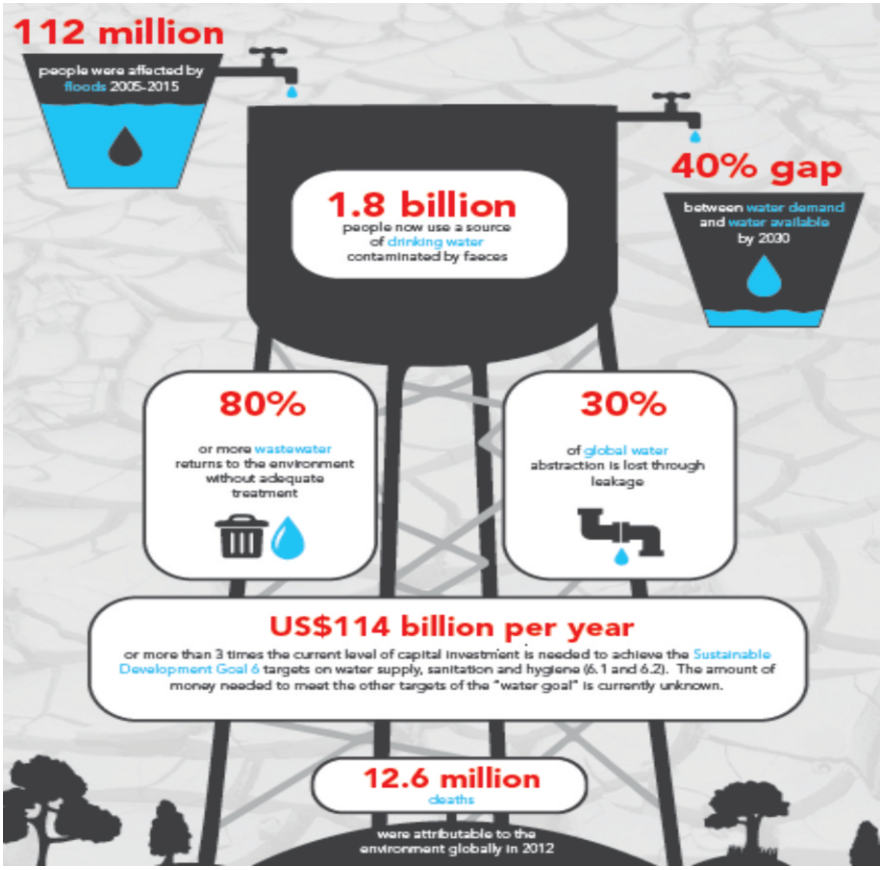


Figure 4. Global Water Crisis Scenario
(Source: Lisa Guppy and Kelsey Anderson, 2017)

Water insecurity may be worsened by drought. In 2016, 411 million people were affected by disasters and 94% of those were drought affected (CRED, 2016). Droughts are also

the costliest disasters, with significant impacts on agriculture specifically. Droughts cause an average US$6–8 billion worth of losses in agriculture in the USA annually (Zhang et al., 2015). While, in China, from the 1950s to the beginning of this century, the annual average crop area suffering from drought has intensified from 11.6 million hectares to 25.1 million hectares (Chen et al., 2014; Lisa Guppy and Kelsey Anderson, 2017).

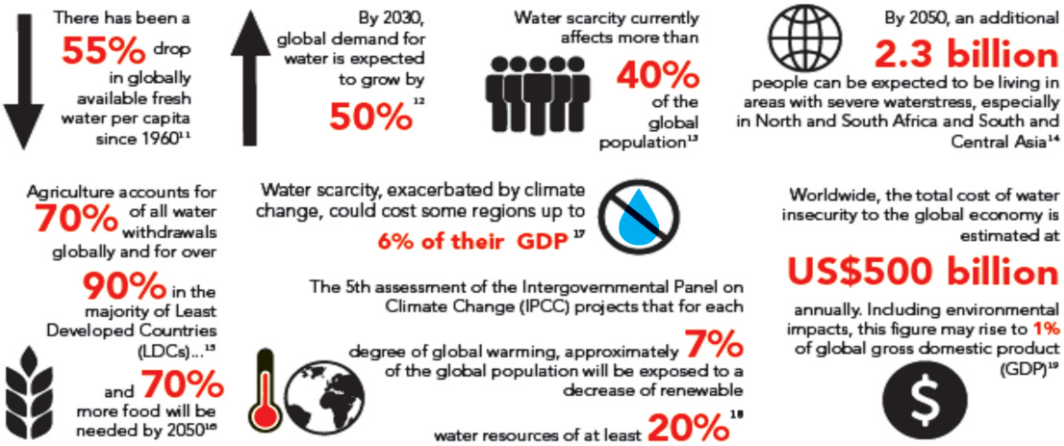


Figure 5. Water scarcity and insecurity
(Source: Lisa Guppy and Kelsey Anderson, 2017)

World Bank in 2009 estimated that by 2030, around half the Bank's water sector portfolio would be at high to medium risk of exposure to climate change impacts (World Bank Group, 2016). Moreover, hydrologic hazards are leading to significant deaths, displacements and injuries. Water-related disasters contribute to 90% of all disasters, whereas, floods have been the most recurrent global natural disaster over the last two decades; where in 2016, 50% of all recorded events were related to flooding. The total value of all assets that are at risk from flooding by 2050 is expected to be US$45 trillion: a rise of over 340% from 2010 (Lisa Guppy and Kelsey Anderson, 2017). Between 1970 and 2010 the world's population amplified by 87%, from 3.7 billion to 6.9 billion. During the same period, the annual average population exposed to flood increased by 112% from 33.3 to 70.4 million per year. By 2050, growing populations in flood-prone lands, climate change, deforestation, loss of wetlands and rising sea levels can be expected to increase the number of people vulnerable to flood disaster to 2 billion (UNU, 2004).

Water-related ecosystems may reduce water-related disasters, such as mangrove and coastal wetlands contribute to avoid more than $625 million in damages from Hurricane Sandy in 2012. Despite these risk reduction benefits, water-related ecosystems are declining globally. In parts of Asia and the Americas, up to half of all coastal mangrove ecosystems have been degraded (Lisa Guppy and Kelsey Anderson, 2017).

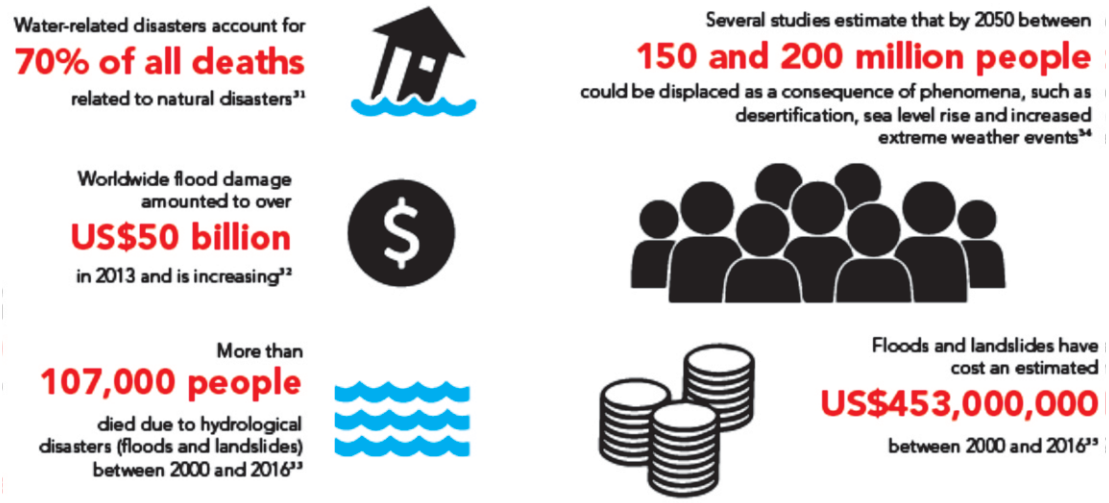


Figure 6. Water-related disasters (Source: Lisa Guppy and Kelsey Anderson, 2017)

Globally 2.4 billion people do not have access to improved sanitation facilities, as a result 1 in 9 child deaths occurs due to diarrheal diseases, making it the third leading cause of death among children under the age of 5. World Bank report found that capital investments must rise by approximately 3 times to achieve the water supply, sanitation, and hygiene (WASH) targets globally (World Bank Group, 2016; UNEP, 2016).

It is vital to protect investments in water-related infrastructure from shocks and stresses. In developing countries, approximately 45 million cubic meters per day are lost through water infrastructure leakage; enough to serve nearly 200 million people. (Lisa Guppy and Kelsey Anderson, 2017).

Another deciding factor in most of the natural resources availability is Poverty in developing nations. More than half of world's population lives in developing countries and the poorest of these communities depend heavily on exploitation of local water resources for their livelihood (Khoso et al., 2015).



Figure 7. Water, sanitation and health (WASH) crisis
(Source: Lisa Guppy and Kelsey Anderson, 2017)

2. Management measures to face water crisis

Countries across the world are facing the problem of water scarcity. But some studies says that it is possible to significantly reduce water stress by 2050, however, a strong commitment and strategic efforts are required to make this happen.

To begin with; Education is utmost factor to disseminate the awareness. There are plenty of opportunities out there that people can use in order to learn more about the world around them. By educating those who are not dealing with water scarcity, they can be in a position to help. Those who are dealing with it can get educated on how they can prevent the problem from becoming even worse in the future.

Moving ahead; Recycling of Water is one of the best solution. There are plenty of technologies out there that allow you to recycle rainwater and other water that you may be using in your home. Consider learning about how you can recycle water. Not only does it help to prevent scarcity, but it can save you some money as well.

In addition to this; Advance Technology Related to Water Conservation is considered to be the need of an hour. There has been a lot of work in the world of water conservation, but there is also a lot that needs to be done in order to ensure that the rest of the world is able to conserve water. Putting money and effort into conservation could be life saving.

Furthermore; Improve Practices Related to agriculture and Farming are most important for the agricultural run country. Farming and irrigation are often a huge culprit when it comes to water scarcity. Because of that, we need to improve practices so that we don't use as much water and those who are using water are using it to its fullest potential. Technology also needs to advance in this manner.

To date, it is evident that efficient desalination plants has been an energy-intensive solution to water scarcity as well. Whereas, by improving the sewage systems in the areas, water scarcity issue may be prevented from becoming any worse as it helps in reduction of diseases.

Through **s**upporting organizations with Clean Water Initiatives located all over the world that are looking to bring clean water to areas that don't have it.

Case Study: The Scenario of Water Crisis in Pakistan

1. Causes of Water Crisis

Water crisis is a serious constraint in Asian states: the densely populated continent. Pakistan while enjoying strategically significant position on the map, has experienced the disastrous effects of climate change which leads to the shortage of water: the most essential resource for the sustenance.

Pakistan is fastly climbing the ladder of water scarce country from the water stressed country and it happens mainly because of the exploding population and their ever increasing demands. Besides this, Pakistan also lack the water storage infrastructure sustainability in water management system. Chashma, Mangla, and Tarbela are primarily use for irrigation purposes and also to provide electricity to a nation of nearly 199 million people. The gross capacity of these dams have reduced because of

continual sedimentation process. The Himalayan glacier, whose ice melt refills the Indus Rivers annual freshwater, is receding by about one meter the approximate equivalent of 3.3 feet per year due to global warming.

Its water demand depends heavily the glaciers and seasonal rains and there might be surfeit rainfall during the wet season followed by the extended dry season where crop production depends very heavily on irrigation water. Pakistan Water Partnership (PWP) states that in Pakistan the total available surface water is about 153 million acre feet (MAF) and the total ground water reserves are roughly 24 MAF, of which a significant portion has been depleted without replenishing. The utilization of groundwater resource for domestic and industrial purposes has incurred too high price but all has gone without notifying. The natural hydrologic cycle has been disrupt because of mal human practices and causes rivers and wetlands to dry up (Aniqa Mubeen et al., 2015).

Table 1. List of main reservoirs of Pakistan and their capacity

S. No.	Reservoir	Location/Near City	Total Storage
	Tarbela Dam	Abbotabad	11 million acre.ft
	Mangla Dam	Mirpur	5.8 million acre.ft
	Hub Dam	Malir	0.8 million acre.ft
	Warsak Dam	Peshawar	0.06 million acre.ft
	Khanpur Dam	Khanpur	0.11 million acre.ft
	Gomal Zam Dam	Wana	1.1 million acre ft
	Rawal Dam	Islamabad	0.04 million acre.ft
	Simly Dam	Islamabad	2314.3 ft

Pakistan has been on the list of water scarce states from the past few years and now its per capita availability of water is 1200 m^3 per year. By considering the current scenario this availability will be reduced to 855m^3 by the year 2020. The expected climate change which has now become the reality is going to hit the water resources more stringently. Fresh water availability is likely to be reduced because of climate change. While the frequency and severity of floods would ultimately increase in river deltas and will engulf the large swathes of Pakistan. According to an estimate today 1.2 billion people lack safe drinking water and 2.4 billion lack access to basic sanitation and the situation is simply getting worse with every tickling second (Khoso et al., 2015).

The other vital concerns to water scarcity are annual and periodic variability in accessibility to surface water and influence of global warming, reduction in capacity of storage reservoirs due to sedimentation, increase in native and industrial demands and resultant reduction in provisions for irrigation, poor delivery-efficiency in irrigation and municipal water supply systems, and deterioration of water-quality due to dumping of crude urban sewage and agricultural drainage waste, reducing groundwater tables due to over exploitation, salt-water incursion due to up-welling from underlying saline aquifer and deteriorating performance of public tube wells, resulting in increased pumping costs (Aniqa Mubeen et al., 2015).

2. Global Population Position: UN Estimated

The global population in 2006 was 6.7 billion, which is increasing at a rate of 78 million/year that has reached 7.13 billion now. It has been predicted that the population will reach up to 10.9 billion by the year 2050. Among all this total population, 90% growth rate occurs in developing countries; already such countries like Pakistan are facing many problems of food, fibre, health and education. Increase in population will put an enormous pressure on water use. Pakistan is 6th most populous nation in the world with 19.6 million population growing at a rate of 1.52% by the year 2014 (The World Fact book 2014).

3. Impacts of water crisis

Water crisis in the country has spread deep concern. The alarming drop in water level has also led to a serious shortage in hydraulic power and these are genuine apprehensions if the condition lingers on for some time more, the energy crisis would excavate as soon as the water level goes further down in Mangla and Tarbela. Pakistan has an estimated potential of 40,000 MW of hydropower in the upper Indus region; only 13% has been tapped. At present Pakistan has an installed electricity generation capacity of 22,797MW. The average demand is 17,000MW and the shortfall is between 4,000 and 5,000MW. WAPDA has projected a power requirement of 75149 MW by year 2025, which can only be achieved by constructing additional storage dams (Khoso et al., 2015).

Agriculture is the backbone of the country and the water flowing in the channels to the crops is its blood line. If there is shortage of water then the country should be prepared for facing problems economically as well as socially. According to the estimates of federal government, the agriculture sector would suffer a loss of about Rs. 90 billion because of drought. Since agriculture has remained a major source of shouldering the already crippled economy, it has a vital role to play particularly in terms of food security and employment of the ever burgeoning population of the country. The adverse effects of water shortage on agriculture would have a spiraling effect on the prevailing level of poverty (Aniqa Mubeen et al., 2015). Water shortage has severely affected the agricultural sector of Pakistan which heavily depends on agro based economy. The direct bearings of water crises in Pakistan have decreased crops, range land, forest productivity and water level. Due to the water shortage out of 80 million hectares of land (Mha), 29 Mha land is cultivable but only 17 Mha is hardly canal irrigated yet, therefore import of food grains put additional stress on economy (Khoso et al., 2015).

There are also some social impacts of water crisis in Pakistan, which have primarily involved public safety, health problems, and clashes between the provinces over water usage. It has also reduced the quality of life. Unsafe drinking water is responsible for several diseases including cholera, malaria, dysentery, diarrhea, typhoid and gastroenteritis (Latest Buzz Staff, 2018; Aniqa Mubeen et al., 2015).

Environmental fatalities in Pakistan are the result of damages to plant and animal species, wildlife, degradation of landscape quality, the loss of biodiversity, air and water quality and the social destruction, caused by the drought. It may increase pressure on the societal structure of the country which may increase poverty, social conflict and culture.

Lastly, water scarcity has several political implications. Numerous disputes have break out between Punjab and Sindh over water use and distribution. As more and more water is conveyed to support Punjab farming industry, there is less water in Sindh for use in consumption, sanitation, and environmental maintenance. By some accounts, the Sindhi portion of the Indus has shrunk to the size of a meagre canal (Aniqa Mubeen et al., 2015).

Water is a limited commodity in Pakistan and has a direct bearing on almost all sectors of economy. In Pakistan its significance is more than ordinary due to the farming nature of the economy. Therefore, it is the need of the hour to take timely management strategies to overcome this looming issue.

4. Strategies to tackle water crisis scenario

Keeping in view the prevalent critical water crisis in the country, the current military regime has prospered in launching its “2025 Vision Program”. The program mainly comprises the projects of Greater Thal Canal, Gomal Zam Dam, Quetta water Project, Chasma Right Bank Canal, Reini Canal, Katchi Canal and to raise the height of Mangla Dam, which are planned to build in various parts of the country. Increases in storing capacity to manage periods of low snowmelt and low rainfall are necessary, as well as the rehabilitation of the distribution system to decrease losses. Wastage of water from canal through percolation can be avoided by lining (Aniqa Mubeen et al., 2015).

Pakistan is agricultural region water is key for survival, water is lost due to mismanagement mainly. A big investment in the repair of existing dams and the large scale construction of new water storage is simple solution of problem. In managing water resources, the government of Pakistan must balance competing demands between urban and rural, rich and poor, the economy and the environment (Khoso et al., 2015).

The growing problem of availability of pure drinking water can be handled by drilling more and more tube wells in the rural areas particularly in Thar and Baluchistan. Moreover, low-cost drinking water can be obtained in coastline by installing low cost water treatment plants that use solar energy for the purification of sea water. Regulating ground water pumpage by issuance of licenses to check overdraft of aquifer, improved water management for increasing cropping intensity with river line area, technical land leveling, high irrigation efficacy technology including drip and sprinkler, consolidation of institutional capacity building, improving economic sustainability, better and more effective use of funds, harness the uncultured lands for irrigation purpose, storage of flood water during Monsoon season are important management practices to lessen the water losses (Aniqa Mubeen et al., 2015).

5. Effective management recommendations

Managing water resources is the need of time, and Pakistan is already facing shortage in water. The solution of this can save around 1.3 MAF of water from existing losses. Following are the recommendations in this regard:

- Most of the water is lost due to seepage, infiltration and leakages etc. Seepage results in water logging eventually making the land less fertile. These losses can be eliminated by lining the canals and watercourses.

- In addition, people should be educated and aware to conserve water by cooperation and using it efficiently.
- Like many western countries the government should make laws on water conservation.
- The second largest contribution to the total water available comes from the groundwater sources. This source has been exploited and very well used by public and private tube wells. It can still provide over 9 MAF of water. This source can be exploited and judiciously used for irrigation purposes. However in some areas ground water is rapidly depleting due to excessive pumping of water with tube wells, authorities should take control in such areas to save them from depleting and to use sources for recharging them.
- Efforts should be made to convert the present rotation based irrigation system to demand oriented system.
- There should be proper use of irrigation water and can be controlled by adopting modern irrigation techniques, that is trickling, sprinkling etc, which have a potential to improve water distribution and its utilization.
- Waste water should be re-used for the irrigation purpose.
- Authorities should take appropriate steps to curb the illegal extraction of water and ensure its equitable distribution.
- Presently irrigation department has failed to stop the illegal theft and extraction; thus irrigation distribution system needs to be privatized through water user associations.
- In addition, water, now-a-days is supplied to farmers at a very negligible cost and that is why they do not treat water as a precious resource; therefore, there is a need to increase the water prices to make irrigators realize the importance of this asset.
- Farmer's organizations, water user association, and private sector be involved in construction, operation, and maintenance of the irrigation system. Such associations are conceived as a mechanism for creating a cooperative frame work for improvement of watercourses (Khoso et al., 2015).

Conclusions

Pakistan is going through the worst water scarcity of history. Therefore, implementation of the recommendations will enable the country to meet the challenges, and attain the objectives of efficient, integrated, environmentally and economically sustainable development and management of limited water resources. Conservation of groundwater aquifers as well as more resourceful use of freshwater derived from rivers is the only way to guarantee that the terrible projection of disastrous regional water wars does not materialize. The solution of prevailing water shortage requires national consensus over proposed projects and their implementation in letter and spirit. At the same time, it will allow us to utilize every drop of our water for our bright future.

In order to succinct the whole discussion it is evident to say that water crisis is the most difficult obstacle of the 21st century and it is the need of an hour to deal it with iron hands. Water is the most abundant natural resource on the surface of the earth and in the light of this known fact people are exploiting this resource. Due to this exploitation water become scarce and it lays huge burden on the socio-economic, political and ecological factor of the earth. Therefore, it is substantial for the national and international management to take essential steps at the right time before the earth take its step to imbibe the whole human being.

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CLIMATE CHANGE, SCARCITY OF WATER/ENERGY IN PAKISTAN AND SOLUTIONS THROUGH EDUCATION, CLEAN ENERGY, FLOODPLAINS/SEWERAGE REGULATIONS/MANAGEMENT

Engr. Abdul Qayyum

CLIMATE CHANGE, SCARCITY OF WATER/ENERGY IN PAKISTAN AND SOLUTIONS THROUGH EDUCATION, CLEAN ENERGY, FLOOD PLAINS / SEWERAGE REGULATIONS / MANAGEMENT

By

Engr. Abdul Qayyum[1]

1. Abstract:

The continuously growing water stressing / scarcity[2], due to global warming impacts, are already observed/experienced, throughout the world, leading to a situation in which available, inter alia, water resources are depleting and/or deteriorating, unable to satisfy the basic needs. Pakistan, especially, being far away from requisite measures/awareness, e.g. special requisite emphasis/focus on clean water/renewable energy[3], has entered in the group of countries that are now moving from the state of water stressing to water scarcity, involving toxins of extremely injurious, both to human and wild/aquatic life. High population growth, increasing urbanization without any regard of the impacts of climate change (e.g. ignoring the need/importance of rainwater-harvesting[4]/floodplains to recharge/ replenishing aquifers), inefficient irrigation practices, indefensible water uses and their fragmented management, especially unacceptable sewerage system and absence of proper evaluation of floods / floodplains against the adverse effects of anticipated climate change[5] and the requisite regulations / their implementations, in the light of flood Management rules, are placing enormous pressure on surface / ground water resources and recreation facilities all over Pakistan. Untreated waste water, both domestic and industry, when enters in adjacent nullahs, streams, canals and/or rivers, heavily pollutes all type of recipients. The dual problems of clean water shortage and untreated waste water overflow triggered with anticipated effects of climate change are serious, present and future, threats to Pakistan and needs serious attention for its solution on top priority / urgently in a strategic / synchronized manner. Presently almost all surface / ground water in Pakistan are polluted with E. coli and Arsenic, causing different deceases. More over the quantity of dissolved oxygen (DO) in river waters, especially when passing through towns / cities, has reduced to a prohibitive limit. Being the member of the United Nation's Framework Convention on Climate Change (UNFCCC) and after passing the climate change Act-2017, Pakistan, as

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[2] https://pubs.acs.org/doi/abs/10.1021/bk-2015-1206.ch010

[3] https://bigpicture.unfccc.int/

[4] https://www.slideshare.net/IEIGSC/techniques-of-rain-water-harvesting-in-urban-and-rural-areas

[5] https://www.businessdailyafrica.com/analysis/columnists/Climate-change-the-missing-link-in-Vision-2030/4259356-3895890-3imq30z/index.html

responsible member to save the planet, should use its indigenous resources, which exist in abundance, of renewable energy with measurable progress and clear targets/deadlines. This in turn will help in achieving the priority thematic areas/goals of climate change, while making Pakistan one of the economical leaders in the world and ensure the prosperity of the people in environmentally sustainable conditions.

Hope the conclusions / recommendations, submitted via this paper through PEC, will form a basis of policy dictating /consideration/ implementation for Government of Pakistan.

2. INTRODUCTION:

a. Literature Survey

More than 50 years ago, impacts, higher average temperatures, increased, prolonged drought periods, may be four to five years, and then excessive rainfall and / or rising seawater levels, of climate change were first diagnosed by the scientists and they started warning the world. Now the scientists have established that the extreme weathers are linked to climate change. This aspect is being observed/experienced throughout the world. The world, especially the developed countries, through United Nation, recognized the severity and, inter alia, following activities[1] were adapted through education:

i. Climate change in the news
ii. Living with climate change
iii. Climate change science
iv. The Earth's energy budget
v. Dynamic modeling
vi. Dynamic modeling 2
vii. A simple climate model
viii. Climate prediction net results so far
ix. Greenhouse gas emissions forecasts
x. Clues from the past
xi. Why is carbon dioxide so important?
xii. Feedback and forcing
xiii. Case study: Why is the arctic warming so fast?
xiv. Climate change impacts
xv. Problem based learning
xvi. The climate change challenge
xvii. Political responses to climate change

[1] http://www.nuffieldfoundation.org/science-society/activities-responding-global-climate-change

xviii. A debate on the issues

xix. Exam-style question: Emission scenarios

xx. International decision making Year by year, as the United Nations Framework Convention on Climate Change 1992 (UNFCCC 1992) moves from one Conference of the Parties (COP) to the next , until Paris Agreement and the upcoming Katowice (Poland) Climate Change Conference (UNFCCC-COP-24) scheduled on 3-14 Dec. 2018.

As a result of above mentioned efforts, climate change Greenhouse Gas emissions have been started to decline[1] in over the two dozen of the largest cities (from Berlin to New York) of the world.

b. According to GCRI-2018[2]- Key Results of Global Climate are:

People all over the world have to face the reality of climate variability – in many parts of the world this has demonstrated in the increased volatility of extreme weather events (exceptional floods, droughts, heat waves, rising of sea level, sinking of adjacent coastal areas etc.). Between 1997 and 2016, more than 524 000 people died worldwide and losses of US$ 3.16 trillion in Purchasing Power Parities (PPP) were incurred as a direct result of more than 11 000 extreme weather events. The UNEP's (United Nations Environment Program) Adaptation Gap Report 2016 warns of the increasing impacts and resulting increases in global adaptation costs by 2030 or 2050 that will likely be much higher than currently expected: "two-to-three times higher than current global estimates by 2030, and potentially four-to-five times higher by 2050". These numbers do not include costs resulting from residual risks or unavoidable losses and damage. This indicates that the gap between the necessary financing to deal with climate-induced risks and impacts is even larger. On the other hand, the report highlights the importance of enhanced mitigation action towards limiting the global temperature increase to below 2°C, which could then help to avoid substantive costs and hardships.

c. Disaster & Climate Resilience

The author, as team leader, has recently completed a Disaster & Climate Resilience Improvement Project named as, "FEASIBILITY STUDY & DESIGN FOR FLOOD PROTECTION OF KOTLI MANDI CITY AND OTHER VULNERABLE AREAS BOTH SIDES OF RIVER POONCH" in AJK Pakistan and the conclusions, recommendations, derived from the study, are urgently needed to be adapted / expanded throughout Pakistan, so that a balance is achieved between the integrated planning / scheduling / designing and implementation vs. vulnerability due to impacts of climate change. Following, impliedly, are the Conclusions / Recommendations:

i. FIRR/ EIRR/ BCR

The Projects, under different scenarios of the expected impacts of climate change, in an integrated/synchronized/systematic manner, should be analyzed

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1 https://www.dw.com/en/climate-change-greenhouse-gas-emissions-decline-in-cities-from-berlin-to-new-york/a-45482304

2 https://germanwatch.org/en/cri

economically/financially as **"risk mitigation projects[1]"**. This will ensure acceptable values of FIRR/EIRR/BCR and consequently arrangement of funds, from any reasonable funding agency, shall be easily managed. Further as, Pakistan contributes very little to the overall (globally) Greenhouse Gas (GHG) emissions, but is extremely vulnerable to the impacts of climate change therefore UNEP and UNFCCC, under its climate change Finance Fund, also can assist, from their funds allocated for climate change, provided the case is prepared in a systematic rational / professional / competent way. All nullahs / streams / rivers, including the three (3) western rivers (figure 01) of Pakistan, should be included in this exercise.

ii. Floodplain Regulations[2]

To cater the possible adverse effects of climate changes, (may be 4 to 5 years drought and then the accumulative rains of very high intensity in one year, during the coming years- title page) adequate legislation regarding Floodplain **(based on appropriate return period of floods)** regulations and then its implementation, followed by Flood Management is needed / recommended, in an integrated / synchronized manner. All nullahs/streams/rivers, including the three (3) western rivers should be included in this exercise (figure 1). Inter alia, this will help recharging of aquifers with clean water in Pakistan.

iii. Biological Contamination in Underground Water/aquifers/ Drinking Water[3] and Its Effects[4]

As per requirements of the standards, mentioned in framework / directives / regulations of EPA Pakistan, E. coli or thermo tolerant Coliform Bacteria must not be detected in all water intended for drinking, but the microbiological analysis of the samples in the project area, including almost whole Kotli, confirmed that nearly every sample, except army area, has some biological contamination (pathogen). Experience while working with WASA Lahore, also confirmed that depleting and contaminating of ground water / aquifers is taking place at large.

iv. Dissolved Oxygen (DO) in Rivers/Streams

As dissolved oxygen levels in water drop (in rivers and streams) below 5.0 mg/l[5], aquatic life (shallow water life, such as fishes etc.) is put under stress, the lower the concentration, the greater the stress. Oxygen levels that remain below 1-2 mg/l for a few hours can result in large fish kills. During study, it was known that the DO level, present in river water was prohibitively (figure 2) low.

To improve this situation, it is recommended that a proper legislation and then adequate regulations on BOD / COD maximum values of waste-water,

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1 http://siteresources.worldbank.org/PROJECTS/Resources/40940-1365611011935/Guidance_Note_Economic_Analysis.pdf

2 https://www.fema.gov/floodplain-management-ordinances

3 https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

4 https://www.epa.gov/privatewells/potential-well-water-contaminants-and-their-impacts

5 https://www.lenntech.com/why_the_oxygen_dissolved_is_important.htm

domestic/industrial, to be allowed to enter in all types of recipients (nullahs, streams and rivers including 3 western river etc.) be made, so that only the adequately treated waste water (having BOD and / or COD values less than or equal to those specified in BOD / COD regulations) should be allowed to enter in the all types of recipients.

d. Integrated Flood Management

Integrated Flood Management (IFM) is a concept that addresses issues of human security against flood risks and sustainable development within the framework of Integrated Water Resources Management (IWRM). This requirement gets special priority when Pakistan, consequent upon climate change impacts, is expected to face exceptional high floods due to Glacier melt in the Himalayas in future. Special attention is required for all rivers included the 3 western rivers. Such an integrated approach to flood management can play an important role in sustainable development and poverty reduction. Integrated Flood Management aims at minimizing loss of life from flooding while maximizing the net benefits derived from flood plains. As part of the approach, the reduction of flood risks is based on a judicious combination of measures dealing with the magnitude of the flood hazard/capacity of stream and the vulnerability of the adjacent areas / community's exposure. Adequate balance with safety factor is needed to the resilience and vulnerability.

e. Impacts on Pakistan

Pakistan contributes very little to the overall Greenhouse Gas (GHG) emissions, but is severely prone to negative impacts[1] of climate change by the following ways:

i. Glacier melt in the Himalayas, due to expected rise in temperature, is projected to increase flooding, which in turn will affect already under stressed water resources. This will be followed by decreased river flows over time as glaciers recede.

ii. Freshwater availability is also projected to decrease further which will lead to biodiversity loss and reduce availability of freshwater for the population.

iii. Coastal areas bordering the Arabian Sea in the south of Pakistan will be at greatest risk due to increased flooding from the sea and in some cases, the rivers.

iv. Being a predominantly agriculture economy, climate change is estimated to decrease crop yields in Pakistan which in turn will affect livelihoods and food production. Combining the decreased yields with the current rapid population growth and poor urbanization in the country, the risk of hunger and food security will raise high.

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[1] http://www.lead.org.pk/cc/basicguide_climate_change.html

v. Widespread morbidity and mortality due to diseases primarily associated with floods and droughts are expected to rise. Increases in coastal water temperatures would intensify the abundance of cholera.

vi. The impact of climate change will also aggravate the existing social inequalities of resource use and intensify social factors leading to instability, conflicts, displacement of people and changes in migration patterns.

vii. Unattended floodplains of all rivers in Pakistan, especially the three western rivers can cause huge disasters.

viii. According to Global Climate Risk Index (CRI-2018) , Pakistan ranks at 7th position (period 1997-2016) among the most adversely affected countries by Climate Change. Inter alia, only financial loss, leaving the residual losses, was of the tune of US$ 3816.82 Million.

f. Rainwater Harvesting

To overcome the adverse effects of climate change / deficiency in recharging of aquifers/pollution of aquifers, to a reasonable extent, we may need, inter alia, shifting away from surface water sources to groundwater seriously, when developing strategies for drinking water provisions. Rainwater Harvesting is an important tool and proven method of recharging of aquifers. Rainwater Harvesting in a sustainable manner, both in urban and rural areas, is also proposed to take in background of strategic approach, for directing policies, inter alia, to meet water stress / scarcity / recharging of aquifers in Pakistan.

g. Pakistan's National Climate Change Policy/Climate Change Act;

Although too late, but Pakistan has launched its Climate Change Policy and Pakistan's National Assembly, to meet Pakistan's obligations under interactional conventions relating to climate change and address the effects of climate change and for matters connected therewith and ancillary thereto, has passed the Pakistan Climate Change Act, 2017 on April 28-2017.

Unfortunately practically nothing out of the activities mentioned in Para 'a' above and/or promised in Climate Change Act, 2017' regarding the UNFCCC's priority thematic actions/activities , is done therefore it can be inferred that: now the time for Pakistan is running out rapidly. Indeed, as per UNEP non-actions on ground, have created huge gap between requirements and actions and thereby with each decade of delay and denial, regarding impacts and measures, the impacts and costs of requisite measures against climate change have continued to mount up.

This paper, to achieve thematic areas/goals indicated by UNFCCC, in light of existing scenario of Vulnerability and/or requisite Resilience of infrastructures against impacts of Climate Change in Pakistan, based on reliable / tested international

documentation[1] on Climate Change / Finance[2]/Pakistan Climate Change Act[3] and as laid in 'UNFCCC Rule Book', will dwell in detail on various aspects of climate change in Pakistan and propose adaptations, specifically indigenous efficient renewable energy against the Vulnerability of existing / future infrastructures[4], inter alia, through appropriate valuation of floods / floodplains / water-supply / sewerage / rainwater-harvesting and then emphasis on legislation / regulations for implementation through adequate management. Special focus shall be on the formulation of strategy regarding production and management of indigenous/efficient renewable energy including other relevant thematic goals. The conclusions/recommendations, submitted through this paper, will form a basis of policy dictating/implementation for Government considerations in Pakistan.

3. Worldwide Actions Vs. Pakistan:

The 1992 United Nations Framework Convention on Climate Change (referred to as the UNFCCC), including the subsequent activities, provide the foundation for multilateral actions to combat climate change and its impacts on humanity and ecosystems. The 1997 Kyoto Protocol and the 2015 Paris Agreement were negotiated and built under the UNFCCC. The objective of the UNFCCC is to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".

In pursuit of this objective, almost all the world is moving forward with climate actions. China has reached its 2020 solar power target three years ahead of schedule[5], after installed capacity topped well over its 105 GW target. Europe has been urged to show similar ambition. In 2016 renewable energy represented 17 % of energy consumed in the EU, on a path to the 2020 target of 20 %[6]. Further the EU has undertaken[7] to reduce its greenhouse gas emissions by 80 to 95 per cent compared with 1990 by 2050. India is one of the countries with the largest production of energy from renewable[8] sources. In the electricity sector, renewable energy (excluding large hydro) accounted for 20% of the total installed power capacity as of 30 June 2018. Large hydro installed capacity was 45.29 GW as of 31 March 2018, contributing to 13% of the total power capacity. Thus, renewable energy including large scale hydro-power currently adds up to more than 33% of the total installed power capacity in India. India has a separate measureable with clear targets/deadlines vision of pumped storage hydro and established an independent ministry for renewable energy. Meanwhile, increasing the renewable energy share to 27% would save the US economy between USD 30 and USD 140 billion per year by

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1 https://unfccc.int/process-and-meetings/the-convention/glossary-of-climate-change-acronyms-and-terms

2 http://www.np.undp.org/content/dam/nepal/docs/reports/2017_reports/CF_Glossary_Final_July2017.pdf

3 http://nasirlawsite.com/laws/pcca2017.htm

4 http://www.who.int/water_sanitation_health/publications/9789241598422/en/

5 https://www.euractiv.com/section/energy/news/china-eclipses-europe-as-2020-solar-power-target-is-smashed/

6 https://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics

7 https://unfccc.int/files/focus/application/pdf/161114_climate_action_plan_2050.pdf

8 https://en.wikipedia.org/wiki/Renewable_energy_in_India

2030 when accounting for benefits resulting from reduced health effects and CO_2 emissions. Germany looks set for a bright future with solar energy. Their renewable energy output including solar has increased more than eightfold since 1990. In 2015, they set a record for meeting up to 80% of the country's electricity demand with renewables by 2050[1].

Contrary, inter alia, Pakistan[2] is facing the worst power and water crises; the average shortfall of electricity is above 6000 MW while 25% of Pakistani population is still not connected to national grids and living in stone ages without modern blessings of electricity. Similarly Water shortage has also emerged as one of the most complex challenges faced to Pakistan and a full-blown water crisis, both quality/quantity wise, is hovering on stability and security of the country. Floodplains of all rivers, including the 3 western rivers need special attention for evaluation of appropriate floods and then management. This requires proper legislation/regulations for designing/implementation throughout Pakistan. Once enjoying abundant availability of water to the tune of 5200 m^3 / capita / annum, the country now possesses alarmingly low quality/quantity water availability i.e. below 1000 m^3 / capita / annum. In an arena of a strong connection among water, food and energy security, decline on almost all these fronts is being felt severely and will exert detrimental impacts on other fronts as well.

As stated earlier, Pakistan has launched its Climate Change Policy and Pakistan's National Assembly, to meet Pakistan's obligations under interactional conventions relating to climate change and address the effects of climate change and for matters connected therewith and ancillary thereto, has passed the Pakistan Climate Change Act, 2017 on April 28-2017. Sole passing the act is not sufficient and indeed now the time is passing out rapidly. Pakistan needs to follow the UNFCCC 'rule book' in letter and spirit.

Nature has endowed Pakistan with a huge solar potential of 9.5 Million MW[3] and 320 plus sunny days in a year. If managed in an integrated/harmonized/synchronized manner the energy / water resources in Pakistan are of heartening picture.

Besides solar energy potential; Pakistan possesses above 46000 MW of wind energy capacities in its defined wind energy corridors of Jhampir, Badin and Gwadar belts. Similarly, Geo-thermal bio-mass, bio-fuels and other resources of alternative energy are also available in bulk in Pakistan. To integrate/synchronize all the indigenous resources of renewable energy and to make the national grid efficient, there are sufficient natural sites of of pumped storage energy in Pakistan.

To meet the climate challenges, renewable energy is ultimately to dominate[4] the market; therefore Pakistan needs (Annex 1) the ways to store the energy so that all renewable indigenous resources are integrated/optimized and then used round the clock. The good news is that it is easy to store energy. All you need is two small reservoirs – one high,

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1 https://www.businesslive.co.za/bd/companies/energy/2017-07-18-germany-aims-for-80-of-its-energy-from-renewables-within-35-years

2 http://fouzintl.com

3 https://sbcp.com.pk/2018/08/05/latest-news-2/#

4 http://theconversation.com/how-pushing-water-uphill-can-solve-our-renewable-energy-issues-28196

one low – and a way to pump water between them, and this type of energy is called pumped storage energy, well established all over the world.

Indeed **Pumped-storage hydroelectricity** (**PSH**), or **pumped hydroelectric energy storage** (**PHES**), is a type of hydroelectric energy used by electric power systems for load balancing. Pumped-storage hydroelectricity allows energy from intermittent sources (such as solar, wind) and other renewables, or excess electricity from continuous base-load sources (such as coal/other fossil-fuel or nuclear) to be saved for periods of higher demand. In other words, the pumped storage energy production provides the means of integrating/ harmonizing/synchronizing/exploiting/optimizing different sources (solar, wind, hydro, thermal etc.) in a cost effective/efficient way, with minimum possible outages.

Countries with the largest power pumped-storage hydro capacity in 2017[1]	
Country	Power capacity (GW)
China	32
Japan	28.3
United states	22.6
Spain	8
Italy	7.1
India	6.8
Switzerland	6.4
France	5.8

In June 2018 the Australian federal government announced that 14 sites had been identified in Tasmania for pumped storage hydro, with the potential of adding 4 8 GW to the national grid if a second interconnector beneath the Bass Straight was constructed.

Pakistan should also contribute (by exploiting/integrating/synchronizing all available energy resources: wind, solar, hydro, pumped storage, conventional hydro and thermal etc.) its part, with time line and targets, having due regard of 'rule-book COP 23 UNFCCC'[2] guidelines., say up to 2020, 2025, 2030 etc., as promised via climate Act 2017/required by UNFCCC, this in turn will enable Pakistan to deal its energy/water and economic crises in a scientific/ respectful manner.

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1 https://en.wikipedia.org/wiki/Pumped-storage_hydroelectricity

2 https://www.dw.com/en/cop23-writing-the-paris-accord-rule-book/a-41200149

4. Vulnerability, Adaptation and Resilience: According to UNFCCC Rule Book:

i. **Vulnerability**: the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed to its sensitivity, and its adaptive capacity.

ii. **Adaptation**, in the simplest terms, refers to the actions that countries will need to take to respond to the impacts of climate change that are already happening, while at the same time preparing for future impacts. It refers to changes in processes, practices and structures that can reduce our vulnerability to climate change impacts, such as sea level rise or food insecurity. It also includes making the most of any beneficial opportunities associated with climate change, such as increased crop yields or longer growing seasons in some regions.

Adaptation solutions take many shapes and forms, depending on the unique context of a community, business, organization, country or region. There is no 'one-size-fits-all-solution'—adaptation can range from building flood defenses, setting up early warning systems for cyclones and switching to drought-resistant crops, to redesigning communication systems, business operations and government policies. Many nations and communities are already taking steps to build resilient societies and economies, but far greater action and ambition will be needed to cost effectively manage the risks, both now and in the future.

iii. **Resilience:** the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

iv. **Climate Finance Fund:** In accordance with the principle of "common but differentiated responsibility and respective capabilities" set out in the Convention, developed country Parties are to provide financial resources to assist developing country Parties in implementing the objectives of the UNFCCC. The Paris Agreement reaffirms the obligations of developed countries, while for the first time also encouraging voluntary contributions by other Parties. Developed country Parties should also continue to take the lead in mobilizing climate finance from a wide variety of sources, instruments and channels, noting the significant role of public funds, through a variety of actions, including supporting country-driven strategies, and taking into account the needs and priorities of developing

country Parties. Such mobilization of climate finance should represent a progression beyond previous efforts.

Overall, efforts under the Paris Agreement are guided by its aim of making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development. Assessing progress in provision and mobilization of support is also part of the global stock taken under the Agreement. The Paris Agreement also places emphasis on the transparency and enhanced predictability of financial support.

At the United Nations climate change conference in Paris, COP 21, governments agreed that mobilizing stronger and more ambitious climate action is urgently required to achieve the goals of the Paris Agreement. Action must come from governments, cities, regions, businesses and investors. Everyone has a role to play in effectively implementing the Paris Agreement.

Global warming isn't just an environmental problem — it will affect every aspect of human life. Our response has to be just a wide-reaching — and experts say people power can still save the planet.

5. Benefits of Clean Water / Energy, Resilient Water Supply / Sewerage, Costal Areas Management, and Rainwater Harvesting:

- Less global warming and thereby less climate effects
- Improved public health
- Inexhaustible energy
- Jobs and other economic benefits, especially for Pakistan it can be a battery for economic growth.
- Stable/reasonably affordable energy prices
- Reliability and resilience to the system
- Improvement in ecosystem of Pakistan
- Improvement in recharging of aquifers with clean water
- The coastal areas of Pakistan against vulnerability to climate change and climate-driven impacts shall gain appropriate resilience

Best managements regarding clean water/energy and resilient water supply / sewerage use and measures for resilient coastal areas are inter-related and also related the impacts of climate change. Most developing [1]countries including Pakistan have more than 500,000 deaths related to unclean drinking water each year, which include at least

[1] https://globalwarmingisreal.com/2017/10/31/is-there-a-link-between-renewable-energy-and-clean-drinking-water/

2,200 children. To combat this widespread issue, researchers have developed or are developing new technologies and processes as long-term solutions.

One of the initial issues of water contamination is human pollution mainly due to inadequate water supply/sewerage in Pakistan and then the use of fossil fuels for energy production, despite the fact that Pakistan has indigenous resources of renewable energy in abundance. Updated/resilient to climate change water supply / sewerage system[1] is a prerequisite of healthy ecosystem of any country. Pakistan is far away from this requirement. Renewable energy technology has taken a front seat on the industrial and economic stage, mainly due to the need to preserve our planet's fresh water supply. Parties, including Pakistan, to the UNFCCC and the Paris Agreement recognize that adaptation is a global challenge faced by all local, subnational, national, regional and international dimensions.

Water / water supply / sanitation / sea rising/ energy issues are multi-dimensional including economic, social, political and cultural aspects. The United Nations Millennium Declaration adopted the goal of reducing by half the proportion of people without access to safe drinking water by the 2015. An additional goal was set at the World Summit on Sustainable Development in Johannesburg to reduce by half the proportion of people without access to basic sanitation by 2015[2]. Proper assessment of vulnerability and then requisite resilience through appropriate adaptation of all water supply/sanitation system/floodplains/coastal areas against anticipated impacts of climate changes is needed on urgent/priority basis. Unattended/unplanned, with illegal encroachments, floodplains, almost of all the rivers / nullahs (Fig. 1), are a serious threat to whole Pakistan under the anticipated floods due to climate change. Adequate legislation / regulations / implementation are required on urgent / necessary basis.

Pakistan ratified[3] as member of UNFCCC on June 01, 1994 and Pakistan's Parliament passed[4] climate change Act on March 24-2017, to fulfill its obligations, as member, laid in UNFCCC rule book.

6. Summary for Policy[5] Makers / Climate Actions Now:

According to UNFCCC, the Priority thematic areas are**:**

i. Renewable energy.
ii. Energy efficiency.
iii. Transport.
iv. Carbon capture, use and storage.

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1 https://link.springer.com/book/10.1007/978-94-007-0280-6

2 http://www.dsi.gov.tr/docs/iklimdegisikligi/post_2012_climate_change_negotiations_guidebook_turkey.pdf? sfvrsn=2

v. Non-CO^2 greenhouse gases.

vi. Land use climate action.

vii. Adaptation co-benefits.

Further Climate action now offers every nation on the planet a clear path towards the shared aim of a healthier, more prosperous and more secure future. Nations now increasingly understand that economic prosperity, sustainable development and environmental stewardship present an intertwined challenge that must be addressed with coordinated and consistent policies both in and across ministries and nations. **All Nations also understand that climate change presents the single biggest threat, to the hard won advances, the world has made, under the Millennium Development Goals and will be a defining factor in the success or failure of the 2015 Sustainable Development Goals, depending on whether or not we allow the global temperature rise this century to exceed 2 degrees Celsius.** Responding to climate change is a generational journey, an effort that must be sustained and increased over decades to come. The sooner and faster the world acts the greater chance of arriving at the future we all need.

7. Conclusion:

As Pakistan is a developing country, therefore renewable energy/efficiency thereof/ Water/ water-supply/sanitation/energy issues / floodplains and coastal area issues are covered under UNFCCC's rule book and come under the definition of "**Adaptation**" and as promised by Pakistan via climate act 2017, must be assessed and developed/prepared in a strategically systematic/efficient way which optimizes benefits thereof, while minimizing negative environmental impacts. In this way Pakistan can meet the present economic/water/energy/floodplains/coastal areas' issues while can get reasonable financing from **Climate Finance Fund** and manage the floodplains of all rivers, almost 40 smaller or larger (fig 1), and also fulfill its commitment regarding green Pakistan, promised via climate act 2017. The only stipulation is that the assignment should be performed under established good engineering practices using advanced technologies while maintaining requisite transparency[1] with measurable targets and clear deadlines for improving the lives of all Pakistani's especially the Pakistan's poorest people.

8. Recommendations:

As stated above, responding to climate change is a generational journey, the sooner and faster Pakistan acts the greater chance of Pakistani people of arriving at the future, they indeed need. Therefore to meet the target following recommendations are made;

i. Education[2];

Like other countries, the activities mentioned in paragraph (2. a), may be started in Pakistan through education and news, so that the general

[1] http://www.mdgfund.org/node/922

[2] http://www.nuffieldfoundation.org/science-society/activities-responding-global-climate-change

people/society gets requisite awareness/relevant-actions regarding climate change and its impacts.

ii. UNFCCC's the first two Priorities thematic areas are **Renewable Energy** and **Energy efficiency** while almost all countries, except Pakistan, have set with measureable progress and clear deadlines, their goals for the inclusion of renewable energy with means of efficiency in their national grid-systems. Indigenous means/resources (Solar, Wind, geothermal, pumped storage) of clean energy are available in Pakistan and as recommended, regarding pumped storage energy- a proven mean of making the system efficient, by the then General Manager Hydel WAPDA, in 2007, to all concerned, Annex 1, it is now recommended that :

Some very highly qualified and competent group(s) of consultants be engaged to carry out comprehensive studies in the overall perspective of available; Hydro (conventional + pumped storage), wind, solar and geothermal energy potential, system conditions and country's future demand with measureable progress of renewable energy/efficiency means and clear deadlines as how/when the total potential can be exploited, so that Pakistan is able to fulfill its obligations, as member of UNFCCC, promised in 1994 and again confirmed via Climate ACT 2017. This in turn will improve the economy of Pakistan, ensuring the prosperity of the people of Pakistan; rather it can become the battery of economic growth in Pakistan.

iii. Pakistan, like United Nations' Millennium Declaration, should adopt/formulize some mechanism[1] so that vulnerability of the existing water-supply/sewerage system is determined[2] and then adaptation to water supply and sanitation under the UNFCCC program, for existing and future requirements, is carried out in a measureable progress with clear deadlines. It will improve the ecosystem in Pakistan.

iv. One of the most adverse effects of the climate change is the occurrence of exception high floods, therefore it is recommended that:

Adequate valuation of floods, legislation regarding Floodplain Regulations and then its implementation on urgent basis in all over Floodplains (fig. 1), including the three(03) western n rives, of Pakistan is recommended on urgent basis. If formulated and enforced, then Flood Plains are to be used

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1 20in% 20Moldova_ENG%20web.pdf

2 http://ec.europa.eu/environment/marine/international-cooperation/pdf/Moldova_Task%201_Final_EN_26%20Feb.pdf.pdf

under proper Flood Regulations followed by flood management[1], and can provide best measures of recreation/ environment to local people and can cause guaranteed protection which can reduce poverty and improve quality of life thereby associated with reducing the vulnerability of the people. It, in a scientific/safe way, will fulfill Pakistan's promise, made through Climate Act-2017 to UNFCCC, of making green Pakistan.

v. Rainwater Harvesting[2]: While developing rural/urban areas, due provisions should be made for rainwater harvesting. It, inter alia, will help in charging the aquifers with clean water.

vi. The impacts of climate change, inter alia include sea level rise and sinking of the coastal areas (Karachi etc.), therefore proper/ investigations arrangements are recommended[3].

vii. In general the UNFCCC's remaining five thematic areas (Paragraph 6 above) are, perhaps indirectly, covered under the above recommendations and/or must be taken care of on urgent/ top priority basis, through a competent group of consultants

9. Important note[4]:

i. As actions/activities, required to fulfill the above recommendations come under the UNFCCC's definition of "**Adaptation**", therefore, if the above recommendations are worked out in a systematic/ competent/ efficient/transparent way, **UNFCCC Finance Fund**, can easily be prayed[5]**.**

ii. Primarily the paper is prepared for Pakistan, but it, after incorporating the specific data of any other developing/poor country, is equally good for that specific country.

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1 https://www.fema.gov/floodplain-management-definition

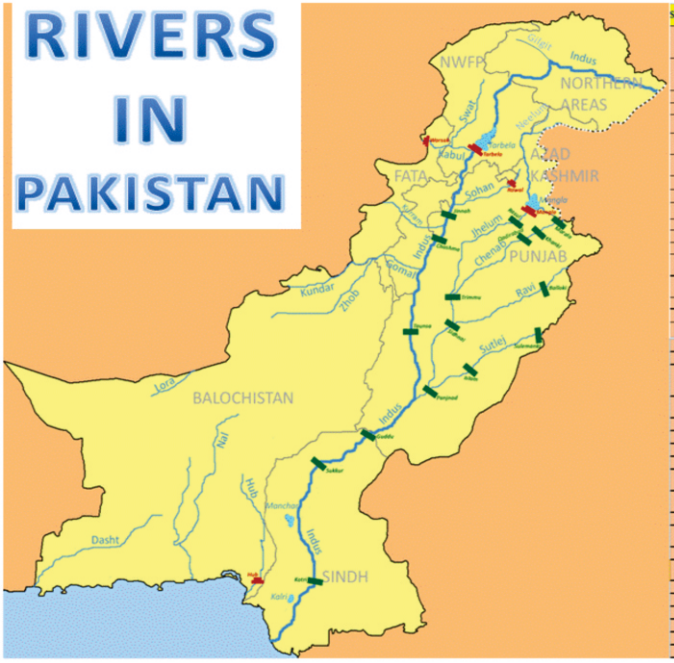
2 https://www.slideshare.net/IEIGSC/techniques-of-rain-water-harvesting-in-urban-and-rural-areas

3 https://www.epa.gov/arc-x/climate-adaptation-and-sea-level-rise

4 https://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/pub_07_financial_flows.pdf

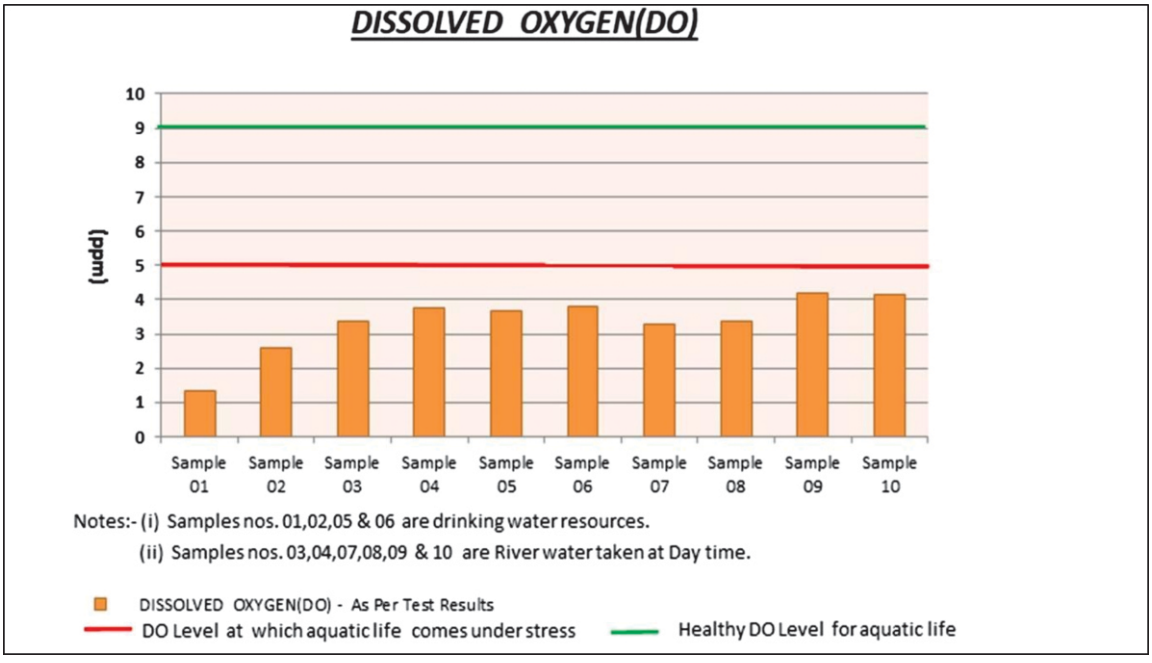
5 http://www.mof.gov.np/uploads/document/file/CCFF_FINAL_Web_20180222050438.pdf

Figure 1



S.No	River	Sources of water	Details
1	Indus River	Sênggê Zangbo	At Tibetan Plateau The Tibetan Plateau lies between the Himalayan range to the south and the Taklamakan Desert to the north.
2	Jhelum River	Verinag Spring	At Pir Panjal Range is a group of mountains in the Inner Himalayan region, running from east-southeast to west-northwest across the Indian
3	Sutlej River	Mount Kailash	Himalayas
4	Chenab River	Bara-lacha la	Himalayas
5	Ravi River	Chamba district	Chamba district of Himachal Pradesh, India
6	Kabul River	Sanglakh Range	Sanglakh Range is an offshoot of the Hindukush just west of Kabul
7	Gomal River	Katawaz Region	Is a town in and administrative seat of Zarghun Shar District, Paktika Province, in eastern Afghanistan.
8	Neelum River	Vishansar Lake	Jammu and Kashmir, India.
9	Swat River	Hindu Kush Mountains	central Afghanistan to northern Pakistan
10	Zhob River	Paiseen Valley(Tsari Mehtarzakai	Balochistan
11	Soan River	Bun Village	foothills of Patriata and Murree.
12	Gilgit River	Shandur lake	Gilgit-Baltistan
14	Kunar River	Hindu Kush Mountains	central Afghanistan to northern Pakistan
15	Hunza River	Kilik and Khunjerab nalas(fed by glaciers)	Gilgit-Baltistan
16	Dasht River	Mirani Dam	south of the Central Makran Range in Kech District in Balochistan
17	Shyok River	Rimo Glacier	One of the tongues of Siachen Glacier
18	Hub River	Pab Range	south-eastern Balochistan
19	Kurram River	20 km southeast of Gardez,	Afghanistan
20	Kunhar River	Lulusar Lake	Kaghan Valley.
21	Panjkora River	Hindu Kush Mountains	central Afghanistan to northern Pakistan
22	Gambila River	The source of the river lies in the hills six miles south of the Safin Ghar range	eastern Afghanistan
23	Ghaggar-Hakra River	Shivalik Hills, Himachal Pradesh	foothills of the Himalayas
24	Rupal River	Rupal Glacier	northern Pakistan
25	Lyari River	Drainage basin	North east of karachi
26	Tawi River	Kali Kundi glacier	Bhaderwah in Doda district of jammu and kashmir
27	Suru River	Panzella glacier	Kargil district of Jammu and Kashmi
28	Poonch River	south-facing foothills of Pir Panjal range	south of Jammu and Kashmir
29	Shigar River	Baltoro Glacier and Biafo Glacier	Gilgit-Baltistan
30	Neelum River	Vishansar Lake	Ganderbal, Kashmir valley
31	Dori River	sub tributary of the Helmand River	Kandahar Province in Afghanistan
32	Korang River	Murree Hills	Murree
33	Rakshan River	Nidoki pass, south-west of Shiroza	District Washuk, Balochistan, Pakistan.
34	Braldu River	Baltoro Glacier, Biafo Glacier	Gilgit-Baltistan
35	Haro River	Murree Hills	Murree
36	Bara river	Tirah Valley	Bara Tehsil, Khyber Agency.
37	Hispar River	Hispar Glacier	In the Karakoram mountains of Gilgit-Baltistan
38	River Sindi	hills of Malakand Agency	district of Charsadda, in Khyber-Pakhtunkhwa
39	Kundar River	Sulaiman Mountains	Balochistan

Figure 2



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WATER CONTAMINATION AS A MAIN SOURCE OF WATER SCARCITY IN PAKISTAN

Muhammad Iftikhar, B. K. Bakht, Dr. Engr. A. Yasir, Dr. A.B. Tabinda, M. N. Anwar

WATER CONTAMINATION AS A MAIN SOURCE OF WATER SCARCITY IN PAKISTAN

By:

Muhammad Iftikhar, B. K. Bakht, Dr. Engr. A. Yasir, Dr. A.B. Tabinda, M. N. Anwar

Abstract

In Pakistan the ground water is one of the major sources of water consumption and it is also a valuable resource, but due to landfill leachate, uncontrolled hazardous waste sites, freeway disposal of wastewater from industries and agriculture causes the pollution of natural water resource. The research shows that Arsenic and Fluorine are two major pollutants in groundwater of Pakistan and more than 50% of groundwater wells have their increase concentrations even it exceeds from the permissible WHO limits results in water shortage and various health related problems like anemia, gastrointestinal irritation, lung infections, hepatitis, intestinal infections and diarrhea, dysentery, cholera, respiratory paralysis, typhoid fever, jaundice and skin diseases in children as well as in older and younger adults. This review sums up the outcomes of various research studies conducted for groundwater quality status and water shortage in Pakistan. The scarcity of safe and healthy water sources causes 20% of the population to use clean water, but the rest of 80% population has no access to safe water. The study shows that there is an immediate need of taking measures to control groundwater contamination and water scarcity such as management of waste, use water wisely, reduce, reuse, recycle, use fewer chemicals, plant more trees and spread awareness about water contamination and water scarcity.

INTRODUCTION

The most important element of the life is the water it is the essential element of the human body and comprises of almost 60% of the human body. Almost 71% of the Earth's surface is covered with the water of which almost 3% is covered with the fresh water. Furthermore, of all the total fresh water present on the earth surface only a very small portion about 0.01% of the total fresh water is available for the human use (Hinrichsen and Tacio, 2002). This small fresh water available for the human use would have been enough for all the requirements of the human and their future generations if this water would have been consumed on the principle of sustainability. But unfortunately, unplanned and unsustainable consumption along with the contamination of the fresh water with the pollutants and rapid population growth has resulted in the immense stress of fresh water. It has been recently reported by UNO (United Nation Organization) that the population of the world is increasing rapidly while on the other hand availability of the fresh water is decreasing exponentially. It is studied that once the water is contaminated it is known as "not available water for consumption"

According to the report many countries of the world including Middle East, Africa and South Asia would have serious threats of water shortage in the upcoming two decades of the world. In the developing countries this problem is further stressed seriously by the poor management and lack of the professional and financial support (PCRWR, 2005).

Pakistan is among the developing countries and like other developing countries .Pakistan is also facing very serious threat related to the upcoming episode of the water scarcity and water pollution (PCRWR, 2005). Pakistan has almost consumed all its available water sources unsustainably and is considered as the water stressed and is expected to be water scarce country in the upcoming few years (Hashmi et al., 2009a; WWF, 2007). One of the reason for the exponential continuous decrease in the water quantity from the rivers, lakes, and ground water as well is the precipitation rate. This precipitation rate in Pakistan is very lower than the evaporation rate in the Pakistan. This water is further enhanced by the financial and professional constrains like lack of the new water reservoirs and some natural factors like long droughts etc. (PCRWR, 2005; Ullah et al., 2009). In Pakistan decrease in the quantity of the water along with the increase in the demand of the water and unsustainable use of the water has resulted in the severe water shortage in almost all sectors of the country. It is estimated that water availability per capita is decreased from 5000 in 1951 to 1100 m^3 per annum in Pakistan (WB-SCEA, 2006). It is also proposed that the exponential increase in the population of the Pakistan along with the no development in the reservoirs of water storage may cause decrease in the water availability per capita of less than 1000 m^3 from the year 2010 and onwards3 (PAK-EPA, 2005b). This situation could get more worst in the areas located outside the Indus Basin where the per capita per annum water availability is already very low almost below 1000m^3.The water availability situation in certain areas is more worst where people do not get clean fresh water even for the purpose of drinking and are forced to drink brackish polluted water (Ullah et al., 2009). The behind the scenes are worst in the Baluchistan Province where the underground aquifers and the water reservoirs are decreasing by a rate of 3.5 m annually and these are expected to be exhausted in the upcoming 15 years (Sajjad et al., 1998). The increasing demand of water in the multiple sectors along with the decrease in the quantity of the water has resulted into the severe problems and issues related to the water. This has also affected the quality of the water and has resulted into different types of the water pollution. Due to this water pollution a large amount of the water available in different reservoirs like rivers, aquifers and lakes is not considered safe for the use of human. Thus this water is also considered as no water.

STATUS OF WATER QUALITY IN PAKISTAN

A detailed study on the water quality of the Pakistan in different cities of the four provinces was conducted by Pakistan Council of Research in Water Resource (PCRWR) from 2002 TO 2006. This study was conducted in major 23 cities in all the four provinces. The conclusion of this study is presented in the table below. The study has revealed that almost 84-89% of the water available in the country was below the drinking standards recommended for the human consumption by WHO (World Health Organization) (PCRWR, 2008a). It was also surveyed that due to the poor quality of the fresh water available in the reservoirs people were compelled to use mineral water provided by the different companies in plastic bottles. Furthermore, this water available

in the packed plastic bottles is also of not good quality because of no proper processing and monitoring systems (Rosemann, 2005).

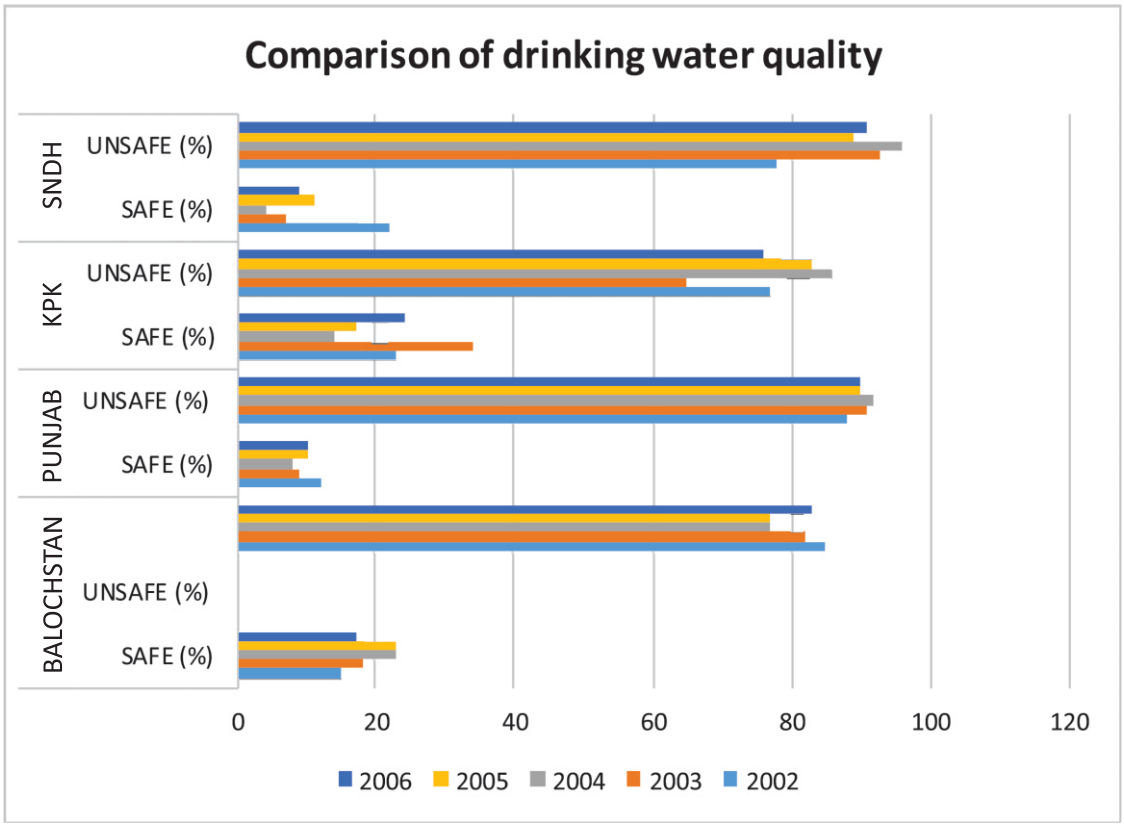


Table 1: Five year comparison of drinking water quality in provinces of Pakistan. Percentage of safe and unsafe drinking water samples (PCRWR, 2008a).

MAJOR POLLUTANTS OF WATER

There are many matters and substances which are considered as the major and active water pollutants which are further classified into different groups. Some important and most common are listed below:

- Pathogens
- Inorganic Pollutants
- Anions and Cations
- Water-Soluble Radioactive Substances
- Organic Pollutants
- Heavy Metals

All the pollutants mentioned above if cross their threshold limits in the water are harmful and can cause severe health problems in humans as well as in other living organisms in the ecosystem. In some areas heavy metals and pathogens are providing serious threat to the water quality and providing high level of water pollution.

PATHOGENIC (BACTERIAL) CONTAMINATION

Most common bacteria found in the water are the coliforms and the microbial analysis of the water especially of the drinking water is done for the purpose of the detection of the bacteria, protozoa and other pathogens. Califorms bacteria are commonly present in the environment and their presence in the environment is not harmful for the humans but their presence in the water is the indicator that the water is contaminated by the pathogens (Farooq et al., 2008). According to the WHO standards no E.coli or Califorms bacteria should be present in the water supposed to be consumed for the drinking purpose (WHO, 1993). (Fig 1)

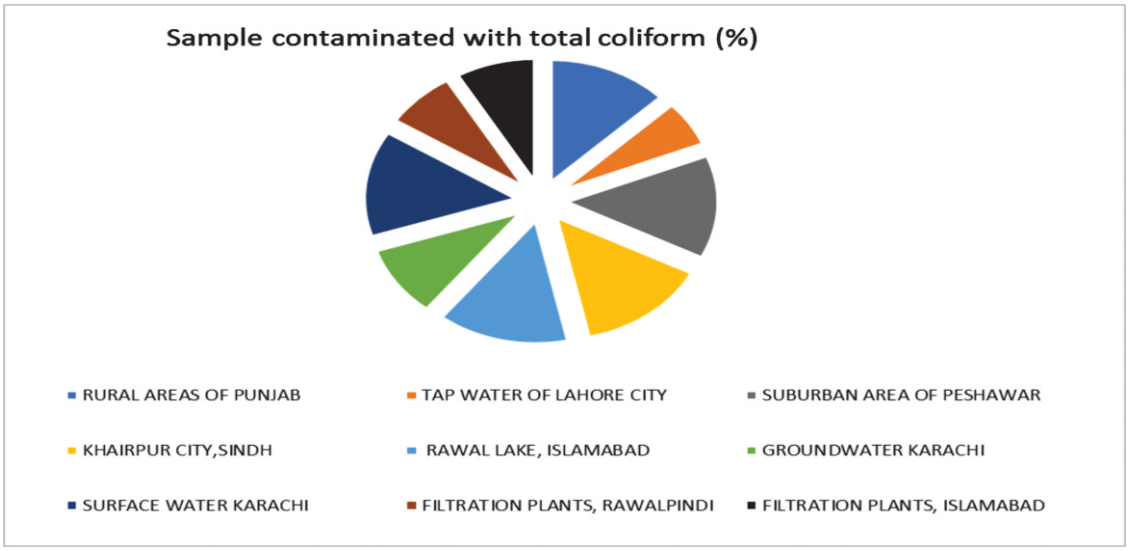


Figure 3: Bacterial contamination of the drinking water from different sources (A. Azizullah et al).

HEAVY METAL CONTAMINATION

Natural water also contain impurities in the form of toxic elements or heavy metals as these elements dissolve in water and consumption of this water may lead to serious threats(Ilyas and Sarwar, 2003). These metals contaminate water at both surface and groundwater levels. This contamination is mostly through most of the human activities for example improper disposal of industrial, agricultural and municipal waste. Some of these metals are important for the human health but because of the extreme pollution the amount of these metals has increased in water which possess serious threats to the human health (Midrar-Ul-Haq et al., 2005). In Pakistan toxic metal concentrations has increased the maximum admissible limits both at the ground and surface water levels, water situation of different locations of Pakistan are discussed below in table.

GROUND WATER					
LOCATION	**Zn(µg/l)**	**Cu(µg/l)**	**Fe(µg/l)**	**Mn(µg/l)**	**Cd(µg/l)**
KARACHI	4.02	0.09	-	-	0.04
HASANABDAL	0.009	0.02	0.07	0.02	0.001
PALSOI	0.34	0.34	0.3	0.21	0.04
MULTAN	-	-	2.7	1	-
MUZAFFARGARH	-	-	1.65	0.69	-
RISALPUR	0.13	0.21	0.16	1.22	0.04
FAISALABAD	1.84	1.3	3.7	1.06	-
GADOON	0.066	0.893	0.037	0.164	0.025
HATTAR	0.05	0.03	0.08	0.12	0.03
HAYATABAD	0.1	O.36	0.08	0.12	0.03
KALALANWALA	-	-	-	-	-
KASUR	0.14	-	2.57	0.04	0.007
SIALKOT	0.16	0.06	0.3	0.03	
MANCHAR LAKE	-	-	-	-	-

SURFACE WATER					
LOCATION	**Zn(µg/l)**	**Cu(µg/l)**	**Fe(µg/l)**	**Mn(µg/l)**	**Cd(µg/l)**
TARBELA RESERVIOR	0.028	0.04	0.012	0.018	0.004
CHASHMA RESERVIOR	0.029	0.004	0.004	0.004	0.003
LLOYD RESERVIOR	0.028	0.004	0.012	0.018	0.002
RIVER RAVI	0.034	0.006	0.127	0.0097	0.0014
PALOSI DRAIN	0.239	0	0.75	0.242	0.004
MALIR RIVER	0.16	0.31	0.78	0.33	-
RIVER CHENAB	-	-	0.18	0.28	-
BARARIVER	0.06	1.2	1.75	0.85	0.2
KALAR KAHAR LAKE	2.82	1.2	5.46	-	0.05

HUDAIRA DRAIN	1.7	0.45	7	0.85	0.18
MANCHAR LAKE JAMSHORO	-	-	-	-	-

Table2: Heavy metal contamination of the water was done from the different locations of the Pakistan (A. Azizullah et al).

FLOURINE AND ARSENIC

There are two types of sources of fluorine the natural and the anthropogenic activities. Volcanic gases and F-bearing minerals like igneous and metamorphic rocks are natural sources of fluorine. Mining activities of phosphate and industrial waste water disposal are anthropogenic sources that contribute in excess amount of fluorine in groundwater. Fluorine excess amount causes negative effects in humans such as alteration of DNA-structure, the destruction of immune systems and damage to nervous system. The study shows that fluoride concentration in the Tharparkar region of Pakistan is very high 1.27-43.11 mg/L. (Zia. 2018)

In Southeast and South Asia the groundwater is highly contaminated by the carcinogenic element known as Arsenic (As) (Singh and Ghosh 2012; Sing et al). The WHO standard of this hazardous compound is 10 microgram per litre but in Pakistan the local standard is adopted of less than 50 micro gram per litre. The research shows that in Lahore 89.71 %(Fig 2) of groundwater wells are composed of Arsenic contamination (Environmental Protection Department 2010) .This element is highly hazardous as it causes serious disease like cancer, anemia and cardiovascular disease. (Muhammad and Sohail, 2017)

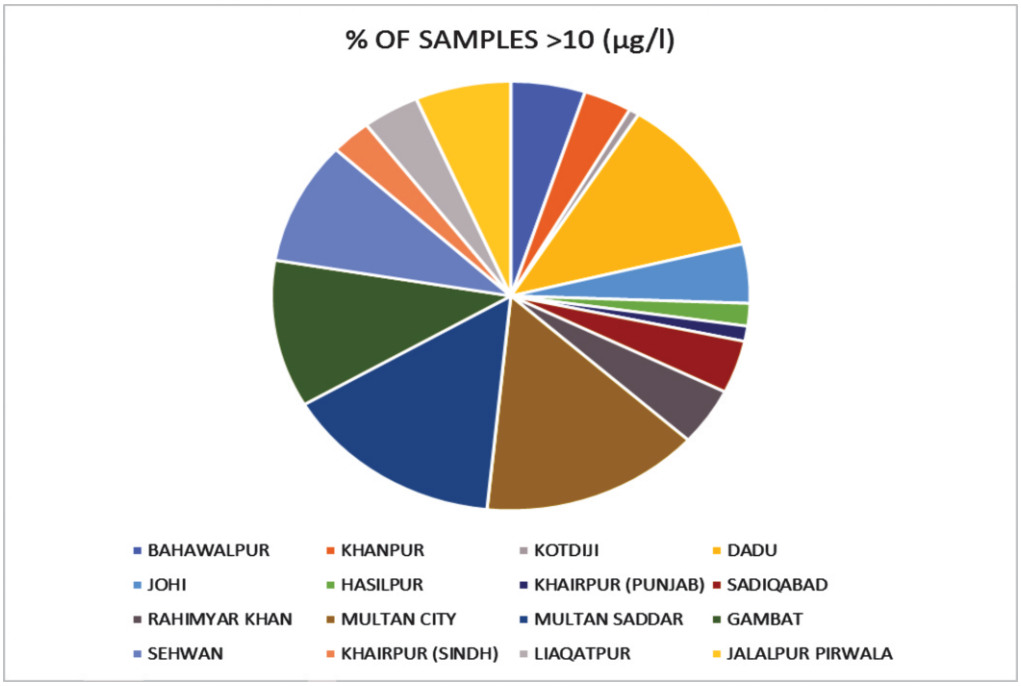


Figure 4: Arsenic contamination in various districts of the Pakistan PCRWR (2008b,c)

PESTICIDES CONTAMINATION

Pesticides are present in surface as well as in groundwater sources of the world. In most parts of the world this resource is used as source of drinking water and for agriculture use. The use of pesticides from past few decades induce its presence in the whole environment. It is present everywhere including air, soil, water and biotic environment. (Julia Plattner, 2018) The pesticides mainly through rainfall move into groundwater. Pesticides causes water contamination at larger extent that many governmental and non-governmental organizations are forced to regulate the pesticides concentration in drinking water. (Chbib Chaza, 2018)

Table 3: Pesticide concentration in ground and surface water samples of Pakistan (Tariq et al., 2007).

Sampling Location	Water Type	Concentration (micro gram per litre)	Pesticide Detected	References
Samundri, Faisalabad, Kala Shah Kaku and Lahore	Shallow groundwater	0.1-0.2	Endrin	Jabber et al. (1993)
Swabi, Chota Lahore, Takhbai Mardan	Groundwater	0.0-0.03	Chlorpyrifos	Ahad et al (2000)
Multan	Groundwater	0.0-0.13	Endosulfan	Ahad et al (2001)
Different Districts of Punjab	Surface and groundwater	0-0.935	DDT (Dichlorodipheny ltrichloroethane)	Asi et al. (2008)
Rawal Lake, Pakistan	Water from surface	0.06-13.28 (3.3)	Azinophos-methyle	Ahad et al. (2006)

WATER QUALITY STANDARDS

The toxicity of water is related to the High TDS level. The groundwater with high TDS causes indigestion diseases in humans. Turbidity of the water accounts for cloudiness of the water. This becomes the cause of microbial growth result in water borne disease.

Parameter	National Drinking Water Quality Standards	WHO (World Health Organization)
Conductivity (S/cm)	1000	_
Total Dissolved Soild (mg/L)	1000	1000
pH	6.5-9	6.5-8.5
Total Suspended Solid (mg/L)	25	_
Turbidity (mg/L)	_	5
Arsenic (mg/L)	0.01	0.01

Zinc (mg/L)	3	None
Iron (mg/L)	0.3	0.3
Copper (mg/L)	1	2
Magnesium (mg/L)	150	None
Cadmium (mg/L)	0.003	0.003
Chromium (mg/L)	0.05	0.05
Tin (mg/L)	_	_
Mercuty (mg/L)	0.001	0.006

The safe limits to determine drinking water quality (N. Rahmanian, 2015)

The presence of sulfate and carbonates of calcium and magnesium contributed in the hardness of water. The pH maintenance for the drinking water is also very important. The increase pH above 11 or below 4 causes many kinds of problems in humans like eye and mucous membrane irritation and skin diseases

WATER POLLUTION SOURCES:

Water pollution is mainly caused by human activities such as municipal, domestic and industrial wastes in water bodies. (Hammer, 1986) (Kahlown and Majeed, 2003) .Everyday approximately 2 million tons of sewage is discharged into world's water and in developing country like Pakistan the 90% of untreated sewage is added into the water sources. There are very few collecting systems in the country which collect 50% of the urban cities pollution and only 10% is treated (WWF, 2007). There are few countries which has lion's share in the waste water:

- Hyderabad
- Sialkot
- Lahore
- Karachi
- Rawalpindi
- Faisalabad

As Pakistan is the agriculture country this also poses its negative effect because excessive use of agrochemicals in agriculture. In developed countries like China and USA there is a huge contamination of agriculture chemicals (Li and Zhang, 1999). In Pakistan the natural groundwater is highly effected by the use of fertilizers and pesticides results in the alarming situation of waste water.

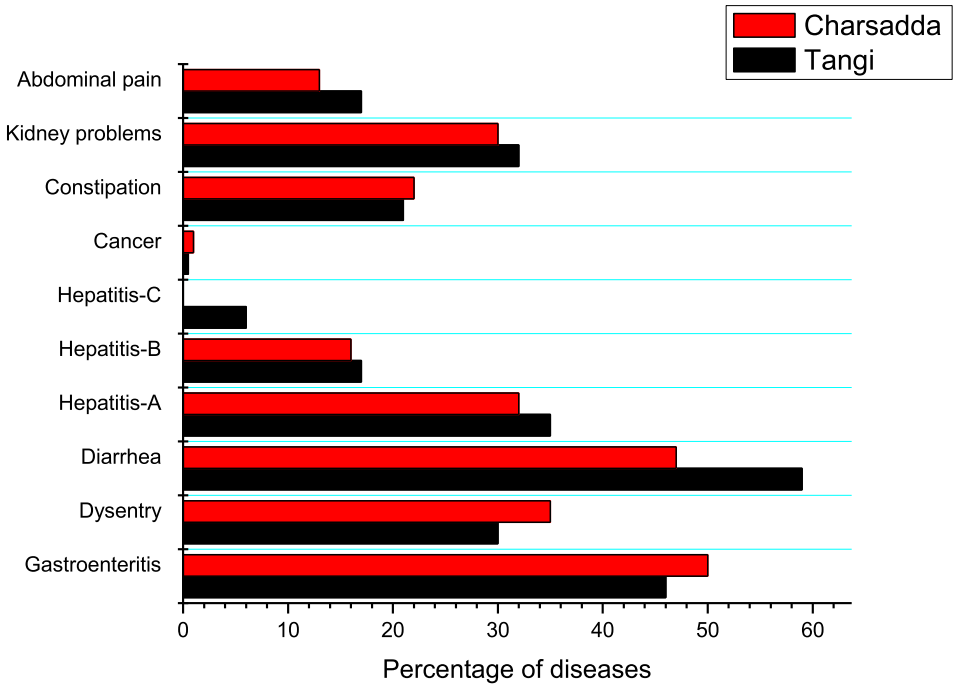
The agriculture water leaches into the nearby water bodies and causes threat to marine life as well as human life. The nitrates, ammonia, sulphates, phosphates and nitrites causes eutrophication in the water and become the indirect harm to the environment. Many algae are harmful to animals as well as humans like cyanobacterium microcystis produces hepatotoxic microcystin.

Many fertilizers are direct threat to the groundwater. Fertilizers produce by product which are harmful compounds for nature of soil as well as water. When they accumulated in the soil they give rise to compounds that are dangerous for humans. In this way the contamination by agrochemicals are more than industrial and domestic wastage. (MOE-PAK 2005a)

HUMAN HEALTH

Water contamination is a big threat to health of human beings. The large part of human body is composed of water. If this is in large quantity then its poor quality directly effects the health of human. The WHO and UNISEF reported that in developing countries more than 2.2 million people are at verge of death due to poor water quality . Water related infections and parasitic diseases are causes more than 60% mortality in the whole world.

“An estimated 1.1 billion people lack access to safe drinking water, 2.5 billion people have no access to proper sanitation, and more than 5 million people die each year from water-related diseases — 10 times the number killed in wars, on average, each year. All too often water is treated as an infinite free good. Yet even where supplies are sufficient or plentiful, they are increasingly at risk from pollution and rising demand. By 2025, two thirds of the world's population is likely to live in countries with moderate or severe water shortages” (UNO Secretary General on world water day 2002).



Sardar Khan, 2013

A study is conducted in which number of households are selected in order to measure the rate of diseases caused by consumption of contaminated water. There are two

districts selected Tangi and Charsadda .The number of households of Tangi is 1620 and of Charsadda is 1554. The number of males are 3000 (Tangi) and 3500 (Charsadda) and the number of females are 3200 (Tangi) and 3157 (Charsadda). The chart above represents the percentage of different diseases prevailed in two different areas by the consumption of contaminated water. (Sardar Khan, 2013)

CONCLUSION AND RECOMMENDATIONS

In Pakistan the drinking water is not safe for human consumption because the pollutant contents are in increase concentration even they exceed from permissible quality standards. The heavy metals concentration is also increasing from standards and limits set by WHO (World Health Organization). The most common heavy metals are Chromium, Iron, Cadmium, Nickel and Arsenic. Fluoride and Nitrates are also a threat in some parts as fluoride in some areas is very low whereas in some parts it is very high. The main source of water pollution is uncontrolled municipal waste and untreated industrial wastes. In rural areas the monitoring of water quality is totally absent (Aziz; 2005). The water disinfection practices like chlorination is either unsatisfactory or nonexistent. This causes serious human related problems.

Waterborne disease is the main issue cause by the chemical and bacteriological pollution of public drinking water. The is an insufficient record of water related diseases and the lack of diagnostic technology contributed to the blur picture of water linked diseases result in poor handling of these diseases.

There are various recommendations to the problem of deteriorating water quality:

1. The proper monitory procedures should be introduced in every part of the country.
2. Purification of water should be made mandatory by local authorities.
3. The continuous water supply should be compulsory in order to avoid intermittent contamination and to fulfill the water needs.
4. The sewage pipelines should be away from water supply.
5. It should made compulsory for industries to install waste water treatment plants. The industrial water should be monitor regularly.
6. The pesticides should be treated safely. The farmers should provide regular education and awareness about the use and disposal of pesticides.
7. There should be guidance for storage of water inside the houses.
8. There is a strong need of implementation of strict laws.
9. The old rusty water supply lines should be treated regularly.
10. There is a need for proper sewage handling in urban areas of Pakistan. (Azizullah ;2011)

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WATER STEWARDSHIP-AN INTEGRATED WATER MANAGEMENT APPROACH FOR THE INDUS BASIN

Sohail Ali Naqvi, Dr. Masood Arshad

WATER STEWARDSHIP-AN INTEGRATED WATER MANAGEMENT APPROACH FOR THE INDUS BASIN

By:

Sohail Ali Naqvi[1] and Dr. Masood Arshad[2]

Abstract

Pakistan is a water scarce country. Additionally, environmental issues such as climate change, reduced agriculture productivity and compromised water quantity and quality are negatively affecting our food chain. In the past, there have been multiple initiatives by the Government, Private sector and Civil Society Organizations in the water sector but the approach was usually limited in nature or non inclusive in terms of stakeholder involvement. WWF-Pakistan introduced a concept of water stewardship and tried to bring stakeholders at one platform. This paper reviews the basic concept of Integrated Water Resource Management (IWRM) and how the Water Stewardship approach integrates into IWRM. Furthermore, this paper will also share few examples of successful Water Stewardship through ongoing projects at WWF- Pakistan such as Basin Assessment Scenario Intervention Tool (BASIT), International Labour & Environmental Standards (ILES), Alliance for Water Stewardship, Revitalization of Ravi River and City- Wide Partnership.

Integrated Water Resource Management and Water Stewardship- Mitigating Water Risk to Achieve Water Security

Integrated Water Resource Management (IWRM) involves planning and implementing a shared vision for sustainable water resources. It revolves around management strategies for the development and utilization of water resources while understanding and respecting the interconnectedness that exists between natural processes, humans and ecological uses of water. The decision making in IWRM is embedded in various disciplines such as hydrology, climatology, ecology, environmental science, water resource engineering, remote sensing, law, socioeconomics and public policy. However, public policy actors are usually in the position to make crucial decisions regarding water resource management ((Georgakakos, 2007). They are the ones who take decisions based on information generated by technical experts. This implies that all stakeholders involved in water management are imperative and have specific roles.

Water Stewardship (WS) is about businesses understanding that water scarcity and pollution poses serious risks to their business, and taking timely action is necessary for sustainable water management. As Water Stewards, businesses realize and accept that water is a shared, public resource (WWF-International, 2013). Stewardship does not only mean becoming efficient water users. As Stewards, the private sector

1 WWF Pakistan

2 WWF Pakistan

collaborates with governments, other businesses, NGOs, communities, and others to protect and conserve shared freshwater resources (WWF-International, 2103). Water Stewardship provides an enabling environment for policies and legislation which is important for bringing about holistic change in attitudes about water and the ways it is used. Pakistan is an agrarian country and majority of businesses and their supply chain revolve around agriculture. For the basin approach on stewardship, there is a need to take stakeholders onboard from agriculture, irrigation to industry and retailers/exporters in order to come up with a comprehensive water resource management plan. WWF-Pakistan conducted a study in 2014 on water footprint of industrial sector in Punjab, Pakistan. This study revealed that blue water footprint of four industrial sectors (textile, leather, pulp and paper and sugar) is 29,000 MCM which is 20-30% of our rivers flow (Linstead et al, 2014).

The Sustainable Development Goal 6.5 aims at implementing IWRM at all levels by 2030. However, it is regrettable that in order to fulfill the goal, private sector participation is not as common as it should be. Experts suggest that Corporate Water Stewardship (CWS) initiatives are usually limited in scope and their scale is not large enough to alleviate business risks at the watershed level. The solution lies in joint, collaborative efforts that will yield change in a broader ambit and is likely to be more successful.

WS and IWRM are both embedded in mitigating water risk to achieve water security. Multistakeholder engagement and collaboration are at the core of both WS and IWRM. Unless all stakeholders do not share the same vision, it would be difficult to manage water resources in a sustainable manner (Engle et al., 2011)

Through Water Stewardship, companies begin by identifying their water-related business risks and decide on strategies to manage those risks and mitigate the adverse effects on ecosystems and communities at large. IWRM is an overall process that also integrates Water Stewardship for coordinated development and management of water, land, and related resources for maximum economic and social welfare while ensuring equity and sustainability of ecosystems.

Water Stewardship contributes critically to IWRM and holistic stakeholder engagement is a must for successful water management. A shift towards integrated rather than fragmented stakeholder approach is the need of the hour (GWP, 2018).

Why is Water Stewardship Essential for Managing the Indus Basin?

The Indus River is the backbone of the water resources of Pakistan. Furthermore, there is little uncertainty about the fact that the Indus basin water is becoming scarce. In parallel the demand for water is rising due to increasing population, urbanization and climate change (Hussain et al., 2011). In future, hydrological, socioeconomic, technical, political and environmental challenges are expected to arise in the basin due to its mismanagement.

Research findings predict that in short term, the river basin runoff will increase due to fast melting of glaciers while there will be a decrease encountered in long term due to retreating glaciers as a result of climate change. For example, 30 to 40% reduction in runoff from the basin is expected by 2030 primarily due to climate change (Mukhopadhyay 2012; UNESCO 2012).

The Water quality is also expected to jeopardize due to reduced flows and increased chemical and sediment loading. Additionally, increased domestic and industrial wastes, agricultural pollution, groundwater salinization, and sedimentation are major threats for water quality (Laghari, Vanham and Rauch 2011)

Moreover, 32% decline in river flow is projected for 2025 which could lead to 70 million tons of food deficiency in the Indus basin (Cheema & Pawar 2015).Other Environmental problems such as water logging, salinity, reduced soil productivity and land degradation may continue to be experienced or exacerbate further due to poor water management. We need to realize that the purpose of rivers is not only to feed our agriculture system, but they really contribute into the eco-systems, habitats survival as well as save our deltas by depositing sediments etc..

The solution lies in creating social awareness and strengthening institutional capacity of government and private organizations. Water Stewardship is the key word in this regard. All stakeholders; major and minor need to understand that water quality and quantity risks are shared and will have an overall negative effect unless channelized strategic measures are taken. Thus collective action by all stakeholders is incumbent for successful Integrated Water Resource Management (Akhtar, 2016).

WWF-Pakistan's Initiatives in Establishing Water Stewardship in the Indus Basin

Since 2013, WWF-Pakistan has been involved in various projects that included propagating and encouraging Water Stewardship for successful management of the Indus Basin. Major initiatives are discussed briefly to throw light on how Water Stewardship approach plays a positive role in managing water resources.

City Wide Partnership

City-Wide Partnership is a voluntary initiative started by WWF-Pakistan in 2014. It is a network of public, private and civil society actors committed to mitigating shared risks. The City-Wide partnership aims to promote open dialogues on priority water risks by mobilizing resources, fostering driven solutions and making measurable improvements in the overall water management.

This partnership forum contributes towards water resource management through a stakeholder inclusive process. A ground water working group has been established which comprises of stakeholders prominently working in water management in the Indus Basin. A similar group will be established to discuss how Environmental efficiency of industries in the catchment can be improved. A platform is provided to all relevant stakeholders to initiate a healthy discussion with special emphasis on bridging the gap between industry, policy makers and the government.

Alliance for Water Stewardship

WWF-Pakistan believes in the concept of Water Stewardship. As part of this commitment, WWF- Pakistan is supporting businesses in improving water management within their premises and along the supplychain.

WWF-Pakistan has initiated a venture with different corporate for the implementation of Alliance for Water Stewardship standards in its facilities. The AWS standard guides

companies with a systematic and verifiable way to assess their own water use and impact on the surrounding catchment, while providing a mechanism through which they can engage constructively with other stakeholders. Multi-stakeholder participation is at the heart of water stewardship. Membership of AWS offers a platform to share and learn from experiences, and to work collaboratively to promote sustainable water use.

AWS employs three mutually-reinforcing programmes to bring about improved water stewardship: a standard and verification system, membership of a multi-stakeholder association, and training. Together, these programmes are designed to build capacity and provide a forum through which knowledge on water stewardship can be generated, accessed and shared, helping us to address our shared water challenges.

WWF-Pakistan is striving hard to implement AWS in Pakistan's companies to steer a collective response to shared water risks and for the sustainable water management of the Indus Basin through a stakeholder endorsed process.

International Labour and Environmental Standards (ILES)

In 2016, WWF-Pakistan started an initiative for industries funded by European Union (EU) in collaboration with International Labor Organization (ILO) to work for promoting labour and Environmental standards in Pakistan in order to improve the competitiveness of the industrial sector and to strengthen the capacity of the public sector to implement multi-lateral-environmental agreements (MEAs) and national environmental laws and standards in Pakistan. Water Stewardship is an integral part of ILES as it aims at apprising the potential stakeholders about Smart Environmental Management Practices (SEMPs) to reduce energy and water use. One of the project goals is to provide an enabling environment for legislators, policymakers, lawmakers and enforcers, concerned government officials and other key stakeholders to learn about environmental challenges and develop an enhanced capacity to ensure adherence to environmental standards. Water stewardship sessions are scheduled regularly for the purpose of promulgating the Water Stewardship approach towards water resource management.

Basin Assessment Scenario Intervention Tool (BASIT)

Basin Assessment Scenario Intervention Tool (BASIT) is an example on River Ravi in the Indus River Basin. It is a hydrological modeling tool which integrates surface water and groundwater modeling. The purpose is to help decision making in future for water recharge hotspots. The findings from such a tool will help key stakeholders get a view of the watershed health. Identification of potential water issues provide a baseline for Water Stewards to come up with a shared vision and collaborate on the water resource management strategies.

Revitalizing the Ecosystem of Ravi River

Through this project WWF-Pakistan aims at inculcating the spirit of Water Stewardship in potential stakeholders especially Industrial stakeholders in the Ravi River catchment. Through Multi-stakeholder discussions and visioning exercises, the project aims at establishing the approach of water stewardship in businesses beyond their fence line. The aim is to provide a platform for discussions amongst businesses on how they can

bring in-process changes for reducing the pollution load in the basin while maximizing resource efficiency. Further, it aims at bridging the gap between policy makers, government and the industries to identify hurdles that curtail cleaner production and find solutions for those problems.

Conclusion

Conclusively, WWF-Pakistan is striving to redefine the role of the private sector in promoting better basin management and governance in the Indus Basin for the benefit of people and nature. Through various projects and platforms, WWF-Pakistan tries to bring all stakeholders on one platform to propagate the concept of Water Stewardship where stakeholders identify that water risks are shared and the true solution lies in united efforts and combined strategies. Stewardship is a tool which compels you to think in a different way as compared to a conventional thinking on water resources and these approaches are now-a- days getting success globally. In Pakistan we need to promote water stewardship approach to take stakeholders at one forum (from research to water practitioners and policy makers to decision makers) then we can claim right IWRM approach is key to success. There is also need to think in a different way on the valuing the river water.

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WATER SCARCITY COPING WITH INTEGRATED WATER RESOURCES MANAGEMENT IN PAKISTAN

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WATER SCARCITY COPING WITH INTEGRATED WATER RESOURCES MANAGEMENT IN PAKISTAN

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Abstract

The increasing scarcity of water in dry areas is now a well recognized problem. According to the World Commission on Environment and Development, approximately 80 countries with 40% of the world population already suffer from serious water shortages. At present, water shortages have led most of arid and semi-arid countries to increase food imports because the local agricultural sector is not able to produce sufficient food to fill the existing food gaps. The increasing food gaps are posing serious challenges beyond the economic and political capacity required for the necessary adjustments concerning the allocation and use of water in all sectors, particularly agriculture.

Integrated Water Resources Management (IWRM) is the practice of making decisions and taking actions while considering multiple viewpoints - how water should be managed? These decisions and actions relate to situations such as river basin planning, organization of task forces, planning of new capital facilities, controlling reservoir releases, regulating flood plains, and developing new laws and regulations. The need for multiple viewpoints is caused by competition for water and by complex institutional constraints. The decision-making process is often lengthy and involves many stakeholders.

The agricultural sector is by far the largest user of water in the world. On a consumptive use basis, 80–90% of all the water is consumed in agriculture. Unfortunately, water use efficiency in this sector is very poor not exceeding 45% with more than 50% water losses; thereby, enormous water saving could be achieved in the agricultural sector comparable with other sectoral water uses. The growing water scarcity and the misuse and management of the available water resources are nowadays major threats to sustainable development for the various sectors, especially domestic, industrial and agricultural.

To integrate the available water in the system management of water resources and its utilization, a series of dams are needed, in a way that river flows are tamed in steps and reservoirs are managed as a cascade. The integrated water resources management includes harvesting the rain water by developing small and medium dams on hill torrents and by adopting techniques of ground water recharging so as to mitigate effects of extensive pumpage. The IWRM at all levels and its use is earnestly needed. The water

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resource potential on western rivers is to be exploited, and there are number of projects, which are at different stages of planning and execution by WAPDA to harness the western river flows to meet the irrigation and power requirements of the nation.

1. Introduction

Pakistan, one of the world's most arid countries, with an average rainfall of under 240 mm a year, is heavily dependent on an annual influx into the Indus River system. About 180 billion cubic meters (John Briscoe and Usman Qamar, 2006) of water of the system emanates from the neighboring country and is mostly derived from snow-melt in the Himalayas. This hydraulic economy of Pakistan faced massive challenges right from the independence of country in 1947. The first challenge arose at the time of partition of the Indo-Pak subcontinent which detached the irrigated heartland of Punjab from the life-giving waters of the Ravi, Beas and Sutlej rivers which had become part of India. The situation became worst when India stopped the water flow of Pakistan in April 1948.

Then, water diplomacy started and both states under the mediation of the World Bank negotiated the Indus Waters Treaty (IWT) in 1960, giving Pakistan rights in perpetuity to the waters of the three western rivers; Indus, Jhelum, and Chenab rivers. While the three eastern rivers (Beas, Sutluj and Ravi) came under total jurisdiction of India. This arrangement resulted in a new challenge that was of a mismatch between the location of Pakistan's water (in the western rivers) and the major irrigated area in the east. Again Pakistan's water engineers were up to the task, building the world's largest earth fill dam, the Tarbela on the Indus, and link canals, which ran for hundreds of miles and carried flows ten times the flow of the river.

Water problems was settled and IWT was regarded as a remarkable example of conflict resolution yet the recent Indian intentions of building "chain of dams" on Pakistani (western) rivers have once again posed a serious challenge for Pakistan. Further, UN reports are suggesting that Pakistan is going to become a water scarce country in near future. In this premise, this essay intends to highlight the reasons of water shortage in Pakistan, its implications and a proposed way out. The paper will first highlight the availability of water and emerging challenges, then discuss the different water saving techniques.

1.1 A water-intensive country

Pakistan has the world's fourth-highest rate of water use. Its water intensity rate, the amount of water, in cubic meters, used per unit of GDP is the worlds highest. This suggests that no country's economy is more water-intensive than Pakistan's.

The bulk of Pakistan's farmland is irrigated through a canal system, but the IMF says in a report that canal water is vastly underpriced, recovering only a quarter of annual operating and maintenance costs. Meanwhile, agriculture, which consumes almost all annual available surface water, is largely untaxed.

Experts say that population growth and urbanization are the main reasons behind the crisis. The issue has also been exacerbated by climate change, poor water management and a lack of political will to deal with the crisis. "Pakistan is approaching the scarcity threshold for water. What is even more disturbing is that groundwater supplies, the last resort of water supply are being rapidly depleted. And worst of all is that the authorities

have given no indication that they plan to do anything about any of this," Michael Kugelman, South Asia Expert at the Washington-based Woodrow Wilson Centre, told to Deutsche Welley (DW), News Channel of Germany in a 2015 interview.

Water scarcity is also triggering security conflicts in the country. Experts say the economic impact of the water crisis is immense, and the people are fighting for resources.

1.2 Climate Change

Water scarcity in Pakistan has been accompanied by rising temperatures. In May, at least 65 people died from heatstroke in the southern city of Karachi. In 2015, at least 1,200 people died during a spate of extremely hot weather. "Heat waves and droughts in Pakistan are a result of climate change," Mian Ahmed Naeem Salik, an Environmental Expert and Research Fellow at the Institute of Strategic Studies in Islamabad, told to DW.

"The monsoon season has become erratic in the past few years. The winter season has shrunk from four to two months in many parts of the country. On top of it, Pakistan cannot save floodwater due to a scarcity of dams," Salik said. "At the time of Pakistan's birth in 1947, forests accounted for about 5 percent of the nation's area, but they have now dropped to only 2 percent. Pakistan must invest in building water reservoirs and plant more trees," he added. (The News International).

2. Water Resources of Indus Basin

Water availability in Pakistan is largely from precipitation (rainfall and snow), river flows from snow and glacier-melt and runoff from summer and winter rains from the watersheds. Some of the water from precipitation and surface water flows recharges the aquifer in terms of large storage of groundwater in the Indus Basin. Pakistan benefits a great deal from all these sources of water and the availability of precipitation and river flows, marked by unique temporal variability. For example, the variability in the historical maxima and minima is 170.1 and 92.6 MAF, thereby indicating the distribution of floods and droughts in the Indus Basin. The extreme variability in river flows makes resource management quite complex. Similarly, the recharge to the aquifer and availability of groundwater is also dependent upon the probability of wet and dry years. The trends of water availability in the Indus Basin covering western and eastern tributaries are presented in Table 1.

Table 1: Trend of Indus River Historical Flows in Million Acre Feet (MAF)

No.	Year	Indus River Flows (MAF)
1	1937-38	156.7
2	1940-41	130.5
3	1950-51	183.4
4	1960-61	178.2
5	1970-71	128.3
6	1980-81	134.7

No.	Year	Indus River Flows (MAF)
7	1990-91	163.5
8	2000-01	97.6
9	2010-11	157
10	2012-13	121.5
Average Flows		147.8
Minimum Flows		92.65
Maximum Flows		207.7

2.1 Glaciers and Snow Deposits

Gilgit Baltistan contains the largest area of perennial glaciers outside the Polar Regions (22,000 km^2) and estimates are that as much as 28 percent of the region is glaciated, and winter snow cover occupies up to 30-40 percent of that area. More than a 100 glaciers stretch over 10 km in length, with several extending beyond 50 km. Hence, glaciers and seasonal snow constitute a huge reservoir for freshwater in the area and contribute vastly to the flow of the Indus River.

2.2 Precipitation

Mean annual rainfall varies from less than 100 mm in parts of Balochistan and Sindh, to more than 1500 mm in wet mountains. In Gilgit-Baltistan (GB), at altitudes exceeding 5000 m, snowfall exceeds 5000 mm and provides the largest resource of water in the glaciated zone as shown in Figure 1. About 60 percent of rainfall is received during July-September. Contribution of rainwater to crops in the Indus Basin Irrigation System (IBIS) is 13.4 MAF, which is 13.5 percent of the mean annual canal diversions in the Post-Tarbela period (Ahmad, S. 2008a.). Extreme variability in seasonal rainfall has direct impacts on the river flows. Ninety-two percent of country's area is classified as semi-arid to arid (Bhutta, M.N. 99).

2.3 Surface Water Resources

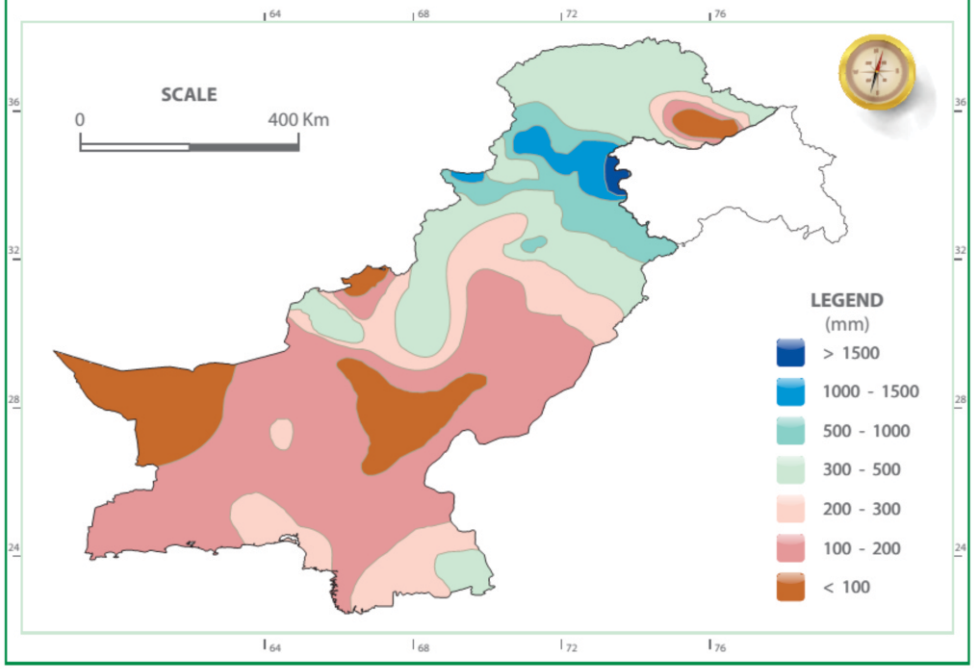
Pre-Storage

Glacier melt, snowmelt, rainfall and runoff constitute the river flows. Inflow measurement facility has been established at the Rim of the Indus River tributaries and thus referred to as Rim Station inflows. The Rim Stations of the western rivers are located at Tarbela, Attock, Mangla and Marala for Indus, Kabul, Jhelum and Chenab rivers, respectively. The Rim Stations for the eastern rivers are located at Balloki and Sulaimanki for Ravi and Sutlej rivers, respectively.

River flows were limited in the Rabi season because of limited glacier and snowmelt and low rainfall during the winter season. Western rivers have provided 173 BCM of surface water in an average year during the pre-storage period of 1937-67. Bulk of the river flow was during the Kharif season, which was more than five times the flow in the Rabi season. Variability in flows of the eastern rivers was even higher than the western rivers (Ahmed, S. and M. F. Joyia. 2003.). Before the construction of Mangla and Tarbela

storages, the eastern rivers have contributed about 26 BCM of water to the Indus River system in an average year of which about 84% was in the Kharif Season (Table 2). Contribution of the eastern rivers to the annual total inflows of the Indus River system was around 13%, whereas it was 11% during the Rabi Season, which was a significant contribution (Table 2).

Figure 1. Mean Annual Rainfall in Pakistan



Source: Pakistan Met Department and WRRI, NARC, 1999

Table 1: Variability of Rim-Station inflows to Indus River System (Pre-Storage Period)

Probability (%)	Rim-Station Inflows (BCM) for Pre-Storage Period 1937-67						
	Western Rivers			Eastern Rivers			Total
	Kharif	Rabi	Annual	Kharif	Rabi	Annual	
Minimum	110.0	19.1	134.5	9.6	1.7	11.3	145.8
10	123.9	22.8	143.9	15.6	1.9	17.5	161.4
25	136.2	24.2	163.1	17.9	2.9	22.3	185.4
50	144.5	26.3	173.0	22.1	3.3	26.2	199.2
75	155.3	30.5	184.9	27.4	4.9	35.2	220.1
90	166.8	32.6	198.2	32.2	8.6	38.1	236.3
Maximum	192.7	40.7	231.7	39.3	18.1	44.5	276.2

Post-Storage

Seasonal, annual and daily river flows in the Indus river system are highly variable. River flows are generally limited in the Rabi season because of limited glaciers, snowmelt and

rainfall, with flows increasing by almost five times in the Kharif season. During 1975-2013, Western Rivers contributed nearly 134.7 MAF of water in a median year (50 percent probability). After the construction of Mangla and Tarbela dams, eastern rivers contributed 7.0 MAF of water in a median year, of which 80 percent was in the Kharif season. Total median annual flows from both western and eastern rivers were 141.7 MAF. Variability in river flows during droughts has given rise to water crises and fuels interprovincial water conflicts. The Water Apportionment Accord, based on the mean annual river flows of143 MAF, indicates that the apportioned amount of water will not be available to provinces in one out of two years (Altaf & Samia, 2009).

Variability in river flows is a major limitation in the development of run-of-river type irrigated agriculture in the Indus Basin, especially to meet crop irrigation requirement during low flow period of the Rabi season and early and late Kharif season.

2.4 Flows to Arabian Sea–Down Stream of Kotri Barrage

Annual variability of river flows downstream Kotri barrage has been very high. In the median year, annual flow was 26.9 MAF during 1975-2013. In one out of ten years, the flows below Kotri are almost negligible. The construction of Kotri barrage reduced seasonal and annual flows below Kotri owing to enhanced canal diversions. Seasonal and annual flows were further reduced during the Post-Mangla and Post Tarbela periods due to increases in canal diversions at Kotri and upstream commands.

2.5 Per capita surface water availability and storage

Per capita designed live storage capacity available in Pakistan is 121 m^3 per person, which is only higher than that of Ethiopia. USA houses the largest storage capacity of 6000 m^3 per person, followed by Australia and China. When compared with a storage capacity of 900 days in the Colorado River, USA, Pakistan stands with a storage capacity at a mere 30 days (IWASRI. 1997).

2.6 Groundwater Resources in Pakistan

Other important source of water is groundwater which consists 99 percent of freshwater and easily accessible for the world. In Pakistan the volume of ground water is immeasurable. In recent years its availability has been increased from 3 percent to the 40 percent of total water available at the farm gate. The Government of Punjab has underlain unconfined aquifer covering about 79 percent of area, whereas the Government of Sindh has underlain about 28 percent of area of fresh ground water. The water is used for irrigation purposes and pumped through tube wells. Whenever groundwater is saline, it utilized for the irrigation proposes after diluting with the fresh canal water. In the last 25 to 30 years, especially in the Upper Indus Plain the groundwater is utilized to cover the deficit of canal supplies where the quality of groundwater is good. It has been estimated that the pumpage in all command area is 55 MAF. The total potential of groundwater in Pakistan is 65 MAF (Pakistan Water Strategy Report). In the last 40 years (1976-16), groundwater contribution to irrigated agriculture has doubled from 25.6 to 55 MAF and it is currently stagnant. Ground water now contributes 47 percent of surface water available at the farm head (Michael et, al., 2009).

2.7 Groundwater Recharge

Estimated annual recharge to groundwater in the IBIS is 55 MAF, out of which 36 MAF occurs in the freshwater zone. Owing to drought and increased abstractions in 2002, the waterlogged area reduced from 42 to 32 percent. In the IBIS, the total groundwater reservoir of fresh and marginal quality water measures to 810 MAF (gross command area of 16.7 million ha and depth of freshwater of 15 m), equivalent to six times that of mean annual river flows. Excessive pumping will have negative impacts on the resource, however it will create a space for excessive recharge during wet years (WAPDA. 2006).

2.8 Current budget

Water conveyance efficiency of the IBIS at farm gate is 55.3 percent based on canal and watercourse conveyance efficiency of 79 and 70 percent, respectively. Field application efficiency is 75 percent. Thus, overall irrigation efficiency stands at 41.5 percent. The net water availability for crop consumptive requirement is 79.89 MAF, whereas net water requirement for crop consumptive use for existing cropping pattern in the IBIS is 101.7 MAF. With rainfall contribution of 13.4 MAF, the shortfall stands at 8.41 MAF (8.3 percent), and 21.81 MAF (21.4 percent) vice versa. The shortfall during dry years continues to increase due to reduced canal water supply and less rainfall. Farmers adapt either by reducing cropped area, deficit irrigation or enhanced abstractions from groundwater (World Bank. 2005)

3. Future Water Demand

The country's current population stands at approximately 207 million (2018), due to increase to 227 million by 2025, using a growth rate of 1.93 percent per annum. Thus, an increase of 18.5 percent in water availability is needed to meet the requirement of the population in 2025. In order to meet the net crop water requirement, the demand of water would be 120.5 MAF for 2025.

3.1 Water Availability and Scarcity

Water availability in the post-Accord period was significantly less when compared with Accord Entitlements of 114.3 MAF of canal water supplies. Maximum amount of water diverted to canals during 1975-2013 was 111.1 MAF, with median year supplies of 101.84 MAF, which is 12.2 percent less than the Accord. Variability in canal water supplies ranges between 76.2 to 111.1 MAF, which is 33.3 and 2.9 percent less than the Accord and is creating water disputes among provinces.

The issue of sharing water shortages among provinces then remains, especially when they feel that their entitlements are as per the Accord. Also of pertinent concern, is the issue as to why water entitlements are higher than the availability of water itself? The reason is that these entitlements are based on the fact that additional storages will be constructed in the future, which have yet to be initiated. Although there have been past disputes on water distribution, however, the Indus River System Authority (IRSA) was successfully able to distribute water without any grievances, referred to by the Council of Common Interests (CCI).(Alif Ailaan, 2017).

The Indus Main houses an inadequate storage capacity incapable to regulate water supply ensuring that surpluses are not wasted and there is sufficient water to meet

needs in times of shortage. Pakistan's water storage capacity ranges between 0 to 40 days of river flows during dry and wet years, respectively. Storage availability is around 18.6 MAF, which is insignificant to meet the future water demand and to ensure availability of water to provinces as per Accord. Pakistan's river flow hydrology is such that there is no water to store during the dry year, whereas the situation is opposite during wet years.

3.2 Rising and Competing Water Demand

The water demand continues to increase owing to a rise in population and a higher demand for multiple water uses. The water demand for domestic and industrial subsectors of water use will receive higher priority and compete with water required for agriculture. In case no new water resources are developed in the near future, rise in demand for domestic and industrial sectors would largely be met from water allocated and used for the agriculture subsector.

3.3 Environmental Flows (E-Flows)

Environmental flows are essential for providing water for nature. The most important E-flows in the IBIS are: a) Indus delta below Kotri barrage to maintain ecosystem and habitats; and b) Three eastern rivers owing to Pakistan with the right to flow in order to maintain river ecosystems. The Water Accord provides entitlements for E-flows below Kotri and a study conducted estimated minimum E-flows there. Priority allocations for E-flows in times of droughts when water is not adequate to meet the demand of the agriculture sub-sector, is an issue that requires addressal. Thus, provinces will not assign high priority for minimum E-flows.

The minimum E-flows for eastern rivers to Pakistan were not allocated and consequently the rivers have lost the right to flow in almost 335 days in a year, and water is available only during floods. This has had severe impacts on river ecosystems and the livelihood of local people. Even areas of dry rivers are facing difficulty in obtaining access to water for multiple uses. The resultant impact is the degradation of dry beds of the eastern rivers that lie in Pakistan.

4. Way Forward

The Indus Basin Irrigation System reflects a situation in which the primary resource constraint on agriculture production is water. Pakistan has very little water storage capacity and can barely store 30-40 days of water in the Indus Basin. When river flow is variable, then storage is required in order to match the water demands. Growing shortfall in water availability compared to demand will continuously increase in future at the basin level. Holistic policies for water resources development and management are required to sustain growth in the context of resource limitation. Development of 15 to 20 MAF of water storage and interventions for improving water availability through water conservation are imperative.

Pakistan water resource sector has to be developed and make significant investments. There is a need of further intensification of canal water supply and land development to meet the future needs of population growth. The conjunctive surface and groundwater management would require water from additional storage reservoirs, and to have

alternative water management regulatory framework/institutional setup and use of new technologies in irrigation to improve water productivity.

4.1 Integrated Water Resources Management (IWRM)

Integrated water resources management (IWRM) has been defined by the Global Water Partnership (GWP) as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems".

In the Indus Basin the main issue is water shortage, to solve the issue, IWRM techniques must be adopted. The lack of water does not allow industrial, urban and tourism development to proceed without restriction on water uses and allocation policies for other user sectors, particularly agriculture. Poverty associated with water scarcity generates migratory fluxes of populations within countries or to other countries where people hope to have a better life, but where they may not be well received.

Strengthening IWRM and water management capacity is needed to deal with both the existing and emerging water challenges taking into account the issues like climatic changes, groundwater use, water quality, pollution, urbanization and industrialization, licensing access to water etc. A continuum for decision making in water resources management is to be prepared, identifying the fundamentals of IWRM implementation by addressing the resource condition and allocation issues at the basin level.

4.2 High Efficiency Irrigation Systems

Current irrigation practices are inefficient and water productivity is lowest in the Indus Basin irrigated agriculture. The development of laser levelling technology and furrow-bed irrigation has resulted in saving 30 percent of water and has led to an increase in productivity by 25 percent in the district of Okara, Punjab. Such a model should be replicated in other areas as well. Likewise, the establishment of drip irrigation farming systems, a type of high value farming as a mix of creeper-type vegetables and high density orchards in areas outside the Indus Basin where water is at premium, should be adopted by farmers.

4.3 Groundwater Management

At present, the water demand of agriculture, livestock, rural and urban households, industry and non-agriculture infrastructure has gone far beyond the originally planned surface water supply. The population growth and urbanization are two important factors upsetting the self-sufficient rural canal colony model (The Canal and Drainage Act 1873). In this context, the use of groundwater tremendously increased facing an increasing danger of depletion and quality deterioration. The agriculture sector is the major user of groundwater. The conjunctive use of canal and groundwater does not have corresponding planning and management at the command area level. Groundwater has become a vital and major part of the overall water resources in the Indus Basin irrigation system.

The groundwater use is however reaching to the sustainable limits. The fast growing cities and industries looking for large increases in water supply are adding to the

challenge. An effective monitoring and management system that encourages the private management sustainability of this water source is needed. Punjab must intensify its efforts to put in place an effective framework for groundwater management. The experience in this regard suggest to follow a phased and incremental implementation strategy with initial focus on groundwater monitoring and gradual shift to groundwater management in a phased manner. The awareness raising campaign is also very important for sensitizing the stakeholders about groundwater issues, self-regulation and groundwater monitoring and management interventions. It is relevant to point out that the upcoming institution of Farmers Organizations can play an effective role for management of groundwater in their respective areas.

4.4 Institutional and Policy Reforms

In water sector, the role of Government is coordination and policy formulation. Indus River System Authority (IRSA) coordinates and oversees the distribution of water of the Indus and its tributaries among provinces. Any proposed development in the water sector has to be reviewed by IRSA to ensure conformity to the Water Accord. Implementations of agriculture and irrigation activities were mostly non-collaborative with a very little interaction among respective stakeholders. There is no overall single agency, which is responsible for coordinating water resources development as well as approving inter-sectoral water allocations either at federal or provincial level. A comprehensive strategy and a framework for the water sector is required within which competing demand for water and scarce financial resources can be assessed and service delivery improved. Holistic institutional and policy reforms to improve the management and maintenance of the Indus Basin Irrigation System to ensure its long-term physical and financial sustainability, water resources management reforms to make inter-intra-province water allocation and distribution more transparent, service delivery reforms to improve the quality efficiency and accountability and reforms to improve water use efficiency and on-farm productivity are required.

4.5 Increase Public Awareness

Water has been highly politicized in Pakistan and there is an extreme deficit of trust among the provinces. This deficit of trust is largely due to a lack of access to data and information. Popular papers need to be prepared along with posters and stickers for creating mass awareness. The use of mass media in creating awareness at all levels, including civil society at large, is also integral. Without awareness, water cannot be made as 'business for everyone'.

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GLIMPSES SHOWING WATER SCARCITY IN PAKISTAN



Figure 1: A View of Eastern Dry River.



Figure 2: Canals are Running Dry due to Inadequate Surface Water Supplies.



Figure 3: Limited Access to Safe Drinking Water in the Different Parts of Country.



Figure 4: People are at Protest for their Basic Right of Safe Drinking Water.

GLIMPSES FOR WATER CONSERVATION TECHNOLOGIES



Figure 5: Drip Irrigation is being used to Save the Irrigation Water.



Figure 6: Sprinkler Irrigation is being used to Save the Irrigation Water.



Figure 7: Canal and Watercourse Lining also Reducing Surface Water Losses.

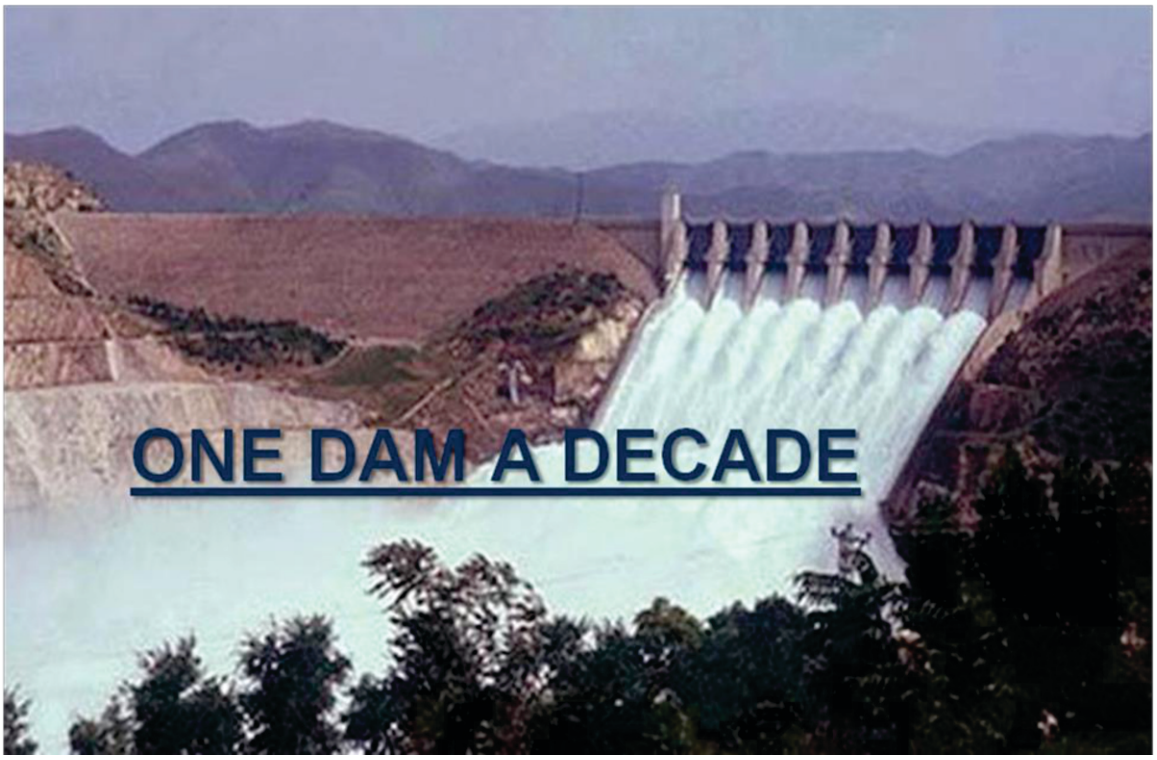


Figure 8: WAPDA's Slogan "One Dam A Decade".

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WATER SCARCITY AND FUTURE OPTIONS IN PAKISTAN

Dr. Muhammad Nawaz Bhutta

WATER SCARCITY AND FUTURE OPTIONS IN PAKISTAN

By

Dr. Muhammad Nawaz Bhutta

ABSTRACT

Pakistan is already one of the most water-stressed countries of the world, a situation which is going to deteriorate into outright water scarcity due to large and expanding population. Water for agriculture will progressively become scarcer due to persistent increases in the competing demand for drinking water, industry and environment. Salt balance in irrigated lands is negative. More salt is being added in the Indus Basin than the quantity of salt that is getting out of the Basin. With the passage of time the soil quality will further deteriorate and crop yields could be seriously affected. For maintaining a favourable salt balance in the root zone of crops, 20% water additional to the crop requirement is needed to flush the salts on continuous basis. Pakistan is fast losing storage capacity of Tarbela, Mangla and Chashma due to siltation. Climate changes, intensifying droughts and floods will have the combined effect of deepening the crisis. The snowfall will occur for a shorter duration and melting will continue for longer period. Snowmelt and supply of water will be available much earlier than the present (prior to Kharif sowing) and may be inadequate for Rabi sowing. Many small glaciers may disappear. With the rise in temperature as a result of climate change, crops will require more water due to excessive evaporation, cattle will consume more water and domestic water consumption would also increase.

Water is crucial for food production. Water scarcity will lead to food scarcity which is a radically different threat because it affects the poor so profoundly. It has been the cause of riots and revolutions. Imported food cannot be relied upon as the era of cheap food is over. It is easier to store water for drought years than store food for such events. Luckily we have water to store and we have sites to store water. Investing in water reservoirs is a key step towards ensuring food security. By far the most effective way of tapering flood peaks and minimizing flood damages and loss of life is flood control through storage reservoirs. To mitigate impact of droughts, it is necessary to build large dams having carry over capacity from wet years to dry years, to build small and medium size dams for local and regional uses and to recharge aquifer. Large dams not only increase the assurance of water availability but they can also generate large amount of electricity which is vital for development of industrial, agricultural and service sectors. Projects ranking highest in technical, economic and environmental viability should be preferred irrespective of any other consideration. The benefits of existing storages are so well demonstrated that all the provinces keenly contest of every cusec of stored water in the existing reservoirs.

To overcome water and power scarcity, and as a short term measure it is recommended that immediate construction work should be started on another large Dam concurrently with Diamir-Bhasha. Long term plan for storing additional 50 MAF (for meeting farmgate requirement of 40MAF by year 2050) water needs to be prepared and implemented starting with the top ranked project.

1. STATUS OF WATER AVAILABILITY

Pakistan is already among one of the most water-stressed countries of the world, a situation which is going to degrade into outright water scarcity due to large and expanding population and demand in other sectors. Per capita availability of water is about 1200 m^3/year which is less than the threshold of 1700 m^3/year for a water stressed country. The water scarcity indicator is 1000 m^3/person/year which is likely to be reached soon. Another water stress indicator applies to river basins having a ratio of withdrawal to long term average annual runoff is above 0.4. In case of Indus Basin system, this ratio is about 0.77.

Per hectare availability of water in the country is less than the world average. The perception that Pakistan is using many times more water in agriculture than other countries is not right. The much talked about water use efficiency in agriculture is not relevant in arid conditions, as 20% excess water is needed to percolate below root zones for keeping a favourable salt balance.

Primary source of fresh water is rainfall, snow and glacier melt. It then transforms into river flows, groundwater and surface storage, evapotranspiration and river outflows into sea. Part of river flows is generated outside the country. Existing and proposed developments on western and eastern rivers outside Pakistan by Afghanistan and India have already impacted water availability and the trend is likely to continue to the disadvantage of Pakistan.

Annual average river inflow measured at rim stations of western rivers is 142 MAF. Khyber Pakhtunkhwa (KP) diverts 5 MAF above rim stations while eastern river runoff within Pakistan averages about 4 MAF. Thus total river flow of Indus Basin on an average is about 151 MAF. Rainfall contribution below rim stations is in addition.

Indus River System inflows vary from 97 MAF to 172 MAF (post storage period of 1967 to 2006). Inflows prior to Indus Water Treaty implementation ranged from 109 MAF to 188 MAF (30 year average for the period 1937 to 1967). The river outflows for post Tarbela period vary from nil to 95 MAF. On the average annually 30 MAF river water escapes unutilized below Kotri. The combined contribution of the eastern rivers generated in Pakistan is estimated to vary between 0.29 and 11.04 MAF with an average of 6.83 MAF (based on data of 1976 – 2017).

There are 14 hill torrent areas with an average potential of 18.6 MAF. Out of this 60 to 70% can be used for the development of 5 million hectares of culturable wasteland lying in the hilly areas of Hazara, Bannu, D.I. Khan, D.G. Khan, Kacchi basin, Kirthar range, Karachi area, Sehwan area, Petaro and vast areas in Balochistan.

The irrigated area of Indus Basin receives approximately 40 MAF of rainfall annually. Rainfall conservation potential outside irrigated area is approximately 20 MAF.

The groundwater is not an independent source. However it is contributing 40% crop water requirement. The safe yield of groundwater is 53.3 MAF (Punjab 40 MAF; Sindh 10 MAF; KP 2.4 MAF; Balochistan 0.9 MAF).

In Balochistan, non-Indus internally generated surface runoff is 12.7 MAF. Out of this 3 MAF is currently being utilized while 9.7 MAF remains unutilized.

2. THE WATER CRISIS

2.1 Competing Present and Future Demands

UNDP 2016 estimated future water demand for five different scenarios based on the following assumptions:

- The proportion of Pakistanis living in urban centre reached 38.8 percent in 2015 and will increase to 46.6 percent in 2030 and 57.5 percent in 2050.
- Water use in rural areas averages 45 litres per capita per day and in urban areas averages 120 litres per capita per day. These use rates in combination with the above projected changes in total and urban population in 2015, 2030 and 2050 was used to create a baseline for municipal water withdrawals.
- Agricultural water withdrawals will primarily be influenced by the country's net sown area.

Using this information, following three water demand projection scenarios are discussed:

1. ***Business-as-usual scenario****:* This baseline scenario assumed that the United Nations' population projections (total and proportion living in urban areas) are realized, rates of rural and urban water use per capita per day remain unchanged, a medium level of economic growth occurs (leading to an industrial GDP growth rate of 6.9 percent), and irrigation efficiency remains at 30 percent. Any potential impacts of climate change were not considered.
2. ***Business-as-usual scenario with exceeded extrapolation of current water demands****:* This scenario projects water demand will be greater than the baseline, business-as-usual scenario due to a higher level of economic growth (leading to an industrial GDP growth rate of 9.7 percent) and an increase in population 15 percent greater than the United Nations' estimate. All other factors remained constant.
3. ***Climate change impact scenario:*** The scenario assumes that temperatures increase by 3°C, which would lead to an increase in agricultural water requirements of 6 percent by 2025 and 12 to 15 percent by 2050. All other factors remain the same.

Outcomes of the analysis are presented in **Figure 6**, which demonstrates that under the baseline, business-as-usual scenario total water demand will increase by about 12 MAF by 2050, when total water demand will be 159 MAF. Business-as-usual with exceeded extrapolation scenario total water demand will increase by about 15 MAF by 2050, when total water demand will be 162 MAF. A much more significant rate of growth is projected to occur under the climate change impact scenario, in which total water demand increases to 220 MAF in 2050. The impact of these measures links to the continuing role of the agricultural sector as the largest source of water demand under all scenarios.

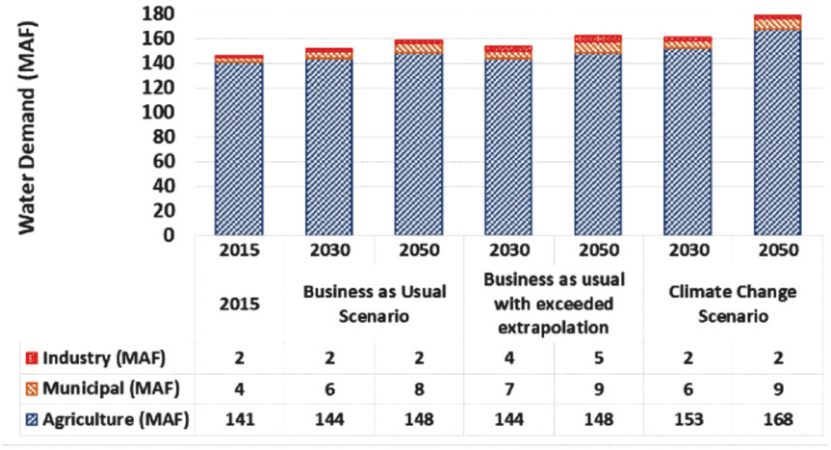


Figure 6: Pakistan Project Water Demands

2.2 Negative Salt Balance

Salt balance in irrigated lands is negative i.e. more salt is being added in the Indus Basin than the quantity of salt that is getting out of the basin. With the passage of time the soil quality will progressively deteriorate and crop yields could be seriously affected. It's like a time bomb. Twenty percent water additional to the crop water requirement, is needed to percolate below the crop roots for maintaining a favorable salt balance. Where will this water come from?

2.3 Reservoir Siltation

Siltation of water reservoirs at Tarbela, Mangla and Chashma has reduced their storage capacity by about 7 MAF (equal to the capacity of one large dam). Releases from these storages had immensely benefited overall agriculture production in the Indus Basin. We are fast losing this benefit. Due to sedimentation of these reservoirs this capability has now reduced from 21% to 35%.

2.4 Upstream Developments

Existing and future upstream developments by India and Afghanistan is also a matter of serious concern. Pakistan is fighting a losing battle on this front. Prospects that we will prevail on India and Afghanistan are not encouraging. Climate changes intensifying droughts and floods will have the combined affect of deepening the crisis.

2.5 Energy Crisis

The water crisis coincides with series of other crises i.e. energy crisis and international recession that imperil economic growth. Water scarcity which can have the affect of endangering food security could become the biggest crisis of all as it hampers the health and wellbeing of people of Pakistan. Our future generations could be lost to the ravages of hunger.

2.6 Water Quality Deterioration

Pakistan faces serious deterioration of surface and ground water quality because of unabated industrial, municipal, and agricultural pollution and lack of universal sanitation. In the absence of a regular surveillance or monitoring program and weak regulatory enforcement, several drains, irrigation canals, and rivers have become severely polluted.

The indiscriminate discharge of untreated industrial wastewater, and municipal sewage is increasingly polluting irrigation systems, streams, rivers as well as other aquatic and marine ecosystems. Subsequently this is leading to severe contamination of groundwater (including drinking water), pollution of surface water in major rivers and seawater and harm to aquatic life. The associated adverse health and productivity impacts are significant, with the poor bearing the brunt. Polluted drinking water is the cause of a rising incidence of water-borne diseases such as diarrhea, dysentery, cholera, pneumonia, and hepatitis. As estimated health costs of polluted water in the country run into Rs. 112 billion annually. According to other studies, water-related infectious and parasitic diseases account for almost 40 percent of all patients and 60 percent of infant mortality.

3. POPULATION DYNAMICS AND SUSTAINABILITY

There is a strong empirical link between population and sustainable development. Pakistan's current population is estimated to be 200 million and is projected to reach over 350 million by the year 2050, thus, further burdening the country's already fragile economy and putting mounting pressure upon its already scarce and depleting natural resources. This burgeoning and growing population poses the most serious challenge to any future water resources, economic and environmental sustainability.

4. IMPACT OF CLIMATE CHANGE ON WATER RESOURCES

Climate changes intensifying droughts and floods will have the combined affect of deepening crisis. Droughts will affect rainfed as well as irrigated agricultural production and depress water supply for domestic, industrial and agricultural purposes. As droughts would become longer and more frequent, small farmers will move to urban areas.

There is growing consensus that the impact of climate change may increase the frequency and magnitude of floods. Monsoons of 2005, 2006, 2007, 2010 and 2014 confirm this trend. Increased incidents of Glacier Lake Outburst Floods (GLOFS) are likely in north western regions.

Under warming conditions, the summer season will expand while winter will shrink. Resultantly the snowfall will occur for a shorter duration and melting will continue for a longer period bringing drastic changes in mass balance. Snow melt and supply of water will be available much earlier than the present (prior to Kharif sowing) and may be inadequate for Rabi sowing. Many small glaciers may disappear.

With the rise in temperature as a result of climate change, crops will require more water due to excessive evapotranspiration, cattle will consume more water and domestic water consumption would also increase. Higher temperatures are also likely to degrade water quality.

Overall scientific consensus is that globally, the Earth will be getting higher than average precipitation. A simple explanation is that "whatever goes up, must come down". All climate model simulations show complex pattern of precipitation change, with some regions receiving less and other more precipitation than they do now. However geographic location of Pakistan places the country in heat surplus zone on the earth making it very high on the vulnerability scale on weather changes.

Predicting how rainfall patterns will shift in a few years and how it will affect aquifers and agricultural outputs has become an urgent task. This kind of local climate modeling requires a lot of data to process. Computing resources need to be pooled to adopt global climate models to local conditions. Collaboration can be worked out with international companies specializing in weather simulation modeling.

5. FUTURE OPTIONS

5.1 Hill Torrents

There is a potential of 9.7 MAF in Balochistan. Approximately 12 MAF is available in the hill torrent regions of the country.

5.2 Rainwater Harvesting

Good quality rainwater is being last as runoff and mixed with polluted water. Rainwater harvesting option shall be considered for barren land, agriculture and houses.

5.3 Recharging Groundwater

Storing water underground will be equally useful particularly during drought years. This can be achieved by recharging aquifers through various means. All potential aquifers need to be identified on the basis of water quality and recharge capacity. Surplus flows during monsoon can then be directed towards these areas during floods for recharging groundwater.

5.4 The Reservoir Option

The additional storage capacity to be created does not have to match with the annual average surplus in the system. It should rather take into consideration the cycle of dry and wet years to mitigate the impact of drought. This essentially means having much larger carry over capacity. Annual rivers rim station inflow distribution for the last 55 years is shown in **Figure 7**. There were only 3 years when rim station inflows were less than 104 MAF.

Figure 7: River Rim Stations Inflows 1962 to 2017

There are however only a few feasible sites on Indus and hardly any on Jhelum. Indus potential therefore needs to be fully developed. A long term additional water supply of 40 MAF at farmgate should be aimed at.

It is well recognized that large seasonal and annual variability of fresh water availability (a situation applicable to Pakistan) makes it necessary to store water. It is a common sense question. All of us do it for our domestic water supply security by building underground and overhead storage tanks. At national level unfortunately we forgot it. Successive governments have lulled into a false sense of complacency about water availability.

We got ourselves involved in a totally unwarranted debate of whether or not the proposed dams will be filled every year. If we want the storages to carry over water from wet years to dry years (which of course should be the objective to mitigate droughts) than the question of whether the reservoir is filled every year to the extent of 100%, 80% or less becomes irrelevant. For satisfactory river control and regulation, internationally accepted practice is to have storage capacity of at least 40 % of river flows. When applied to Pakistan the desirable storage capacity works to about 64 MAF including areas lying outside Indus Basin. Our existing live storage capacity is about 14 MAF. For various known and unknown reasons we failed to create this storage capacity. Our future generations will pay heavy price for inaction on our part with regards to construction of storage.

Environmental and social negative impacts of some of these projects have been played up beyond proportion. No dam was ever built anywhere in the world without such impacts. Most infrastructural developments involve these concerns. But these can be addressed by proper identification and mitigation measures with the involvement of people. If effectees are settled in the same vicinity with their consultation and are ensured livelihood better than the existing, there should be no reason for concern.

6. BENEFITS OF STORING WATER

6.1 Food Security

Self sufficiency in food production ensures national sovereignty more than any other measures of economic independence. It is a mistaken assumption that imported food could be cheaper in certain situations. The era of cheap food is over --- most likely for good. Very few rich countries can depend on imported food.

Food security is a radically different threat because it affects the poor so profoundly. It has been the cause of riots and revolutions. The larger the affected population the more serious the problem. Water is crucial to food production. It is easier to store water for drought years than to store food for such events. Luckily we have water to store and we have sites to store water, although limited. Investing in water reservoirs is a key step towards ensuring food security.

The benefits of water releases from existing storages at Mangla and Tarbela are well demonstrated and clear. Representatives of four provinces bitterly contest for every cusec of water released. If storing water was against the interest of any province no one would be sitting on IRSA panel.

6.2 Drinking Water Supply

Currently 60% of population has access to municipal water supply. The shortages and poor quality of water supply contributes significantly to the high infant mortality rate and sickness. In terms of quantity, domestic water needs (besides industry) will pose rising competition to the traditional irrigated sector. A strong commitment to the domestic water subsector is needed to ensure supply of safe and adequate drinking water to the entire population by year 2025.

Bulk of drinking water requirement is met by groundwater. But groundwater is depleting and its quality is deteriorating. The only way to replenish it and to improve its quality is by recharging it with fresh water which can be made available during monsoons provided we store the surplus flows. The stored water can then be diverted to the areas where recharge is required.

6.3 Sustainable Use of Groundwater

At present dependent upon groundwater is very heavy. The water table in almost entire basin is depleting and groundwater quality is deteriorating. This indicates that present use is not sustainable. The increase in storage will increase canal diversions and consequently dependence on groundwater will be reduced. This will reduce deterioration of groundwater and its use will be more sustainable.

6.4 Soil Salinity Management in Irrigated Areas

The salinity surveys indicate that salts in the root zone of crops has been increasing due increased use of groundwater which has much more salts than canal water. Increase canal supplies due to storage will help to leach down the salts from the root zone resultantly better yields.

6.5 Flood Management

Floods are one of the major national calamities in Pakistan. During last 63 years (upto 2014) Pakistan has suffered cumulative financial loss of US$ 38 billion (present worth of this amount is much higher) and loss of more than 11,939 people, affected villages 192,596 and flooded area 613,721 km^2 (NFPP-IV 2018). By far the most effective way of tapering flood peaks and minimizing flood damages and loss of life is flood control through construction of storage reservoirs. These losses can be largely eliminated.

6.6 Drought Mitigation

National storage capacity needs to be augmented considerably in order to store water during high flow flood periods and use water during drought years. Storage capacity that takes into consideration the historic drought cycles is based on the moving means of surpluses of the period matching the drought years. Creating carryover capacity in the surface storages will ensure that water shall be available for releasing during drought years. Recharging and maintaining underground reservoir is equally effective in mitigating impact of drought.

6.7 Environmental Benefits

Adequate and assured releases below Kotri are needed for maintaining delta and coastal eco system. This requirement is not being presently met as water releases from

existing reservoirs are hardly sufficient to meet the requirement of agriculture. As the demand for agriculture increased, the canal diversions for irrigation also increased during the post-Terbela period. Had there been more reservoir capacity, there would have been no problem for adequate releases for meeting environmental needs.

Power generated from reservoir (hydropower projects) is clean energy as it eliminates the need to burn fossil fuel which pollute the environment resulting in the serious health problems. This element can be traded apart from the advantage of local pollution control.

6.8 Cheap Hydro-power

Large dams do not only increase the assurance of water availability, but they can generate large amounts of electricity. Currently about 30% of Pakistan energy is generated from hydro-power. Even though irrigation requirements are its priority, Tarbela's power benefits account for 60% of the overall economic benefit from the dam. Pakistan has utilized only about 12% of its estimated 55,000 MW of economically viable hydro-power potential, a proportion much lower than India and China (around 30%) and much lower than rich countries (around 75%). Being relatively cheap energy it will have the affect of reduced electricity tariff and continue supply of electricity.

6.9 Economic Benefit during Construction

Large dams and hydro-power projects involve mostly local construction resource content. They are labour intensive and thus generate substantial local economic multipliers. For a typical large dam/hydropower project, the local content is 80% against 20% for the thermal project.

7. WHO BENEFITS?

With the help of Chashma, Mangla and Tarbela Reservoirs seasonal carry over capacity from Kharif to Rabi was increased from 12% to 21%. The available supplies for canals in critical Rabi and Kharif sowing/maturing period are thus progressively reducing. Creation of more storages is an imperative need in the present situation. After the construction of Mangla, Tarbela and Chashma reservoirs, the provincial annual canal diversions have increased by about 16 percent. The increase in magnitude of canal flows of the four provinces is:

Province	Increase under Post Dam Conditions (MAF)	Percentage Increase
Punjab	4.43	9.13
Sindh	6.17	16.59
KP	1.50	32.19
Balochistan	1.18	190.32

The above figures indicate that Sindh Province got the highest share in magnitude as compared to all other provinces and in percentage it received more water as compared to Punjab Province under the post reservoir environments.

It is a misconceived perception that only a particular province will benefit or that the lower riparian will suffer as a result of construction of more storage. As a part of the 1991 Accord, the shares of any increase in water available as a result of new storages are clearly allocated. The Accord provides a strong re-distributional component with the smaller provinces (Balochistan and KP) getting much larger share of the "new water" than they have of the existing allocations.

The shares of both Sindh and Punjab will be less than their share of existing water with Punjab a little less better off than Sindh. With new storages coming online, KP will be able to provide gravity flow to 0.5 million acres in D.I. Khan and Bannu plains which otherwise need to be served with pumped supply at huge cost.

Releases for early Kharif in Sindh will not be a problem nor would retaining of early snow melt flow in Mangla be an issue.

It would become possible to provide perennial supplies in non-perennial areas. Investment in under-construction flood canals in Punjab, Balochistan and Sindh (Greater Thal, Kacchi and Rainee canals) would become more productive due to availability of assured supplies.

Additional supplies in Sindh could help provide leaching requirement in its saline, saline-sodic soils and help reclaim salt affected lands.

Creation of additional storage capacity helps to improve and in no case limits or reduces the existing uses among the co-sharers. Ever since Water Accord 1991, inter-provincial sharing even in extreme shortages and drought periods have been remarkably well managed. Releases from Tarbela and Mangla were minutely monitored by provincial and federal governments.

8. WATER RESOURCES DEVELOPMENT OUTSIDE INDUS BASIN

Being less favored environment for agriculture due resources have not been committed outside Indus Basin. This is one of the causes of un-employment, feeling of deprivation and frustration among the unemployed youth.

Irrigation projects keep people employed on long term and permanent basis while serving the objective of food security. Following initiatives are proposed:

a. Development of small scale perennial irrigation schemes in Northern Areas, AJK, mountainous regions of KP, Punjab and Balochistan with potential of developing new irrigated lands of 1 million hectares.

b. Development of spate and Rod-Kohi or Sailaba farming in all the four provinces, FATA, Northern Areas & AJK with high potential area of spate irrigation of 2 million hectares.

c. Development of Baran & Khushkaba in KP , Punjab, Balochistan, FATA, Northern Areas and AJK with potential of development of dryland farming of 2 million hectares.

d. These 5 million hectares as noted in paras a, b & c would largely come from available culturable waste of 8.33 million hectares. This development can be part of a long term plan which covers the entire wasteland.

e. Rainwater harvesting sites are numerous which shall be developed for the local population.

9. DEVELOPMENT OF FLOODWATER GENERATED WITHIN THE BASINS

- The non-Indus internally generated floodwater is 12.7 MAF.
- The current use of floodwater is 3.0 MAF per annum. The balance amount of water assessed 9.7 MAF should be stored in dams integrated with Sailaba farming and groundwater recharge by developing Spate irrigation. The stored water should be provided in droughts and dry spells to sustain Sailaba farming.
- Carry over dams are needed to sustain Sailaba farming and groundwater recharge.
- Development of floodwater will provide an immense opportunity and potential for generating new livelihoods and groundwater recharge measures in a province where un-employment is a major issue resulting in unrest and insecurity among the un-employed youth.
- The floodwater during wet years should be used to generate new groundwater aquifers in command areas of Spate irrigation and Sailaba farming. This is a cost effective way of managing and developing new livelihood sources in Balochistan. The only effective way of recharging or building new aquifer is through watershed management and expanding irrigated agriculture in pockets of high recharge zones.

10. ACTION PLAN

The following action plan is proposed for the augmentation of water resources in Pakistan.

- As a short term measure, work on another large dam having hydropower potential should be started concurrently with Diamir Bhasha Dam Project.
- A long term plan for storing additional 50 MAF upto year 2050, needs to be prepared and a ranking system devised to prioritize projects for implementation.
- An awareness campaign about the needs and benefits of water reservoirs needs to be launched immediately.

- Rainwater harvesting and groundwater recharge plans be prepared and initiated.
- Steps to be taken to protect water from pollution due to sewage and industrial waste.
- Sprinklers and drip irrigation shall be introduced at feasible locations.

11. REFERENCES

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STRATEGIC INTERVENTIONS FOR TACKLING WATER SCARCITY AT THE FARM LEVEL

Muhammad Akram, Hafiz Qaisar Yasin

STRATEGIC INTERVENTIONS FOR TACKLING WATER SCARCITY AT THE FARM LEVEL

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Abstract

Water is the strategic resource for developing economies like Pakistan. Agriculture sector uses more than 90 percent of available fresh water supplies as agriculture production is mostly irrigated with over 94 percent of total land equipped with irrigated agriculture (CIAT; WB, 2017). Punjab, the most populous province, is called the breadbasket of Pakistan, which produces 76 percent wheat, 83 percent maize, 64 percent cotton, 51 percent rice, 64 percent sugarcane, 75 percent mango, 97 percent citrus and 80 percent gram of total production of these crops, fruits & pulses in the country (PDS, 2017). The farming is mainly dependent on irrigation with 35.52 million acres (86 percent) under irrigated agriculture out of total cropped area of 41.05 million acres. Water is, therefore, the most critical input for raising crops in the Punjab.

Despite spearheaded significance of water in the Punjab's socio-economic and agriculture development, challenges in the form of water scarcity, prevailing in-efficient irrigation practices, lack of modern irrigation technology, non-existence of water regulations and growing water demands have been remained the major reasons of low irrigation efficiency at the farm level. During last decade, climate change has imposed additional stress on already resource constrained country and put Pakistan in the list of most water insecure countries of the World. It has been estimated that over 50 percent of water is lost during its conveyance and application in the field due to deteriorated farm level irrigation infrastructure and lack of modern irrigation technology (NWP, 2018). There is no incremental water resources development and construction of reservoir since 1980' in Pakistan due to political and institutional issues. Only option for sustained water availability at the farm level has, therefore, been through water conservation measures like rehabilitation of conveyance network through improvement of watercourses, promotion of LASER land leveling, adoption of high efficiency irrigation systems, installation of solar systems for operating drip irrigation systems and promotion of tunnel technology.

Since creation of On Farm Water Management (OFWM) Directorate in 1976, it has undertaken various interventions and projects with the assistance from numerous international financial institutions like World Bank and Asian Development Bank as well as through local funding. These projects have created tangible impact in terms of water

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saving, improving the conveyance & application efficiency and enhancing the crop productivity under continuously declining water supplies. Improvement of watercourse, for example, results in saving of minimum 119 acre feet of water per annum, reduction in conveyance losses upto 39 percent, increase in crop yield to the extent of 15 percent and in litigation cases by 91 percent. Similarly, LASER land leveling saves about 0.75 acre feet of water per acre, reduces irrigation time by 31 percent and enhances crop yield upto 23 percent. Installation of high efficiency irrigation systems use 50 percent less water, 40 percent less fertilizer and enhances yield upto 100 percent.

Though substantial achievements have been made but at the same time, adoption issues like high capital cost, less operational capacity of the private sector to install high efficiency irrigation systems, change in mindset of farmers to operate these state of the art systems are hindering the fast-track proliferation of these modern systems amongst the farmers. These technologies have pivotal role in the Punjab's irrigated agriculture and their contributions has strongly been recommended in the National Water Policy, National Climate Change Policy and other national policies. Furthermore, Pakistan cannot comply with the UN Sustainable Development Goals (SDGs) and ensure food security without adoption of these technologies under the current climate change scenario.

Keywords: Water conservation, irrigated agriculture, high efficiency irrigation systems, water saving

1. Introduction

Water-energy-food nexus is the key to food security and sustainable development. This connection has emerged in response to the challenges of climate change, dwindling natural resources, rapid population growth, growing food and fibre demands and competition amongst the resources. These issues are hitting the nodes of economic development and are critical for future socio-economic growth. Among the natural resources, water is playing the critical role in socio-economic development of developing counties, Pakistan is no exception. Water is the key driver of Pakistan's economy and plays an intrinsic role in the economic uplift through meeting food and fibre needs of over 200 million people.

The province of Punjab is the most agriculture-rich province of Pakistan, which produces 76 percent wheat, 83 percent maize, 64 percent cotton, 51 percent rice, 64 percent sugarcane, 75 percent mango, 97 percent citrus and 80 percent gram of total production of these crops, fruits & pulses in the country (PDS, 2017). Punjab's agro-based economy largely depends on irrigated agriculture. The irrigated agriculture accounts for about 28 percent of GDP and employs over 50 percent of labor force as well as contributes in the growth of other economic sectors by supplying raw materials to the agro-based industry. About two third of the population resides in rural areas relying directly or indirectly on this sector for their livelihoods. The farming in Punjab is primarily dependent on irrigation with 35.52 million acres (86 percent) under irrigated agriculture out of total cropped area of 41.05 million acres in the Punjab.

Indus Basin Irrigation System (IBIS) is the largest contagious irrigation network of the World through which river water supplies are transported to agricultural fields

through a diverse network comprising of main canals, branch canals, distributaries, minors and watercourses (**Figure-1**). The IBIS is mainly managed by three public sector organizations. At the apex/ national level, the Indus River System Authority (IRSA) look after provincial interests by ensuring that each province is receiving its share of water in accordance with the Water Apportionment Accord (1991). The Water and Power Development Authority (WAPDA) is responsible for the operation of reservoirs for irrigation supplies, hydropower generation, and flood mitigation. The Provincial Irrigation Departments (PIDs) regulate and distribute the water diverted from the rivers to agricultural farms through a network of canals and distributaries. Agriculture Department through its On Farm Water Management (OFWM) wing is responsible for improvement/ rehabilitation of tertiary level irrigation network (watercourses) at farm level and promotion of modern water management technologies, techniques and practices amongst the farmers.

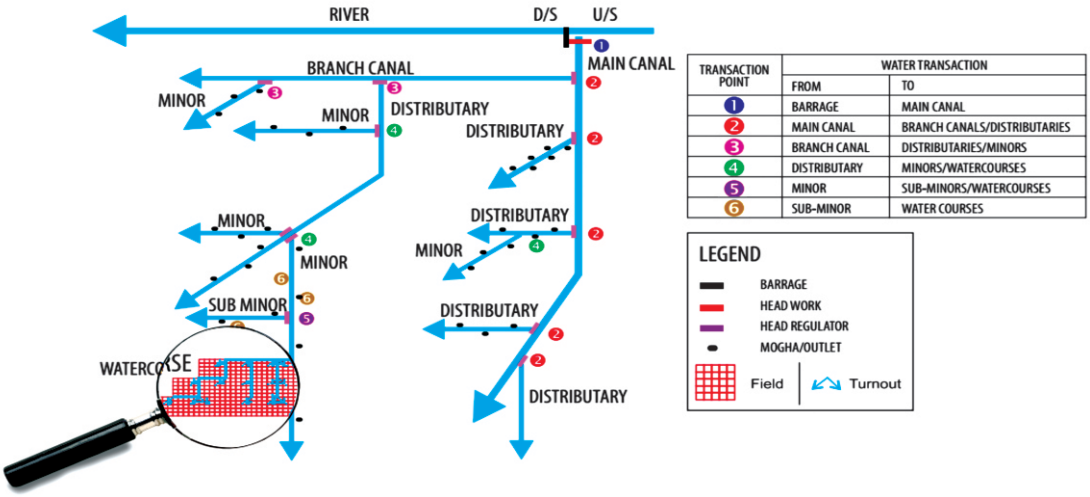


Figure-1: Typical Irrigation Network

The expansion of water resources during last three decades for production of food and fiber did not commensurate with the population growth. The surface water supplies are almost stagnant since Tarbela commissioning in 1976 as no major water resource development has taken place afterwards. The storage capacity has rather been continuously declining due to silting up of reservoirs. Similar is the situation with the energy resources.

According to provincial Water Apportionment Accord of 1991 (**Table-1**), the total surface/ canal water allocation for the Punjab is 55.94 million acre feet (MAF) including 37.07 MAF for Kharif season and 18.87 MAF for Rabi Season. The Punjab is, however, receiving less than 50 MAF because of overall surface water shortage in the country. During 2016-17 and 2017-18, canal water shortage remained as high as 50 percent. Due to short canal water supplies, groundwater pumpage for agriculture has increased significantly with over 50 percent contribution in irrigation meaning thereby that farmers are currently meeting 50 percent of their crop water requirement from groundwater, which is evident from the fact that there were only 10,000 tubewells in 1960 in Punjab that have been increased to over one (1) million. This unregulated proliferation of

groundwater is causing its depletion and quality deterioration. Climate change has further worsened the water security situation in the country and Pakistan ranks 7th on 2018 Global Long-Term Climate Risk Index published by GermanWatch with maximum damages happened in the Punjab due to climate change events.

Table-1: Provincial Water Apportionment Accord 1991

Province	Kharif	Rabi	Total
Punjab	37.07	18.87	55.94
Sindh	33.94	14.82	48.76
KPK (A)	3.48	2.30	5.78
(B) Unregulated Canals	1.80	1.20	3.00
Balochistan	2.85	1.02	3.87
Total			**117.35**
Distribution of Additional Water Supplies			

Province	Punjab	Sindh	KPK	Baluchistan	Total
% of Total	37	37	14	12	100

Source: Indus River System Authority (IRSA), Pakistan

Despite paramount significance and immense potential, Punjab's irrigated agriculture could not perform to its full potential mainly due to water scarcity, prevailing in-efficient irrigation practices, lack of modern irrigation technology, non-existence of water regulations and growing water demands have remained the major reasons of low irrigation efficiency at the farm level. High energy cost and its deficiency is another challenge, which impacted the agriculture growth.

Since creation of OFWM Directorate in 1976, it has undertaken various interventions and projects with the assistance from numerous international financial institutions like World Bank and Asian Development Bank as well as through local funding. These projects have created huge impact in terms of water saving, improving the conveyance & application efficiencies and enhancing the crop productivity under continuously declining water supplies. During last decade, the Punjab OFWM has embarked upon various initiatives with the assistance of World Bank and local funding in the form of modern climate smart technologies in order to address the water, energy and food security challenges at the grassroots level. These interventions includes improvement of community watercourses, LASER land leveling, high efficiency irrigation systems, solar system for operating drip irrigation systems and tunnel farming. This paper will examine the impact these interventions have made in ensuring food security for the people of Punjab and how these water conservation efforts has helped in sustaining the irrigated agriculture under the continuously declining water resources.

2. Watercourse Improvement

OFWM Program was initiated during 1976-77 on pilot basis in seven tehsils of the Punjab for farm level participatory conservation of irrigation resources through improving conveyance efficiency. Upon successful completion of project and based on various studies conducted by many national and international agencies during 1970s

and 80s, watercourse improvement activity was expanded all over the Punjab within next decade.

The standard lining executed under previous OFWM projects has been a rectangular shaped channel constructed by using double brick masonry walls and a brick masonry floor plastered inside and on top of the walls. This type of lining has been adopted since inception of OFWM program mainly being easy to install. However, under continuous rise in demand for bricks, little price control, and day by day dwindling quality of bricks, there was dire need to adopt lining alternatives to overcome the multifarious problems being faced in the field. The Pre-cast Concrete Parabolic Segments (PCPS) lining has, accordingly, been researched and adopted being hydraulically more efficient, durable, quick in installation, and relatively more economical.



Unimproved Watercourse



Improved Watercourse

Figure-2: Unimproved and Improved Watercourses

In Punjab, about 49,000 watercourse have so far been improved out of total 60,000 watercourses. Watercourse improvement is the most studied and researched intervention amongst all OFWM activities. Numerous evaluation and impact assessment studies in this respect have been carried out by various national and international monitoring organizations/ institutions. The findings of these impact assessment studies have indicated huge benefits accruing from an improved watercourse. Watercourse improvement activity has resulted in saving and supplementing over 2 MAF water per annum in addition to enhancement in crop yields and other socio-economic benefits. The results of these studies are summarized below in **Table-1**.

Sr. No.	Performance Indicator	Extent	
		Min	Max
1	Water saving per watercourse per annum (acre feet)	119 (30% lining)	229 (50% lining)
2	Increase in cropping intensity (%)	22	55
3	Reduction in water conveyance losses (%)	22	50
4	Increase in crop yield (%)	10	18
5	Economic Internal Rate of Return – EIRR (%)	25	68

Source: Studies conducted by the World Bank, University of Agriculture Faisalabad, Planning Commission of Pakistan and M&E Consultants of the Punjab Irrigated-Agriculture Productivity Improvement Project (PIPIP)

Project Impact Evaluation Study (PIES) for National Program for Improvement of Watercourses in Pakistan (NPIW)" conducted by the Planning Commission of Pakistan through third party consultants in 2012 revealed that the intervention is highly cost effective option for improving farm gate water availability. The salient features of watercourse improvement impact reported in the study are summarized hereunder.

- Water Saving : **119 AF** per watercourse per annum (22% lining)
- Total water saving : **2.1 MAF** per annum (17,603 watercourses)
- Reduction in conveyance losses : **39%**
- Increase in crop yields : 1**5%**
- Increase in irrigated area : **21%**
- Reduction in waterlogged area : **27%**
- Reduction in salinity : **87%**
- Reduction in litigation cases : **91%**
- Reduction in water tempering : **87%**
- Increase in farm income : **14%**
- BCR : **4.1 : 1**
- EIRR : **68%**

3. LASER Land Leveling

A significant amount of irrigation water (20 to 25%) is lost during its application to the crops because of uneven fields and inappropriate farm designing. This leads to excessive application to low-lying areas and under-irrigation of higher spots. Over-irrigation leaches soluble nutrients from the crop root zone and on the other hand, under-irrigation of elevated parts of the fields results yield loss due to insufficient water besides accumulation of salts in such patches. This ultimately results in less crop productivity, causes water stress and restricts efficient application of agricultural inputs. To overcome this challenge, use of LASER technology in the precision land leveling was introduced in the Punjab during 1985 by the OFWM. It is one of those resource technologies, which has made huge tangible impact in improving the irrigation application efficiency and enhancing crop yield.

The LASER controlled land leveling system consists of a LASER transmitter, a signal receiver, an electrical control panel, and a solenoid hydraulic control assembly (**Figure-3**). The LASER transmitter transmits a LASER beam, which is intercepted by the signal receiver mounted on a leveling blade attached to the tractor. The control panel mounted on the tractor interprets the signal received from the receiver and opens or closes the hydraulic control valve that raises or lowers the leveling blade.



Figure-3: LASER Land Levelers

Government of the Punjab, Agriculture Department through its OFWM wing has so far delivered over 11,500 LASER land levelers to the farmers/ service providers through different projects with the assistance from the World Bank as well as from its own resources. Provision of one time financial assistance of PKR 225,000 per unit for purchase of LASER equipment has been provided to the farmers/ service providers. Locally manufactured LASER land leveling units as well as imported systems are readily available in Pakistan. There are about 2,500 LASER land levelers, which farmers have procured itself. As such, there are about 14,000 LASER land levelers available in the Punjab for providing rental services to the farmers.

LASER land leveling is the most effective and popular technology amongst the farming community because of its highly quick returns/benefits. The LASER land leveling technology is now being used by the farmers in all irrigated areas of the Punjab. The impact assessment of LASER land leveling carried out by the M&E Consultants of the World Bank funded Punjab Irrigated-Agriculture Productivity Improvement Project (PIPIP) has shown significant benefits including improvement of crop yield, saving in irrigation water, enhancement in fertilizer use efficiency etc. Cost of LASER land leveling for one acre ranges from PKR 4,500-5,000 but it results in annual benefits valuing about PKR 15,000 per annum mainly in terms of increase in crop yield. It has been estimated that one LASER unit can level about 300 acres in one year generating total annual return of about PKR 4.5 million. Furthermore, more than 14,000 rural people have got direct employment as LASER Operators and Helpers besides repair shops for LASER units have been established in the private sector throughout the province, which have opened new avenues of employment for skilled workers in rural sector.

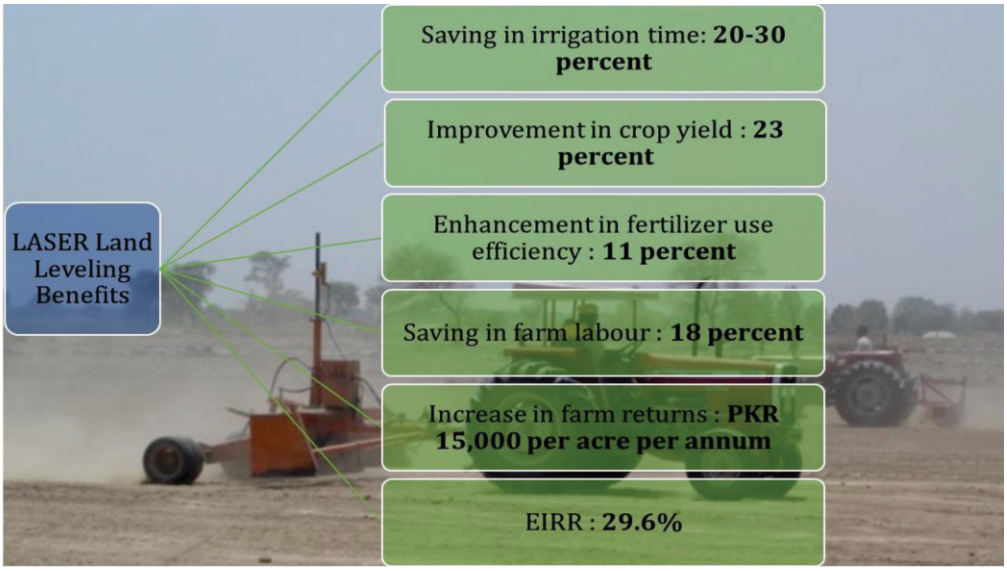


Figure-4: Benefits of LASER Land Leveling

4. High Efficiency Irrigation Systems (HEISs)

Flood irrigation is the most commonly used method for irrigating crops in Pakistan but its efficiency is not more than 50 percent. Lack of modern irrigation technology is one of the key factors for low productivity of precious inputs (land, water & fertilizers) in the Punjab. Drip and sprinkler irrigation systems are referred as High Efficiency Irrigation Systems (HEISs) are the most efficient irrigation systems with efficiency of about 95 percent. These systems are meant to transform the inefficient conventional farming practices to a more productive and profitable irrigated agriculture as they enable timely application of water and other inputs (fertilizers, nutrients etc.) as per plant requirement at various stages of its growth.

The HEISs are versatile in their applicability and provide complete control in irrigation operations. Drip and sprinkler irrigation can be practiced on variety of soil conditions e.g. uneven topography, odd field configurations, rolling sandy areas, long lengths of run etc. The drip is best suited for orchards and high value row crops such as vegetables, cotton, maize, sugarcane etc. whereas sprinkler systems are more suitable for field crops e.g. wheat, rice fodder, gram etc.

Under the World Bank funded Punjab-Irrigated Agriculture Productivity Improvement Project (PIPIP), HEISs have been envisaged to be installed on 120,000 acres. The government is providing 60 percent of total costs as subsidy, while the remaining 40 percent expenditure is contributed by the farmers. These systems have been installed on farmer fields through private sector supply and service companies (SSCs) with the technical guidance of OFWM staff and project implementation supervision consultants (PISCs) and active involvement of the participating farmers. The installation of drip and sprinkler irrigation have so far been completed on about 44,000 acres in the Punjab. The division-wise distribution shows that Rawalpindi is the leading division with about 25 percent (10,578 acres) of total HEIS installed in the Punjab

followed by 12 percent each in Gujranwala and Bahawalpur divisions and 11 percent in D.G. Khan division out of total installations of about 44,000 acres in the Punjab as shown in **Figure-5**.

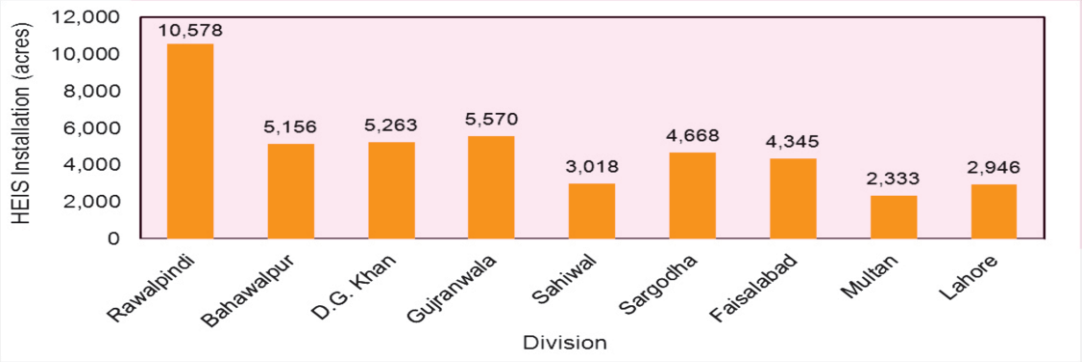


Figure-5: Division-wise Installation of HEIS

The crop-wise distribution of HEIS reveals that orchards cover maximum 55 percent of total installed systems, vegetables & row crops occupy about 25 percent and field crops cover 20 percent area (**Figure-6**).

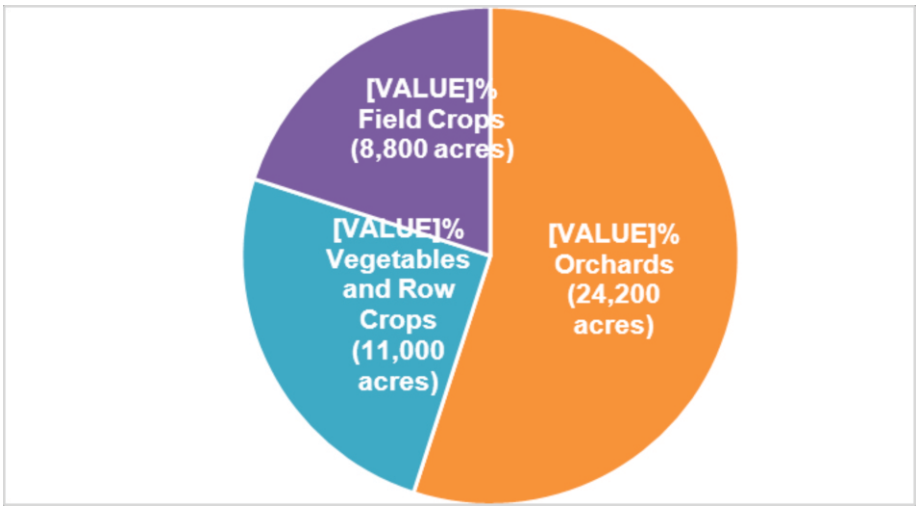


Figure-6: Crop-wise Installation of HEIS

It has been observed that HEIS installations have created very visible impact in terms of water saving, reduction in fertilizer use, and crop productivity enhancement alongwith facilitating crop diversification, value addition, increase in employment etc. The same has also been reported by the M&E consultants of the PIPIP on the basis of field

evaluations conducted. The overall impact of HEIS technologies reported by M&E Consultants is summarized in **Figure-7**.

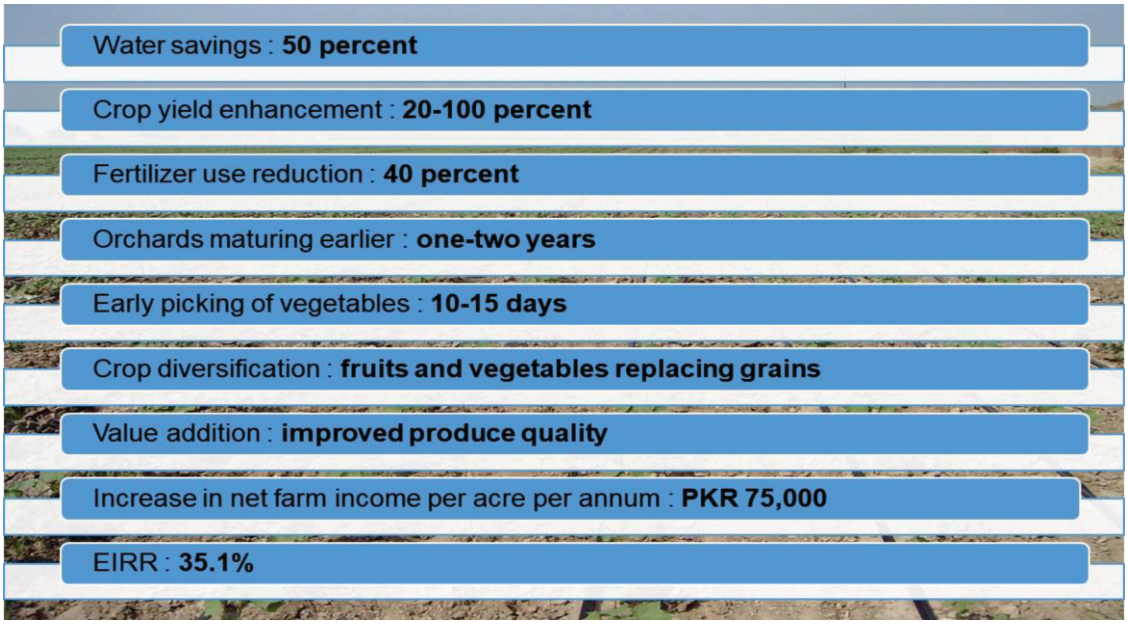


Figure-7: Impact of HEIS

Beside all challenges faces in adoption of HEISs, it has emerged as the multiple solution technology. Like the experiences of other countries, the adoption of HEIS is slow due to following challenging.

- HEIS is a new technology in Pakistan and first time being installed on farmer fields. This involves a complete paradigm shift to move from inexact to exact agricultural practices
- HEIS is a capital intensive technology with high initial cost of its equipment
- Marketing of the agricultural produce grown thorough HEIS remains the major issue as the import of agriculture products (vegetables) from neighboring countries like India have discouraged the farmers to adopt HEIS technologies
- Inadequate capacity of private sector supply & service companies (SSCs) in terms of manpower and inventory to cater for even whatever demand is available for HEIS installation
- Availability of highly subsidized canal water and no groundwater regulatory framework



Figure-3: Glimpses of High Efficiency Irrigation Systems

5. Solar Systems for Operating Drip Irrigation System

During last few years, shortage of energy has negatively impacted the growth of every sector, agriculture is no exception. Keeping in view the energy shortage and emerging use of the solar systems in irrigated agriculture sector under climate change scenario, Government of the Punjab decided to get benefit of this renewable energy resource. Agriculture Department launched "Promotion of High Value Agriculture through Provision of Climate Smart Technology Package" project for promotion of solar system for operating drip irrigation systems and installation of tunnels. It envisages provision of 80 percent subsidy for installation of solar systems for operating drip irrigation systems on 20,000 acres and installation of tunnels on 3,000 acres at 50 percent subsidy. A typical layout of solar operated drip irrigation system in shown in **Figure-8**.

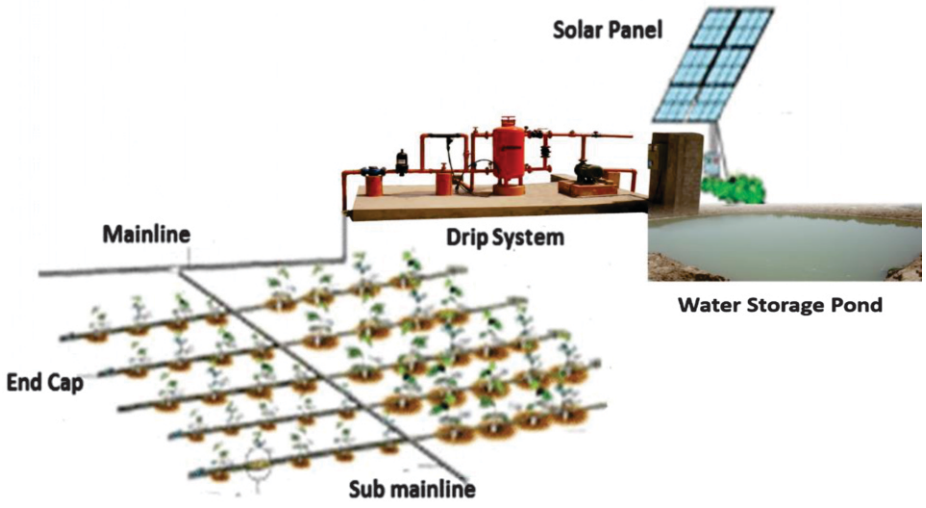


Figure-8: Typical Layout of Solar Powered Drip System

This intervention is resulting in reduction of input cost of farmers and promoting green energy in the agriculture sector. The keep benefits of the solar systems for operating drip irrigation are:

- Reduction in use of fossil fuels vis reduced GHG emissions
- Pollution free energy
- Non-dependant on conventional energy (fuel and electricity)
- Little maintenance and easy to operate & maintain
- Uninterrupted water supply for irrigation during day time
- Decreased irrigation operational cost to almost zero (vegetables)
    - Diesel: Rs. 26,000 per acre per annum
    - Electric: Rs. 14,000 per acre per annum
    - Solar: Rs. 3,000 per acre per annum
- EIRR : 23 %

6. Tunnel Farming

Food security is one of the major challenges faced by the Punjab. Vegetables are cheaper natural source of all essential nutrients i.e. minerals, vitamins, carbohydrates and salts, necessary for human health. The vegetable demand is increasing day by day but the production of the same is stagnant rather decreasing resulting in continuous increase in vegetable prices. There is, therefore, a dire need to adopt specialized technologies to ensure vertical growth in vegetable production i.e. tunnel technology coupled with solar energy and high efficiency irrigation systems for off-season vegetable production, which may result in substantial increase in crop production than open fields from same unit area. Tunnel technology is used for growing off-season vegetables by controlling natural climate settings e.g. humidity and temperature artificially through some structure covered with plastic sheet in such a manner that the environment become favorable for the growth and productive development of vegetables. The department is providing fixed amount of subsidy @ Rs.225,000/- per acre for tunnel installation or 50% of actual cost of the farmer, whichever is less while remaining cost will be borne by the farmer. The impact of tunnel technology is given below.

- Promote crop diversification
- Meet offseason vegetable demand in peri-urban areas
- Controlled environment
- Minimum insets/ pests attack
- Better weed control
- Significant increase in yield as compared to open field cultivation
    - Cucumber: 109%
    - Capsicum: 64%
- EIRR : 30-50%

7. CONCLUSIONS AND RECOMMENDATIONS

In the absence of water resources development, on-farm water conservation activities have shown huge impact at the grassroots level for water, energy and food security, especially under the climate change scenario during last decade. OFWM activities have resulted in very promising results in terms of water saving, enhancing water & crop productivity, reduction in crop production input costs, increase in cropping intensity, crop diversification and significant contribution in the growth of rural economy. Following conclusions and recommendations have been drawn from the analysis of the OFWM interventions.

- Water conservation activities, though, cannot be the replacement of water resources development but these resource conservation technologies have played a major role in sustaining the irrigated agriculture over the years giving hope to the farmers in managing the available resources in the most optimal manner.
- Water availability at the farm level is continuously decreasing and next decade will be very critical. Strenuous efforts would, accordingly, be required for water conservation and ensuring judicious use of available water to save our future generations from water crises. On Farm Water Management (OFWM) activities should be up-scaled under the vison of "**More Crop per Drop of Water**" which is to be achieved through technology driven, sustainable and climate smart agricultural water management with private sector participation to promote high value agriculture for better farm returns.
- OFWM technologies like watercourses improvement, LASER land levelling, high efficiency irrigation systems, solar powered high efficiency irrigation systems and tunnel technology provides an enormous opportunity for water conservation at farm level to meet the food and fibre requirements of future generations.
- Acquired benefits of these resource conservation technologies suggest its adoption on large areas to mitigate the prevailing water, energy and food crisis.
- These OFWM technologies are time-tested, socially acceptable, economically viable and technically feasible options for horizontal expansion of irrigated agriculture by bringing wastelands of Thal, Pothohar and Cholistan under cultivation in coordination.
- Capital cost of these technologies is a major challenge in accelerated adoption of these technologies, especially by the small farmers.
- Government is providing financial assistance for all these technologies, which requires continuity to support farmers in addressing issues of water security and climate change at farm level.
- Active participation of all stakeholders i.e. government, agriculture industry, farmers private sector companies need to collaborate for mobilizing initial investment, its repayments, and follow-up assistance for successful adoption of these technologies by the farmers for sustainability of irrigated agriculture in Punjab.

- Irrigation advisory services for operation and maintenance of these technologies as well as successful crop cultivation with OFWM technologies, especially under HEIS is need of the hour for sustainable irrigation operation and service delivery.
- Although, substantial work has already been done for water conservation at the farm level but still there are sufficient potential in the areas like monitoring and managing of groundwater, developing on-farm water accounting model and ET based water management systems, which have to be emphasised for evidence-based future planning and subsequently its implementation.

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GROUNDWATER REGULATION FOR INTEGRATED WATER RESOURCES MANAGEMENT IN PUNJAB

Ghulam Zakir Hassan, Ghulam Shabir, Saleem Akhtar, Faiz Raza Hassan

GROUNDWATER REGULATION FOR INTEGRATED WATER RESOURCES MANAGEMENT IN PUNJAB

By

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Abstract

Groundwater over-exploitation poses a severe threat to food, water and livelihood security in Pakistan, but the approach to groundwater regulation has been guided by the simplest prescription that to achieve sustainable use, pumping must be less than recharge. This article explains the hydrological cycle and the close relationship between groundwater and surface water, and argues that the conventional notion of sustainable groundwater use is fundamentally flawed. Groundwater, soil moisture and surface water are part of a single integrated resource and cannot be regulated independent of each other. The solution is not sustainable use or the compartmentalization of surface and groundwater but the fair and transparent reallocation of renewable freshwater resources. Although groundwater has improved the livelihood of rural farming communities and has contributed significantly towards national economy, yet at present situation is very alarming indicating serious sustainability concern for food and energy crisis in the Province. Punjab Irrigation Department has installed and monitoring groundwater levels from about 3000 piezometers in canal commanded areas in the province. A groundwater management cell has been established for carrying out research studies. Development of draft "The Punjab Groundwater (Protection, Regulation and Development) Act 2018" and "Punjab Water Policy 2018" are two steps for groundwater regulation and management in the Province. Abnormal lowering of water table in sweet groundwater areas, inter-mixing of saline and fresh groundwater, more energy requirements with declining water levels, deterioration of quality, threats to agriculture due to secondary salinization etc. are the major consequences of ill- planning and over exploitation of groundwater reservoir.

Key words: Groundwater, Integrated Water Resources Management Indus Basin, Policy Regulation, Framework, Punjab, Pakistan

1. Introduction

Water is a life supporting component of the natural environment. It is most essential liquid on the planet earth plays a backbone role both for the existence of mankind and for the sustainable country's economic growth. However, its value is determined differently in different parts of the World. About 97% water exists in oceans that is not suitable for drinking and only 3% is fresh water wherein 2.97% is comprised by glaciers

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and ice caps and remaining little portion of 0.3% is available as a surface and ground water for human use.

Groundwater a precious nature's gift and plays a vital role for the existence of life on the planet. This natural resource is being utilized for drinking, agricultural, industrial, livestock, commercial and other uses and is continuously under threat Agricultural is the backbone of Pakistan's economy. About 68% of the population is engaged in farming directly or indirectly through production, processing and distribution of major agricultural commodities. Agriculture contributes about 21 percent of our Gross Domestic Product (GDP), provides livelihood to about 68 percent people living in rural areas and employs about 45 percent of the total national labour force. The agriculture sector is the major contributor in the overall export earnings of Pakistan **(Pakistan Statistics of Bureau, 2017**). The current irrigation system was designed for 67% cropping intensity but due to increase in population and demand for food and fibre exports, cropping intensity in Punjab has increased even upto 200%. Due to defficiencies in surface water supplies, public and private sectors including agriculture, domestic and industrial sectors are forced to supplement their water requirement by pumping groundwater. To raise more crops, more industrial products for increasing their income and to meet drinking water supply, groundwater user are using even poor quality groundwater. In the short term it is helping to meet their water requirement and to increase their income but in the long term deteriorating the land and water quality due to tremendous groundwater development during the last four decades. Presently, about one million public and private tubewells have been installed in the Punjab mainly for agriculture.

The concurrent use of surface water and groundwater water now takes place on more than 70% of irrigated lands (**Qureshi. A.S 2011**). Successful irrigation requires successful conjunctive management of surface water and groundwater resources. The Government of Pakistan's Poverty Reduction Strategy Paper 1 of 2003 in fact identified water shortage as the most critical challenge, because water for agriculture is the key engine of agriculture growth and poverty reduction.

Groundwater over-exploitation poses a severe threat to food, water and livelihood security in Pakistan, but the approach to groundwater regulation has been guided by the simplistic prescription that to achieve sustainable use, pumping must be less than recharge. As water becomes an increasingly scarce resource, threatened both quantitatively and qualitatively, and as competing demands between different uses and users become steadily sharper, many states are moving faster in the direction of adopting water resources legislation to address in detail the vast array of issues facing or emerging in the water sector. Some countries that already have water legislation in place are realizing that there are major shortcomings with such legislation.

The ability of any state to regulate, allocate, and control its water resources depend primarily on whether the state has in place a legal framework for dealing with water resources and, if it does, what approach the framework prescribes for ownership and allocation of water. Increasingly, states are making explicit references in their constitutions to their water resources and the need to manage them properly and efficiently; they may even lay down basic principles of management and allocation. In a number of constitutions and laws of federal states, provisions are included that clarify the

responsibilities of each of the federal and provincial governments over water resources management.

The purpose of this study is to examine how the regulatory frameworks in various acts have addressed groundwater resources management. The study furthermore discusses what it considers the essential elements for a regulatory framework for water resources management in Indus Basin and to identify some emerging trends

2. Regulation for Groundwater Management

It is widely recognized that groundwater quality and quantity issues challenges facing the country today will need to be solved through improved water resources management. There are several pillars to improve water resources management, of which regulation is one. Other key elements of the water resources management framework include infrastructure operation, maintenance and development, monitoring and assessment, research, and appropriate institutional design. Regulation is, however, a key part of the IWRM.

Policy and Regulation are two important frameworks that govern the management and utilization of water resources are the water law and water policy. Frequently, there is confusion among water stakeholders and scholars across the globe about the difference between the two frameworks **(FAO 2009).** While most countries often ignore the water laws & regulations and prefer instituting the water policy alone **Cullet (2012)** and in their opinion water policy documents are quite often non-binding and do not create any specific obligations. In contrast, water laws are set to be well drafted and binding. They have specific standards that are set, procedures and principles that must be complied with, and more importantly, have provisions that may hold persons accountable for their actions.

The United Nations Water Conference that was held in Mar del Plata, Argentina, in 1977, observed that existing legislation in many countries is often complex, lags behind modern water management practices and techniques, and perpetuates an undesirable fragmentation of responsibilities between different entities within a government. In a number of countries like Pakistan, provisions that regulate water resources are scattered through different laws and regulations and in some instances, they may even be incompatible with each other or with existing practices and traditional rights. Overlapping jurisdiction of different entities working on water resources management is a common. Water legislation is at a very early stage of development. Responsibilities for managing water are frequently fragmented. It is worth noting that the absence of favorable water laws and policies has greater repercussions on water resources management in low- and middle-income countries than in high-income countries **(Wouters & Rieu-Clarke 2004).** Good water laws and policies in place would thus enhance an enabling environment for water governance, improving people's livelihoods and ultimately sustainable water resource utilization and management.

3. Indus Basin Irrigation System

Pakistan's economy is based on the flows of Indus Basin Irrigation System comprising of Indus River and its tributaries (Jhelum, Chenab, Ravi, Sutlej and Beas to the east and the Kabul River to the west). The Indus River has a total length of 2900 km and a

drainage area of ~966,000 km^2. The inflow to these rivers is mainly derived from snow and glacial melt and rainfall in the catchment areas.

The Indus Basin irrigation system commands a gross irrigable area of 16.85 million ha, 14 million ha of which are culturable command area to which water is allocated. The Indus river basin represents an extensive groundwater aquifer. The water table was well below the surface (>30 m) and the aquifer was in a state of hydrological equilibrium before the development of the canal irrigation system **(WCD, 2000).** The water requirements for irrigation in the Indus Basin are estimated at 250 BCM in 2025 against a projected potential availability of 185 BCM from surface water resources. Even if the full groundwater resources are exploited, the water availability will not be more than 190 BCM (**Qureshi, A.S., 2011**).

4. National Water Policy of Pakistan-2018

The National Water Policy (NWP), 2018 was formally approved by the Council of Common Interests (CCI) on 24th April 2018, with consensus of the all provinces. The main features of NWP are to increase development budget for water resources from 3.7% to 10% by 2030 with pricing of water at delivery point and Integration of Strategic Initiatives in policy and in line of National Climate Change Policy 2012. On the other hand, the policy recognizes that the sector has opportunities, such as the availability of relatively abundant water resources, political will, active women and youth, donor support, willingness of private and public sectors' participation.

The National Water Policy lays down a broad policy framework and set of principles for water security on which the Provincial Governments can formulate their respective Master Plans and projects for water conservation, water development and water management. It outlines the strategies to solve the problems and challenges in the Water Sector of the country in an integrated manner in order to achieve the national development. Main features in NWP for monitoring of aquifer potential and its sustainable management are following;

- The Indus aquifer, underlying the vast Indus plains, and other aquifers in valleys and in the hard rock formation are recognized as important national resources and deserve protection from pollution and unsustainable abstractions.
- Monitoring efforts shall be strengthened to determine sustainable groundwater potential and prepare groundwater budgets for sub-basins and canal commands. All measures to prevent lateral/vertical movement of saline water interface shall be introduced. Provincial governments shall be persuaded to enforce legislation and take regulatory measures.
- Various technologies used for sustainable extraction and skimming of fresh groundwater layers overlying saline water shall be evaluated and development of improved techniques initiated.
- The transition of SCARP tubewells in the public sector to the private sector shall be expedited leaving development of fresh groundwater entirely to the private sector, as a local resource.
- All sources of recharge/discharge and their interaction on groundwater reservoir shall be evaluated. Groundwater recharge including artificial recharge shall be

promoted wherever technically and economically feasible. Abstractions from the aquifer shall be managed to the sustainable level that balances the recharge and boundary flows.

- The Provinces shall be encouraged to prepare a Groundwater Atlas for each canal command and sub-basin delineating: Groundwater development potential, water quality zones, water table depth zones, recommendations for installation of different types of tubewells.
- Investment in groundwater recharge schemes shall be given due priority.
- Secondary salinization due to indiscriminate groundwater abstraction shall be avoided by controlling or restricting pumping through enforcement of a strict regulatory framework.
- Encouraging beneficiary participation and public private partnership.

5. Punjab Water Policy

Groundwater Management Cell (GWMC) which has been established in Physics Directorate of IRI by Secretary Irrigation Department vide Notification No. SO (EVL) IRRI-1-2/2006 dated 09.12.2013. Groundwater Management Cell has taken up Real Time Groundwater Monitoring, Groundwater Management, Groundwater Development and Artificial Recharge of Groundwater and Rainfall Harvesting, Water Saving Techniques and other recharge studies/projects etc. Development of "The Punjab Groundwater (Protection, Regulation and development) Act", Development of Punjab Water policy, Development of Integrated Water Resource Management (IWRM) Policy Framework, pilot project on Recharge of Aquifer for Groundwater Management in Punjab (Old Mailsi Canal). Organized two National Seminar at Lahore and Six Field workshop for awareness raising, groundwater governess and management throughout the Punjab Province, Organized Meetings of all Stakeholders regarding issues and management of groundwater, Monitoring of groundwater (Level and Quality) biannually throughout the Punjab province.

Groundwater Management Cell of Irrigation Research Institute, Irrigation Department has framed a comprehensive Punjab Water Policy 2018 (draft) which covers the Integrated Water Resources Management (IWRM) framework and was reframed in line with the National Water Policy, 2018, which has been submitted to the Government for perusal/approval. This policy thus serves as a guideline for proper implementation of various activities like drinking water supply and sanitation. It outlines the strategies on how to solve the problems and challenges that have been faced in the provincial water sector in integrated manner in order to achieve the national development. It is based on the following strategy:-

- Balancing productivity and conservation
- Balancing infrastructure development and environment
- Balancing supply and demand
- Enlarging stakeholder's participation
- Adapting to climate change hazards
- Achieving financial sustainability

- Harnessing information technology and creating knowledge

Its main components are

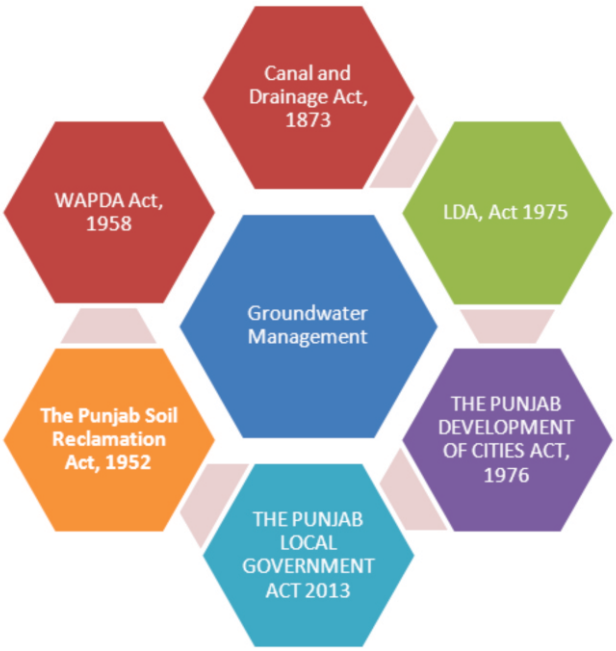
- Enhancing water availability
- Improvement in water quality and environment
- Drinking water and sanitation
- Floods, drought and climate change
- Waterlogging and salinity control
- Demand management
- Financial sustainability
- Water governance
- Transboundary issues, inter provincial harmony

On the other hand, the policy recognizes that the sector has opportunities, such as the availability of relatively abundant water resources, political will, active women and youth, donor support, willingness of private and public sector's participation.

Unlike the Canal and Drainage Act, 1873, the Punjab Water Policy makes a dedication towards promotion of equitable access to safe and potable water. In addition, it has stressed the need for participation of non-State actors and other stakeholders in the management and utilization of water resources.

6. Existing Legal Provisions for Groundwater

For management of aquifer and sub-soil water, different existing provisions are in vogue under different Acts/Laws as follows:



I. The Canal and Drainage Act, 1873

The Canal and Drainge Act, 1873 which is being exercised by the Irrigation Department. Section 62-A of this Act especially deals with sub-soil water management.

Section 62-A: Management of sub-soil water

Under this Section 62-A of Ibid Act, Provincial Government shall take necessary steps for the proper management of the sub-soil water to protect the aquifer, the quality and availability of such water. The Provincial Government, or any person authorized by it, shall carry out the evaluation and assessment regarding the condition of aquifer, quality and availability of sub-soil water in any specified area and draw up the scheme for the proper management of the sub-soil water and publish it in the manner as may be determined by the Provincial Government. Any person violating any direction, order or instruction issued under this section, shall be liable to such charges as may be prescribed.

II. The Punjab Soil Reclamation Act, 1952

The Act was passed by Punjab Assembly on 10th May, 1952 and assented to by the Governor of the Punjab on 20th June, 1952. The Act is related to Soil and Water Management. It's some provisions relate to control over underground water resources.

The duty and power to carry out the provisions under the Act in any local area shall, subject to the conditions and limitations hereinafter contained, be vested in the Board which shall be a body corporate, and shall have perpetual succession and a common seal, and shall be competent to sue and be sued in its name. The provision of Section 26 under the Act is about the control over underground water. According to this Section a local area or part thereof where a scheme is sanctioned, "the use of underground waters in that area except the water used for domestic purposes or for watering livestock shall come under control of the Board. The Board shall frame rules to define, for different areas from time to time, the uses which are to be included in the term "domestic purposes or watering livestock".

Under this section, the Collector shall cause public notice to be given at convenient places in the area concerned stating that the use of underground waters in the said area is controlled, and that all persons using underground waters, for purposes other than domestic or for watering livestock, through tube-wells, wells and other appliances worked by electricity, steam, oil or wind power, should have all such tube-wells and wells and appliances existing on the date of the notification registered in the office of the Collector or the Divisional Canal Officer, as directed, within a period not exceeding three months from the date of the issue of such public notice. After publicity of the notice under sub-section (2) of Section 26, any owner or occupier of land who desires to put up any new tube-well or well, worked by electricity, steam, oil or wind power for using underground waters, for any purpose other than domestic or for watering livestock, shall apply for a licence to the Board.

No claim or suit shall lie for damages against the Board, Government or any other person, on account of any ill-effects on the appliance of the licensee caused by the construction of a tube-well or the working of any appliance for the removal or use of

underground water if the said appliance is erected or used in the manner prescribed by the Board.

In the area for which the scheme has been sanctioned, the Board may order any tube-well or well, worked by electricity, steam, oil or wind power, for using underground waters, to be closed down either temporarily during specified periods of the year or permanently, provided that such order shall not prohibit the use of underground waters by any owner or occupier of land for domestic purposes and for watering livestock. In cases where permanent closing down is ordered, the board shall either provide some alternative source of water-supply or award reasonable compensation.

No claim for compensation for such permanent closing down of appliances shall be made after the expiry of one year from the date of the order unless the Collector is satisfied that the claimant had sufficient cause for not making the claim within such period. Any owner or occupier of land who puts up and uses any tube-well or well, worked by electricity, steam, oil or wind power, without a licence after the publicity of the notice under sub-section (2) of this section or uses such an appliance in contravention of an order under sub-section (5) shall be charged a special rate for each separate occasion on which such use is made. The Board with the sanction of Government may frame rules to fix the amount of such rate and the manner in which it will be levied.

III. WAPDA Act 1958

This *Act* was passed by West Pakistan Assembly on 2nd April, *1958 and* **assented by the Governor of West Pakistan on the 24th April, 1958**

Section 11 of this Act is “subject to the provisions of any other law for the time being in force, the Authority shall have control over the underground water resources of any region in [a Province]. The area over which and the extent to which control is intended to be exercised shall be agreed to and notified by the Government in the official Gazette.

IV. The Lahore Development Authority (LDA) ACT. 1975

Section 29 of the LDA Act 1975 deals with permission and fees for intallation of tubewells to extract groundwater.

Under the provision of Section 29 of this Act, “The Authority shall have the exclusive right to use ground water resources within the area. No person shall, without the permission of the Authority, install a tube-well at such places within the areas, as may be notified from time to time in the official Gazette by the Authority. The Authority may, in the prescribed manner, levy rate on any person who has installed or intends to install tubewell within the area. Any person violating the provisions of subsection (2) shall be liable to punishment under this Act along with closure or sealing of the said tubewell by the Authority.

V. Punjab Development of Cities Act 1976

Similarly, under the Section 28 of the Punjab Development of Cities Act, 1976, the Authority shall have the exclusive right to use ground water resources within the area. No person shall, without the permission of the Authority install a tubewell, for commercial purposes, at such places within the area, as may be notified in the official Gazette by the

Authority. The Authority may levy rates on the persons or bodies who have installed or may install tubewells for commercial purposes, within its jurisdiction.

VI. Easements Act 1882

Act came into force on the first day of July, 1882. An Act to define and amend the Law relating to Easements and Licenses.

Section 2. Savings. Nothing herein contained shall be deemed to affect any law not hereby expressly repealed; or to derogate from—

(a) any right of the 3[Government] to regulate the collection, retention and distribution of the water of rivers and streams flowing in natural channels, and of natural lakes and ponds, or of the water flowing, collected, retained or distributed in or by any channel or other work constructed at the public expense for irrigation;

(b) Any customary or other right (not being a license) in or over immoveable property which the 3[Government], the public or any person may possess irrespective of other immoveable property; or

(c) Any right acquired, or arising out of a relation created, before this Act comes into force.

VII. On-Farm Water Management and Water Users' Associations Ordinance 1981

Moreover, to manage groundwater, Agriculture Department is promoting coordination and improvement of watercourses, provision of laser land levelers, installation of high efficiency irrigation systems, irrigation agronomy practices, and harvesting of water resources in barani or rain-fed areas by exercising and compliance "On-Farm Water Management and Water Users' Associations Ordinance, 1981 (V of 1981)

"An Ordinance to provide for on-farm water management, conservation and optimum utilization of irrigation water sources and formation of water users' associations in the Province".

VIII. Punjab Irrigation and Drainage Authority Act 1997

Under Subsection **30 of Section 5 of** the Punjab Irrigation and Drainage Authority Act 1997, the Authority shall have the powers and duties **to coordinate and regulate the measures** being undertaken or required to be undertaken in the Province for recording and gauging surface waters, monitoring of groundwater table and quality of water and the compilation of data relevant thereto and in this regard to establish and regularly maintain proper liaison with similar work being undertaken in other provinces".

Whereas under Section 8 of the PIDA Act, 1997, the Authority shall have control over all the rivers, canals, drains, streams, hill torrents, public springs, natural lakes, reservoirs (except such reservoirs as are under the control of WAPDA) and underground water resources within the Province to give effect to schemes to be prepared under this Act in relation to public purposes.

IX. Punjab Rules of Business 2011.

a) **Irrigation Department** is exercising different Act, Rules and regulations for water management. These Act, Rules and Regulations include the Canal and Drainage Act 1873, The Soil Reclamation Act 1952, The Land Improvement Tax Act, 1975 (XXXI of 1975), The On-Form Water Management Ordinance 1981, The Punjab Irrigation and Drainage Authority Act 1997 and the Punjab Minor Canal Act, 1905 for legislation, policy formulation and planning for irrigation and drainage, construction and maintenance of: (a) Barrages, rivers (b) Canals, (c) Tube-wells and basic & applied research in Irrigation hydraulics, ground water and land reclamation.

b) **Agriculture Department**

1. Legislation, policy formulation and sectoral planning regarding:
   (a) Improvement of agricultural and water management methods.
   (b) Mechanization, reclamation of land, use of agriculture machinery, ploughing, tube-wells and installation and research Agricultural Engineering (Agricultural Machinery and Implements), Water Management Training and Research Institute, Lahore.
2. Water management operations, planning, bench marks, coordination and improvement of watercourses, provision of laser land levelers, installation of high efficiency irrigation systems, irrigation agronomy practices, groundwater management and harvesting of water resources in barani or rain-fed areas.
3. Coordination and Strengthening of Research activities in Agriculture, Livestock, Irrigation, Water Management, Forest and Fisheries Sector through Punjab Agricultural Research Board.

c) **Revenue Department**

- Minor canals, hill torrents, alienation of rights in water.
- Suspension and remission of land revenue and water rate.
- Water-Logging and salinity other than schemes relating thereto.

d) **Housing, Urban Development and Public Health Engineering Department**

- Provision of drinking water, drainage & sanitation facilities and legislation/policy matters related thereto.

X. Punjab Local Government Act, 2013

Under the Punjab Local Government Act, 2013, a local government shall perform its functions conferred by or under this Act and exercise such powers and follow such procedures as are enumerated in Eighth Schedule. Under Section 103 of Eighth Schedule, all private sources of water supply within the local area of the local government shall be subject to control, regulation and inspection by the local government. No new well, water-pump or any other source of water for drinking purposes, shall be dug, constructed or provided except with the sanction of the local

government. A local government may, by notice, require the owner or any person having the control of any private source of water supply used for drinking purposes– (a) to keep the same in good order and to clean it from time to time of silt, refuse and decaying matter; (b) to protect the same from contamination in such manner as the local government directs; and (c) if the water therein is proved to the satisfaction of the local government to be unfit for drinking purposes, to take such measures as may be specified in the notice to prevent the use of such water for drinking purposes.

7. Development in Groundwater Regulation

i. Punjab Municipal Water Act, 2014 (Draft)

"An Act to recognize, regulate & manage present and future municipal water in the Punjab". Section 5 & 7 of the Act is dealing about regulation, recharge and management of groundwater.

Section 5 Ground Water: Notwithstanding anything to the contrary contained in the Punjab Irrigation and Drainage Authority Act 1997 or any other law for the time being in force, all groundwater used or to be used for municipal purposes in the urban areas shall vest in the Government and shall be regulated by the Punjab Municipal Water Commission.

Rain Water: The Commission shall encourage the use of rain water for municipal purposes and shall prescribe guidelines for the harvesting and management of rain water for municipal purposes, as well as for recharging of the aquifer.

Protected Areas:(1) Any watershed or any area of land adjacent to any surface water or overlying any ground water may be declared by the Government as protected area. These areas will be in addition to those already notified by the Environment Department as Environmentally Sensitive Areas with the prohibition of groundwater extraction. All watershed or any area or land adjacent to any surface water or overlying any ground water may be declared as protected area by the Government.

(2) Regulations may be promulgated by the Commission to prohibit or control such activities by the owners or occupants thereof within the protected area which may damage or cause the deterioration of the surface water or groundwater or interfere with the investigation, use, control, protection, management or administration of such water

ii. The Punjab Groundwater (Protection, Regulation & Development) Act 2018 (Draft)

At present there is no comprehensive legal or regulatory framework for groundwater protection and management in the whole province of Punjab including rural as well as urban aquifers. Currently a comprehensive act has been framed that covers different uses of the groundwater like drinking, irrigation, industry, livestock and other commercial and miscellaneous uses. It covers protection, regulation and development of groundwater under changing climate and future demands in the province. About more than one year has been spent on consultation with a wide spectrum of stakeholders including all provincial

departments, federal ministry of water resources, WAPDA, PCRWR, NGOs, CBOs, media, FOs, individual experts, multinational organizations. Act has been shared and discussed in two national seminars at Lahore and six field workshops with farmers and other stakeholders at grassroots level in different areas in Punjab. It has been framed in line with National Water Policy, Punjab Water Policy (draft) and other existing laws. It has been submitted to the Government for approval. An apex level body "Punjab Groundwater Commission" has been proposed with all relevant provincial departments its members. Functions of this commission are as under:-

- Approve the demarcation of critical areas.
- Coordination between Departments.
- Settle inter departmental disputes.
- Determine priority of water use - Government,
- Make reallocations of available water
- Regulate rain harvesting.
- Organize awareness and educational programs
- Carry out research and development programs
- Annual report to the Government.
- Function under Rules
- Ancillary / necessary functions.
- General control over groundwater.

Further rules and regulation can be framed/developed under this Act as per requirements.

iii. IWRM Framework for Groundwater Management

IWRM is an iterative, evolutionary and adaptive process, conceptualized as a 'spiral' which permits immediate action, builds understanding, develops local capacity and creates ownership. The water resources development and management along with its principles and objectives evolves over time as new demands and needs emerge and innovative solutions are added at each stage. A river basin continuously adapts to those demands as part of an orderly IWRM process. This is facilitated by agreements among basin stakeholders on the necessary trade-offs at each turn of the evolutionary water management spiral.

The IWRM approach provides the mechanism to adjust its goals, implementation process suited to a particular area. The water crises of Pakistan and more so of Punjab, are driven primarily by its population explosion having a direct impact on food security, water and sanitation, disaster preparedness, climate change etc. The rapidly growing population of Pakistan at 2.40% per annum, now highest in

the South Asian region and projected to cross 300 million in year 2050, poses the gravest of all threats to its water security. Punjab being the most densely populated of all the four provinces is affected the most with its water resource base of surface and groundwater now severely depleted.

More than any other province, Punjab is blessed with one of world's largest fresh groundwater aquifers. **Leiftink Report (1965)** mentioned only a pumpage of one MAF in 1965, mostly through Persian wheels. Public tubewell development peaked at 12 MAF in 1970s and then faltered. Now, the number of private wells in Punjab has grown to 1.2 million (**Punjab Development Statics Report 2017)** and pumping in excess of balanced recharge of 43 MAF.

8. Limitations and Constraints

- There is no any provision in any Act relating to water resources availability and quality assessment before NOC to install tubewells.
- No rule for pumping of groundwater quantitatively has been defined. Also no rule for pumping fees like abiana has been approved in any approved groundwater law.
- Proper zoning with ownership has not been defined.
- Polluter to pay principal has not been defined in any approved law.

9. Recommendations

- Existing rules and regulations on groundwater water resources should be reviewed in order to improve and streamline their scope to cover aspects pertaining to groundwater resources management, protection of quality, prevention of pollution, penalties for undesirable effluent discharges, licensing, abstraction, and ownership.
- The legislation should be comprehensive, integrated and should be framed in the simplest way possible and be consistent with the need to spell out the respective responsibilities and powers of governmental agencies and the means for conferring rights to use water on individuals.
- The legislation should allow for the easy implementation of policy decisions, which should be made in the public interest while protecting the reasonable interests of individuals.
- The legislation should define the rules of public ownership of water projects, as well as the rights, obligations, and responsibilities, and should emphasize the role of public bodies at the proper administrative level in controlling both the quantity and quality of water. It should also spell out, either in the primary or subordinate legislation, administrative procedures necessary for the coordinated, equitable, and efficient control and administration of all aspects of water resources and land use problems, as well as the conflicts that may arise from them.

- The legislation should take into account the institutional capacity building to implement it.
- There should be necessary efforts for effective participation in the planning and decision-making process involving all stakeholders and there should be a continuous two-way flow of information.
- In the field of community, groundwater management, special emphasis should be given to the role of women.
- For promoting better management of groundwater demand and encouraging better use of available resources, water tariff policies should be evaluated in accordance with the general development policies so that they may be effectively used as policy instruments.
- Responsibilities of each of the federal and provincial governments may be clarified over water resources management

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