Address of Welcome

By

Engr. Husnain Ahmad

President

Pakistan Engineering Congress

At

World Water Day March 2007

WAPDA Auditorium

WAPDA House Lahore.

Honorable Engr. Tariq Hameed Sahib, Respected scholars, Executive Council Members, fellow Engineers, Ladies & Gentlemen:

It is indeed my profound privilege to welcome you all on behalf of Pakistan Engineering Congress for discussing a mega issue, not only of the present day but of all times.

All the ancient civilizations were founded on the banks of various rivers, such as Nile Euphrates, Indus, and Ganges etc.

It was mainly because the ancient man was more near to and appreciative of nature. For him supply of water not only ensured economic survival but also provided trade and commerce through navigation in Rivers and canals, Fish Catch & proper maintenance of Livestock.

An Indian naval Guru Admiral Mahaan when quite a while ago made the statement that the future wars will be on water, his statement was difficult to understand at that time but now his vision is being appreciated in almost every advanced institute of strategic studies.

It is the importance of water in the life of individuals and nations that the United Nations Conference on Environment Development (UNCED) held in Rio de Janeiro in 1992 declared 22nd March as “World Water Day”. Since then, it is being celebrated the World over. At the occasion of World Water Day experts on “Water Resources” speak on the Theme (& the related issues) laid down for that particular year. The Theme for this year is “Coping With Water Scarcity”.

There are numerous verses in the Holy Quran that speak about the crucial role played by “WATER” in the Socio-Economic Life of Mankind.

“And He is Who created the Heavens & the Earth in Six Days and his Throne was on Water (Sura Hud).

He showeth you the lightening for a fear and for a honour sendeth down water from the sky and thereby quincheneth the earth after death.” (Sura Rome)

“And have sent down from the raining clouds abounded water thereby to produce gram and Gardens of Thick foliage (Sura An Naba (i.e. Tidings).

Ladies and Gentlemen:

Water is the omen of life, Surest Source of Nourishment and countenance and economic development. Despite scant average annual rainfall of barely 250 Millimeters, the country boasts of the largest net-work of Irrigation Canals of the World. The Agriculture Sector sustained by canal waters contributes 25% of GDP and above all approximately 80% of the exports.

Ladies and Gentlemen:

The average available River water is 143 MAF but the average utilization is only about 103 MAF. Resultantly 40 MAF of water flows down to the Sea un – tapped. As the water flows in rivers varies seasonally, the country experiences 30% to 50% shortages of water during “October – March” and the sowing kharif period of “April – May”. Studies show that by 2020 the country would be facing 15 – 20 MAF of additional water shortages. The water availability for human consumption has also shrunk from 5650 cubic meters in 1951 to 1200 cubic meters in 2006 (close to 1000 cubic meters Bench – Mark of “Water Short Country”).

Ladies and Gentlemen:

Water is the cheapest source of generation of electricity without which the industrial advancement and prosperity of the county would be a hallucination. The county has tapped only 10% of its 40000 M.W potential whereas China & India have attained 30% target.

We in Pakistan have shown gross indifference towards conservation of water spreading over a period of 3 – decades by not constructing any major Dam despite about 35-40 MAF of water flowing un-tapped in the Sea.

Had a big Dam been constructed 4 – million acres of Land would have been brought under –cultivation with annual benefits of the value of Rs. 25 Billion.

With the storage capacity of existing Dams shrinking due to sedimentation coupled with serious shortages of water during “Rabi” and “Khaif” crops, the only alternative is to go for construction of large Dams.

Ladies and Gentlemen:

It is a matter of great satisfaction that the present Govt took notice of this grave situation. The President performed the ground Breaking of the Mega Basha Dam. Also ordered immediate action of construction of following Dams:

- Kala – Bagh
- Akori
- Kurram Tungi
- Munda

In addition, the raising of Mangla Dam was started and is in full swing now. Also numerous small Dams are under construction. However, the Basha Dam etc. will be completed by 2016 whereas, we are in need of additional 15-20 MAF water now. Hence, the only alternative is to go for construction of Kala – Bagh Dam to save the county from drought and God Forbid from Famine.

Ladies and Gentlemen:

Coping with Water Scarcity brings us face to face with following issues:

- To construct Big Reservoirs for proper storage and conservation of Water.
- To maintain a balance between availability and demand of water.
- Conservation & Storage of Water for assured supplies at the proper time.
- To avoid degradation of "Ground Water" and "Surface Water".
- Proper Planning, Legal Frameworks and governance of Ground Water usage to avoid depletion of Ground Water Resources.
- Economical domestic use of water / Re-use of Water through re-cycling.
- Switching from High Delta Crops to crops requiring less water in – puts.

Pakistan Engineering Congress being the oldest body of engineers engaged in promotion of science and professional expertise not only realizes that water scarcity is a serious threat which is aggravating exponentially and therefore is also committed to contribute along with in all possible manners. I would also like to highlight here that we at present are one of water stressed nations and it is the high time that we need to put an end on disputes and implement the water apportionment accord of 1991 signed in by Chief Ministers of all the four provinces of Pakistan, which shall certainly facilitate rapid development and significant economic growth in Pakistan. Similarly, rehabilitation / survival of drought hit areas require special considerations.

Ladies and Gentlemen:

With papers from eminent speakers of the day, and experience of galaxy of engineers present here, I am sure towards the end of this seminar we'll not only be wiser but will also have concrete recommendations for better solution to cope with water scarcity in general and with reference to Pakistan in particular.

Thank you,

Pakistan Paindabad.

World Water Day - 2007
Address

By

Engr. Tariq Hamid, Chairman WAPDA
Chief Guest

Fellow Engineers and Gentlemen:

Assalam-o-Alaikum

It is my proud privilege to speak in this gathering of eminent engineers and scientists on WORLD WATER DAY organized by the "Pakistan Engineering Congress and WAPDA".

The annual "WORLD WATER DAY", 22nd of March, as established by the United Nations, in view of the increasing importance that water is assuming in the face of its growing scarcity globally, is observed through out the World, after the 1993 convention of the International Commission on Irrigation and Drainage in the Hague. The conference had agreed that providing Water Security is a key dimension of poverty reduction. Water Security "FOR ALL" is an achievable goal and there is enough water for everybody in the World, provided we change the way we mange it. The "World Water Day" calls on each nation, and each one of US to maintain and improve the quality and quantity of fresh water available to future generation. The "WORLD WATER DAY" event is now gaining importance. This year the World Water Day is being celebrated on the theme of "Coping With Water Scarcity". It is hoped that World Water Day will gradually make all nations and people of the World realize that availability of fresh water is something we cannot take for granted, and that water is indeed one of the earth's most precious as well as the most threatened resource.

Looking at the global water resources, it seems there is far more water than human needs. However 97% of this water is contained in the Oceans, which is highly saline. Most of the fresh water on earth is in the shape of polar ice caps and the glaciers. Although water in all rivers and lakes in the World is in substantial quantity, there are two problems. First of all; the present World population of 6.5 billion is growing fast. So with time more and more people would need water and also water use per person would grow. Secondly it is even more serious that much of our waters are being polluted by industrial wastes. Furthermore, it should be realized that in pre-industrial times rivers could purify themselves as a natural process. Today, many of our rivers are polluted from source to end. There is a task ahead for all of us in creating awareness about the water problems and mobilizing support for action. In this regards World Water Day can help.

In Pakistan there is increasing competition between domestic, industrial and farm users. Population growth, rapid urbanization and industrialization are imposing growing demands and pressures on water. The rising imbalance between supply and demand has led to shortages and unhealthy competition leading to inter-provincial tension. In Pakistan, availability of water resources and their development has been slowly turning into a crisis situation and has reached a level of inter-provincial conflicts which immediately need to be addressed. The challenge lies in raising the political will to implement water related commitments; water professionals need a better understanding of the broader social, economic and political context, while politicians need to be better informed about water resources issues.

The growing shortage of water, which reaches alarming proportions during drought years, requires that a concerted effort be made to conserve Water develop available water resources to the optimum and adopt modern technologies for more efficient irrigation techniques. Unless it is done, self- sufficiency in food, socio-economic amelioration, alleviating poverty and conservation of environment would not be possible and eventually food shortages and even famine-like conditions may arise in the country.

Irrigated agriculture is by far the largest user. In spite of its rivers, Pakistan is facing a water shortage, which affects irrigation. Water shortages are going to get worse with every passing year not only for urban centers but more so for irrigation, aggravating another deficit that is of food. It is therefore necessary that water must be conserved to the maximum and the only solution is construction of reservoirs wherever feasible and their optimum utilization.

Besides irrigated-agriculture usages, water plays an intrinsic role in many other sectors such as domestic, industrial mining, livestock and fisheries development, etc. hydropower is the cheapest and environmentally the cleanest way of generation of electricity. Its abundant potential in Pakistan has to be developed on a priority basis of the current trend of rising power tariff is to be reversed.

Pakistan needs to work urgently to better utilize its water resources by building of dams. But how this is to be done remains a center of much controversy? So far 81 large, medium and small dams have been built across the country since 1947. Construction of mega water projects including Diamber Basha Dam, kalabagh Dam, Akhori Dam, Kurram Tangi Dam, & Munda Dam, as announced by President of Pakistan on January 16, 2006, will be completed by the year 2016.

At the end, I would like to complement the Pakistan Engineering Congress to collaborate with WAPDA, jointly organize this event for observing World Water Day and I hope that initiative will create awareness among the Pakistani people and raise public support for government action. Meeting the challenges in the water sector requires public support and participation and the World Water Day 2007 will help mobilizing both the aspects in saving every available drop of water for the beneficial use of our present and future generations with calmness and harmony with nature.

Thank you.

WORLD WATER DAY DELIBERATIONS - 2007

KEY NOTE ADDRESS

By

ENGR. CH. GHULAM HUSSAIN[1]

Honourable Chief Guest, Engr. Tariq Hamid, Chairman, WAPDA, Engr. Husnain Ahmad, President, Pakistan Engineering Congress, brother Engineers, Ladies & Gentlemen!

اَلسَّلَامُ عَلَيْكُمْ وَرَحْمَةُ اللّٰهِ وَبَرَكَاتُهُ

Water is big news. Rarely does a day pass when a water issue is not featured prominently in the media. It is news when floods wash away lives and livelihoods, and when economies show signs of stagnation because of diminishing water resources. It is news when water supply projects come to town and when chemicals contaminate drinking water. And it is news when agriculture, industries and commerce are forced to look elsewhere for their water needs.

Ladies and Gentlemen!

Less prominent are the everyday stories of the silent masses without access to safe water supply. The figures are staggering: one in five people in Asia and the Pacific lacks access to safe drinking water. Two out of three people in the world will face water shortages by 2025. But the burden of water related problems falls most heavily on the poor. The vast majority of these people live in the rural areas of Asia. They are particularly vulnerable to water scarcity, pollution, drought and flooding. Problems with water are a burden to their health, productivity, and quality of life. Improving access to clean water for poor people is a critical element in the battle against poverty and integrated water resources management.

Ladies & Gentlemen!

In Pakistan, development of water resources is essentially required for the sustained economic development. As genuinely claimed the Irrigation Network of Pakistan is the largest infrastructural enterprise, costing about $ 300 billion (at the current rates) and contributing approximately $ 16 billion, or nearly 25% to the country's GDP. Irrigated

[1] Secretary, Pakistan Engineering Congress & Managing Partner, National Development Consultants

agriculture provides 90 percent of food and fiber requirements while the remaining 10 percent is contributed by “barani” (rainfed) agriculture.

Due to construction of large number of irrigation networks and a huge number of tubewells, irrigated areas in Pakistan has increased from 8.40 Mha at the time of Independence to 18.09 Mha at present.

Notwithstanding these appreciable achievements in the water sector, population growth, rapid urbanization and industrialization, are imposing growing demands and pressure on the diminishing water-resources. The expanding imbalance between supply and demand has led to shortages and unhealthy competition between the end users. This is also resulting in environmental degradation by creating persistent increase in water logging and salinity in certain parts, lowering of groundwater levels in other areas; and intrusion of saline water into fresh groundwater acquifers.

Ladies and Gentlemen!

If we evaluate water availability starting from the time of Independence, per capita availability of water in this region was over 5,000 cubic meters in 1948 which is a water-surplus situation by all current standards. According to international standards, a region with water availability below 1,000 m^3 per capita is ranked as water-deficit area. However with all that comfortable position of overall water availability, it was not equitably distributed. Thar and Cholistan deserts and some areas of Thal and Potohar had inadequate water availability. This situation should have been improved by providing adequate water storages and water distribution infrastructure to have fairly equitable distribution of fresh water to all the parts of the Country. It is alarming to mention that presently the water availability per capita in Pakistan has fallen down to just over 1000 cubic meters. This drastic decrease in water availability may be attributed to the rate of development of fresh water resources not matching with the growth of population, sedimentation of built reservoirs, higher rate of water losses through water carrying infrastructures and pollution of fresh water resources by municipal and industrial waste-waters.

Storage capacity of reservoirs constructed on the Indus and its tributaries provided overall increase of about 22 percent in the canal supplies as compared to the post-dams scenario. Nevertheless, due to progressive sedimentation of these reservoirs, the storage capacities of these dams is anticipated to reduce by over 6.03 MAF by the year 2010 which is equivalent to a mega reservoir. On the other side the current population of about 150 million is projected to become 220 million in 2025. Hence, without building another major storage dam by the year 2015, it will not be possible to feed the growing population. Accordingly immediate measures are required to start construction of Kalabagh, Basha and Akhori Dams.

Ladies and Gentlemen!

The commodity of water, as it would have it, is depleting fast and is not keeping in with the growing demand of the burgeoning population on earth. Foreseeing such an abominable situation which looms large in the decades to come, the 'Think Tanks' predicted future national and international wars on the issue of water. The comity of Nations, the UN realizing the significance of this situation, during their Conference on Environmental and Development, in the (UNCED) meeting in 1992 took the initiative for observance of World Water Day, in every country and every year on 22 March starting from 1993.

Its cardinal aim is to educate the humanity all over the world to preserve, both the surface and underground available water resources, and stress upon the frugal and justifiable use of this God gifted rare commodity. Further UNO during its 58th Session declared the period from 2005-2015 as the international decade for Action "water for life" starting 22nd March 2005.

Pakistan Engineering Congress rose to the occasion and in collaboration with WAPDA observed WWD on March 22nd in 2005 and 2006. At the year 2005 World Water Day, six papers on various water related studies in the context of Pakistan were presented and discussed. At the World Water Day of year 2006, eight such papers were presented and discussed. Papers of both the years were published and bound in exquisite volumes and duly circulated.

This year due to some unavoidable constraints the World Water Day is being observed on March 31, 2007. Following Eight (8) papers are being presented:-

1. Water Scarcity and WAPDA Vision 2025
   By Engr. Muhammad Mushtaq Chaudhry, Member (Water) WAPDA and Dr. Allah Bakhsh Sufi, Director (WRPO), P&D WAPDA.

2. Role of Groundwater in Coping with Water Scarcity of Water
   By Dr. Muhammad Nawaz Bhutta, Director General (IWASRI), WAPDA.

3. Growing Scarcity of Water Resources
   By Engr. Shafqat Masood, Former Chairman IRSA.

4. Combating Water Scarcity
   By Dr. Izhar-ul-Haq, General Manager (Technical Services) WAPDA, and S. Tanveer Abbas

5. Waste Water Re-use for Crop Production: "An Option for Sustainable Agriculture under Water Scarce Environment"
   By Sarfraz Munir, Abdul Hakeem Khan, Waqar Ahmad and Amir Nazeer (IWMI)

6. Groundwater Sustainability to Cope with Water Scarcity
   By M. Arshad and Jehanzeb Musud, University of Agriculture, Faisalabad.

7. Efficient Irrigation Techniques to Cope with Water Scarcity
   By Muhammad Yasin, Principal Scientific Officer, WRRI, NARC, Islamabad.

8. Coping with Water Scarcity and the Indus Water Treaty 1960.
   By Usmane-Ghani, Joint Commissioner (Pakistan Commissioner for Indus Waters).

I am sure the presentation of these papers will deepen our understanding of critical water issues and help this forum to recommend some proper measures to overcome the growing water scarcity in Pakistan.

It is hoped audience comprising, inter-alia, Elite Professional Engineers will take keen interest in the proceedings and offer their valuable observations and remarks, which the Engineering Congress will appreciate and make part of the volume of this year's publication.

Thank you for bearing with me.

PAKISTAN PAINDABAD

WATER SCARCITY AND WAPDA VISION 2025

By

M. Mushtaq Chaudhry[2], & Dr. Allah Bakhsh Sufi[2]

ABSTRACT

The economy of Pakistan is greatly dependent on inflows in the Indus River System. The agriculture which largely depends upon river flows stores about 23% in GDP. Since agriculture is the major user of water, its sustainability depends on the timely and adequate availability of water. The increasing pressure of population and industrialization has also placed greater demands of water. Pakistan once the water surplus country, with huge water resources of the Indus River System is now a water deficit country. The annual river flows are about 154 MAF, out of which 105 MAF are being diverted through canals for irrigation purposes and about 35 MAF is flowing to Sea. The ground water is another important resource with annual pumpage of 42 MAF for irrigation and drinking needs of the country. The river flows are highly seasonal with 83.4% flows in Kharif and 16.6% in Rabi. The gross storage capacity is about 18 MAF which is only about 13% of the total inflows. The storage capacity of major dams has been lost 5.15 MAF upto year 2006 due to sedimentation and is decreasing gradually. Increase in population expected to rise upto 221 million by the year 2025, rapid urbanization and better socio-economic conditions would put more pressure on food consumption and hence would need 45 MAF additional water for agricultural and other sectoral water requirement at canal head. The water resources available for future development are about 35 MAF of river flows, 6.4 MAF of ground water contribution and 3 MAF of rainfall harvesting.

The paper discusses the present water resources inventory, present and future needs, cross cutting issues and ways and means to cope with the situation. The WAPDA Vision Projects which are at various stages of planning/development are envisaged to store about 26 MAF after completion. About 6.4 MAF groundwater aquifer will be utilized through pumpage in private sector and about 6 - 8 MAF water will become available by saving through National Watercourse Rehabilitation/ Improvement Programme. These arrangements will only be sufficient to meet the water requirement upto year 2025 and afterwards reliance will have to be placed on various conservation measures.

1. INTRODUCTION

Water is essential for sustenance of life in all forms and it is a finite resource, progressively becoming scarcer due to persistent increases in its competing demands.

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[2] Member (Water), [2] and [2] Project Director (WRPO), WAPDA, Wapda House, Lahore.

Pakistan is one of the world's arid countries, with yearly average rainfall of under 240 mm. The population and the economy are heavily dependent on annual inflows of about 154 MAF in Indus River System. It commands an area of about 35 ma. The system includes three large reservoirs (Tarbela, Mangla and Chashma), 19 barrages/head works, 12 inter-river link canals and 45 canal commands and more than 107,000 farmer operated watercourses.

The economy of the country is of agrarian nature with its share of about 23% in GDP. Since agriculture is the major user of water, therefore, sustainability of agriculture depends on the timely and adequate availability of water. The increasing pressure of population and industrialization has already placed greater demands of water. The high aridity index of the country is adding further to the significance of water in development activities.

Though once a water-surplus country with huge water resources of the Indus River System, Pakistan is now a water deficit country. The per capita surface water availability per annum in the year 1951 was 5260 cubic meters, has come down to about 1100 cubic meter by 2006 and the countries begin experiencing chronic water stress below 1000 m^3. The situation in Pakistan is nearing conditions of chronic water stress. The gap between demand and supply of water is further being aggravated due to periodic drought and reduced fresh water supplies due to depletion of existing water storage capacities of the country. This situation demands for the development of new sources, adopting water conservation measures for extremely judicious use of the finite quantity of water to avert the water scarcity situation.

2. WATER AVAILABILITY

2.1 Rainfall

The natural precipitation in Pakistan is low and irregular. The average annual rainfall is about 240 mm. Most of the rainfall occurs in the monsoon season of July and August. Both the intensity and volume in the monsoon season are high and cannot be fully utilized. The occurrence of rainfall varies widely. On the whole more than half the country receives less than 200 mm of annual rainfall. In non-irrigated areas (barani areas) rainfall is utilized for rain-fed agriculture and for meeting the drinking water needs of the people and livestock. It is estimated about 9.9 million acres of the area is rain fed.

2.2 Surface Water

2.2.1 The Indus and Its Western Tributaries

Pakistan's primary water resource is the Indus River and its tributaries. With division of rivers under the Indus Water Treaty (IWT–1960), Pakistan is now dependent on three western rivers of Indus (including Kabul), Jhelum and Chenab.

River flows in Pakistan are highly seasonal, about 18 percent of annual flow occurring in Rabi and 82 percent in Kharif seasons. At present, three dams namely

Mangla on Jhelum river and Tarbela and Chashma on Indus river with an original gross storage capacity of 18.37 MAF are in operation since 1967, 1974 and 1971 respectively. These reservoirs store part of flood flows during monsoon (Kharif period). The stored water is released during low flow periods to supplement river discharge for irrigation and hydropower generation. The storage facilities in Pakistan are very small as compared to other countries as is evident from Box 1.

Box-1
Average Annual Flow & Storage Capacity of Dams of some Major River Basins

Sr. No.	Name of River Basin	Catchments Area (1000 sq.km)	Length (km)	Average Annual Flow (MAF)	No. of Dams	Storage Capacity (MAF)
1.	Nile	3,349	6.650	38	1	132.00
2.	Sutlej - Bias	-	1,440	32	5	11.32
3.	Yangtze	1,959	5,494	870	1	32.00
4.	Columbia	668	1,950	179	3 Canada: 2 USA: 1	34.00 24.45 9.55
5.	Indus (2006)	1,166	2,880	145.00	3	13.22
6.	Yellow River	745,920	5,464	345	7	68.95
7.	Colorado	141	2,320	12	3	59.62

The gross storage capacity at present (2006) in Indus Basin is about 13.22 MAF against the annual flow of 140.69 MAF of the three Western Rivers, which is not sufficient against the available river flows to regulate its supplies and meet present and future needs. Existing storage capacity is only 13% of total annual river flows.

Historic canal head withdrawals data shows that these were 68.20 MAF during 1947-48. In the pre-Mangla period (1960-67) these increased to 87.90 MAF and to 95.90 MAF in the post Mangla period (1967-76) and to 105.50 MAF in the post-Tarbela period (1976-2006). This trend has now started diminishing and significant loss of on-line storage capacity through sedimentation, which as of 2006 amounts to 5.15 MAF. Post-Tarbela (1976-2006) average Kotri below escapages are 35.20 MAF annually with a maximum of 91.83 MAF in 1994-95 and minimum of 0.77 MAF in 2000-01.

2.2.1.1 Western Tributaries (Indus Basin)

Annual average western river rim station flows (Indus at Kalabagh, Jhelum at Mangla and Chenab at Marala) from 1922 to 2006 are 138.41 MAF with Kharif inflows as 115.47 MAF and Rabi as 22.94 MAF, while post-Tarbela (1976-2004) are 140.69 MAF with Kharif 115.55 MAF and Rabi 25.14 MAF. Post Tarbela data has been used for subsequent analysis. In NWFP, the rivers Swat and Kabul contribute about 5.4 MAF and the remaining flows of Kabul joins Indus at Attock Bridge.

2.2.1.2 Eastern Tributaries (Indus Basin)

The three eastern tributaries of the Indus – Ravi, Sutlej and Beas have been allocated to India for its exclusive use. India has constructed the Bhakra Nangal Dam to harness the Sutlej, Pong Dam on Beas and Thein dam for harnessing the Ravi. The spills from these dams and unutilized flows enter Pakistan at Madhopur on the Ravi and below Ferozpur on the Sutlej. At present there is about 4.60 MAF of water which flows from India to Pakistan through eastern rivers. In addition, there is 3.33 MAF of run-off which is generated in eastern rivers catchments within Pakistan, particularly on the Ravi where a number of streams (Deg, Basantar and Bein Nullahs) join the Ravi upstream of Balloki.

2.2.2 Small Rivers (Small River Basins) – Outside Indus Basin

Out side the Indus Basin, there are smaller river basins, which drain directly to the sea on the Mekran Coast of Balochistan and a closed basin (Kharan), which in total amount to an inflow of less than 4 MAF annually. These streams flashy in nature do not have perennial supply. Some of the inflows are used for flood irrigation. There two main hydrologic units, namely the Kharan Desert, which is a closed basin, and the Makran Coastal basin, both in Balochistan. The rivers of the Makran coastal Basin flow into the sea. The water resources of these basins are small in relation to the Indus basin. Some flood irrigation is practiced from the flows of these rivers, which generally carry high sediment load as their watersheds are degraded.

2.3 Ground Water

Ground water has played a progressively increasing role in meeting the country's food and fiber requirements. Groundwater now supplies over 40 percent of crop water requirements of the country. There are about 1,000,000 tubewells installed to abstract groundwater in private sector. In addition, there are 16679 public sector tubewells (Scarps), of which approximately 50% are operational.

The groundwater is not really an independent resource since it owes its existence largely to the operation of canal system, but is of immeasurable value to the economy of Pakistan. The underground reservoir permits farmers to exercise greater control in terms of point of extraction, demand-based water use and results in timely application of water to crops. This has transformed the century-old concept of low crop yields to more secure and predictable form of crop production in Punjab and Sindh. Away from the Indus Plains, in the highland areas of Balochistan and North West Frontier Province also, localized groundwater has been crucial in supporting the agricultural sector. Latest studies indicate that there is a further development potential of approximately 6.4 MAF of groundwater, 1 MAF in Punjab, 4 MAF in Sindh, 0.4 MAF in NWFP and 1 MAF in

Balochistan. Recharge to groundwater reservoir, its existing uses and sustainable future development is given in Box 2.

Box-2 Existing Utilization and Sustainable Groundwater Potential		
Sr. No.	**Items**	**Quantity MAF**
A.	Total Annual Recharge	64.0
B.	Existing Uses (Average)	42.0
C.	Gross Potential (A-B) x 1.2*	26.4
D.	Non-Useable Groundwater in Saline Areas	20.0
E.	Sustainable Groundwater Potential (C-D)	6.4

*Recirculation of remaining ground water potential will be 4.4 MAF (20% of 22 MAF).

Source: National Water Policy by ACE and Halcrow (2003)

Despite this, however, there are certain high-economy areas such as the Quetta Valley where groundwater extraction has far exceeded the recharge and creating a disastrous situation. It may be stated here that groundwater use by private tubewells in Punjab and Sindh has risen by as much as 4 MAF largely through more pumping from the existing wells during the year 2001-2002 facing recent drought. Such emergency withdrawals are frequently accompanied by deterioration in the quality susceptible to vertical or lateral intrusion of saline water from deep saline aquifers or adjoining areas. There are other areas, within the Indus Valley, where marginal quality or even highly saline groundwater is being used for crops, leading to sodicity of soils. Besides marginal/deficient quality of groundwater, its usage costs many times more than the canal water does. For these reasons, the use of groundwater cannot be considered at par with the surface water supplies.

3. WATER REQUIREMENTS

3.1 Population and Food Projections

The population of the Pakistan in the 1972 census was 65.3 million with an annual increase of 3.2%. The population rose to 83.8 million in 1981 and 130.6 million in 1998 showing an increase of 2.64 percent from 1981 to 1998. It has been estimated that the rate of increase during the latter few years (immediately before 1998) had dropped down to 2.2 percent which is likely to further decrease with time. The anticipated population by the year 2010 would be 168 million with an annual increase of 2%, and 221 million by the year 2025 with an average annual increase of 1.81 percent.

Increase in population, rapid urbanization by the year 2025, and better socio-economic conditions, would put more pressure on food consumption. The consumption of various items for the year 2000 is 66 m tons and the anticipated requirements for the projected population of 221 million by the year 2025 would be 139 m tons (National Water Policy 2003).

3.2 Agricultural Water Requirements

To meet the food requirements, the increases in agricultural production are to be brought about through a combination of; a) increasing yields, which requires an improved agricultural policy environment, covering input supplies, production efficiencies, prices and marketing as well as improved research and extension services; b) increasing irrigation intensity of the existing cropped land, which requires additional water to be available which will have to be achieved though a combination of improved water management and improved efficiency and additional water availability at critical times of the year; c) increasing the irrigated area, for balanced regional development, poverty alleviation and higher functionality per unit of water.

On the foregoing basis i.e to meet the year 2025 food requirements with a nominal annual increase of 2 percent in export, the additional agricultural water requirements at farmgate are estimated to be about 20 MAF assuming 50 percent increase in crop yields due to non-water inputs. At canal head, the additional agricultural water requirement is 37 MAF (National Water Policy, 2003). To meet the short falls up to 2010/11, the additional irrigation water requirement at farmgate have been estimated at 12.61 MAF, which is 31.93 MAF at canal head (Pakistan Water Sector Strategy 2002).

3.3 Municipal Water Requirements

Most of the urban water is supplied from groundwater except for cities of Karachi, Hyderabad and part of the supply to Islamabad which mainly uses surface water. Most of the rural water supply from groundwater except in saline groundwater areas where irrigation canals are the main source of domestic water. The total existing water use for domestic and municipal purposes both urban and rural, is estimated to be 4.5 MAF. The estimated requirements for water supply, rural potable and sanitation requirements are estimated to be 10.5 MAF by the year 2025 which indicates the short fall of 6 MAF by the year 2025 (National Water Strategy, 2005). The shortfall up to 2010/11 have been estimated at 3.2 MAF (Pakistan Water Sector Strategy, 2002).

3.4 Industrial Water Requirements

There are over half a million big and small industrial units in the country of which nearly 120,000 units are involved in textile, chemical, fertilizer, tanneries, and other manufacturing and processing activities. The estimated existing uses of water by all industries and mines are estimated to be approximately 3.5 MAF. The industrial water requirement is expected to increase from 3.5 MAF at present to 4.8 MAF by the year 2025 indicating the additional requirement of 1.3 MAF (National Water Policy, 2005). Additional industrial water requirement have been estimated as 0.39 MAF upto 2010/11 (Pakistan Water Sector Strategy, 2002).

3.5 Environmental Water Requirements

Only small quantity of water at present is being used for wetland protections (400 major and 15,000 small), environmental preservations below Kotri, irrigated forestry and irrigated plantation along railway lines and roads. Existing uses are estimated about 1.3 MAF. In order to provide proper water to wetland areas, environmental protection, increase irrigated forestry along railway lines and roads about 1.7 MAF water will be required by the year 2025. For the year 2010/11, additional water requirement for this category would be 1.5 MAF. According to para 7 of the Water Apportionment Accord (1991), the need for certain minimum escapages to the sea below the Kotri Barrage, to check sea intrusion, has been recognized. The Sindh Province is of the view that the optimum level is 10.0 MAF, while recent studies have shown 8.6 MAF.

4. WATER AVAILABILITY AND REQUIREMENT GAP

The water resources available for future development are 35 MAF of river flow, 6.4 MAF of groundwater contribution and 3 MAF of rainfall harvesting. The additional agriculture water requirements for the year 2025 at farmgate have been estimated as 20 MAF. Besides, agriculture requirements, the estimated additional water needs to meet the municipal water supply, rural potable and sanitation industry and environment are estimated as 8 MAF (National Water Policy 2003).

Thus gross additional water requirements (at Farmgate) for all sectors will be 28 MAF. The corresponding requirement at Canal Head (including system losses where applicable) would be, nearly 45 MAF. As compared to the additional water requirement of 45 MAF, the total additional water available is about 35 MAF. Thus there is a gap of about 10 MAF of water to meet the future water requirements upto the year 2025. In the circumstances, the availability of 35 MAF will limit our development potential in various sectors.

5. HOW TO MEET THE SUPPLY, DEMAND GAP?

5.1 Situational Analysis

In meeting the future water requirements, it must also be recognized that river flows in Pakistan are highly uneven across the seasons and years. More than 80 percent flow is concentrated during three of the summer (Monsoon) months as compared to irrigation requirements of winter (Rabi) and summer (Kharif) crops which vary in the ratio of 40 and 60 percent, respectively. The year-round agricultural requirements can only be met if sufficient additional storage capacity is made available.

There is nearly 45 MAF shortfall in irrigation water requirements upto 2025, as estimated under Pakistan Water Sector Strategy (2002). This additional water has to come necessarily from flood flows, for which the need for creation of storages on Indus and other rivers has been recognized for planned future agricultural development.

By analyzing the situation, it becomes clear that about 35 MAF on the average water is escaped to sea. According to environmental studies commissioned by the office of CEA/FFC, 8.6 MAF of water is to be released below Kotri for environmental safeguard. Further anticipated uses to the volume of 5.2 MAF are as detailed: Mangla Raised Project (2.9 MAF), Afghanistan uses on Kabul river (0.3 MAF and Indian future uses western rivers (2.0 MAF). The balance surface water potential available for developing storage is 21.4 MAF against our total demands of about 45 MAF. The WAPDA Vision 2025 projects including Mangla Raised Project at various stages of planning/development are envisaged to store about 26 MAF surface water flows about 22 MAF in Indus River Basin and 4 MAF outside Indus Basin). After commissioning of WAPDA Vision 2025 projects, there will still be a gap of about 19 MAF at canal head. A potential of 6.4 MAF from ground water aquifer is available which need to be explored and is expected to be utilized through private sector. This ground water contribution will bring the gap to about 5.6 MAF at farm gate. The National Watercourse Rehabilitation/ Improvement Programme will result in saving of about 6 to 8 MAF water which will bridge the anticipated gap of 5.6 MAF.

From the discussion, it is clear that the balance of total additional water resources i.e. 35 MAF escapages to sea} ground water exploitation and conservation measures (watercourse improvement) are only sufficient to meet the requirements of water for nearly two decades or so, afterwards increasing reliance shall have to be placed on other measures such as adoption of conservation techniques to save water at all levels, adoption of demand based high efficiency irrigation systems, harnessing hill torrents, and employing modern water management technologies. As these change-overs cannot be brought about in a short span of time, it is necessary that the path to conservation and modernization be developed gradually to sustain future water demands.

5.2 Additional Storage: Large and Small (WAPDA Vision 2025)

To meet future water requirements, to an appreciable measure, it would be necessary to create large storages on Indus River. It is well known that storage projects take considerable time and effort for completion and need mobilization of heavy capital investment. Considering the acute shortage of water in coming years, the need for starting work on a major storage project is eminent.

In view of above situation, The Pakistan Government through WAPDA has launched a comprehensive integrated water resource and hydropower development Mega Plan Vision-205 for development of water reservoirs and hydropower generation. Under this programme water storage/reservoir sites of about 65 MAF total capacity and Power

Potential sites of 35,000 MW in whole of Pakistan including Northern Areas and A.J.K, have been identified. The Vision Programme envisages a comprehensive programme for undertaking feasibility studies, detailed engineering designs and preparation of tender documents of a number of projects, at a cost of approximately Rs. 4 billion to be financed by WAPDA from its own resources. Under Vision 2025 programme implementation of such projects as Raised Mangla Dam, Gomal Zam Dam, Hingol dam & Mirani Dam, etc. are undertaken on fast track basis. The implementation of vision 2025 will not only generate additional power and agricultural produce at cheaper rates but will also provide the employment to millions of people during and after construction of the projects.

On 17th January 2006, President of Pakistan, General Pervaiz Musharaf announced the construction of five water resources projects on priority basis. These projects which include Basha-Diamer, Kalabagh, Akhori, Munda and Kurram Tangi Dams, would be completed by the year 2016.

Under WAPDA Vision 2025 Programme, the following storage projects are at different stages of development and engineering studies:

5.2.1 Raised Mangla Dam (AJK)

Mangla reservoir provides storage to the two perennial rivers Jhelum and Poonch. At conservation level of 366.35 m the reservoir has a surface area of 100 sq miles and a peripheral length of 402.25 km. By now about 1.20 million acre feet sediment has deposited in the reservoir. The average rate of deposition has been about 34,000 acre feet per annum. The main objective of Mangla Dam Raising by 9.14 m is to regain the storage capacity of Mangla reservoir lost to sedimentation. Direct benefits would include additional water availability, additional power generation, flood control and increase in fish yield.

5.2.2 Mirani Dam Project (Balochistan)

Mirani Dam Project is located on Dasht river, about 40 Km west of Turbat in Makran Division of Balochistan. The Dam will create a storage of a capacity of 0.302 MAF. This carry over type storage would be able to sustain an annual water availability of about 114000 Acre Ft. This water would be distributed through a lined irrigation system to 33200 acres of land, lying on both banks of Dasht river. This project has been completed and was inaugurated in November 2006 by the President of Pakistan.

5.2.3 Gomal Zam Dam Project (NWFP)

Located at Khajuri Kach 24.38 m . wide narrow gorge on Gomal River in the federally administered South Waziristan tribal territory, about 100 Km to the west of Dera Ismail Khan, the Gomal Zam Dam is a multipurpose irrigation, power generation and flood control project. It will bring 1,63,086 acres, in Tank and Dera Ismail Khan districts, under cultivation besides generating 17.4 MW of electricity. It will cost Rs. 12.829 billion and will be completed in March 2010.

5.2.4 Subakzai Dam (Balochistan)

The proposed dam, having a live storage capacity of 0.0147 MAF is located across "Sawar Rud", a small tributary of Zhob river, in district Zhob of the province of Balochistan. It will store flood water for the development of irrigated agriculture on command area of 6,680 acres. The project is studied to be completed in March 2007.

5.2.5 Satpara Dam (Baltistan)

Satpara multipurpose dam site is located on Satpara nallah at the downstream end of Satpara lake, which is about 9 Km South of Skardu town. The dam will have a storage capacity of 0.083 MAF and will provide irrigation to about 15,536 acres of land located on both banks of the Nallah. Te proposed project would produce 16.76 MW electric power. The project is studied to be completed in June, 2008.

5.2.6 Diamer-Basha Dam Project (Northern Area)

Diamer Basha Dam is planned to be constructed on Indus River near Chillas (Northern Areas & NWFP) 300 km upstream from Tarbela Dam and about 40 km downstream of Chillas Town. The project includes construction of a 270 m high dam to create a reservoir of 7.00 MAF gross storage capacity and 4,500 MW power generation. The feasibility of the project was completed in 2005. Detailed engineering design and Tender Document preparation work is scheduled to be completed in March 2008. PC I for land acquisition has been sent to CDWP and is under approval process.

5.2.7 Kalabagh Dam Project (Punjab)

Kalabagh Dam Project site is located 210 Km downstream of Tarbela Dam and 26 Km upstream of Jinnah Barrage on the river Indus. The project envisages construction of 79.24 m high rock-fill dam. With its maximum retention level at 278.88 m SPD it will create a reservoir with usable storage of 6.1 MAF. The project has two spillways on the right bank for disposal of flood water. In the event of the highest probable flood, these spillways will have a discharge capacity of over 2 million cusecs. On the left bank is the power with ultimate generation capacity of 3600 MW. Implementation of the project would take 7 years for the first power unit to come in operation. Kalabagh will yield direct annual benefit of Rs. 56 billion from irrigation supplies, power generation and flood alleviation. Additionally indirect benefits like more industrial and food production, employment and agricultural boost will accrue.

5.2.8 Akhori Dam Project (Punjab)

Akhori Dam is planed on Nandana Khas River about 6.44 km u/s of Attock District near Akhori Village. The objectives of the project are storage supplies of Indus River for supplementing the existing system of Indus Basin and development of new irrigation to some extent. The project includes construction of a Earth Core and Rockfill dam of 122 meter to create a reservoir of 7.00 MAF gross storage capacity. The power generation would be 600 MW. The feasibility study of the project has been completed on 27.01.2006.

5.2.9 Munda Dam Project (NWFP)

Munda Dam is planned on Swat River about 5 km u/s of Munda Headworks Mohmand Agency (FATA). During the pre-feasibility study 213 m high dam has been found to be more technically and economically viable. The reservoir would be developed having a gross storage of 1.30 MAF. It has installed capacity of 740 MW. The project would irrigate 15,097 acres of land on left side of the Swat River besides, this will supplement the shortage of irrigation in Lower as well as Upper Swat Canals. The project will also provide the flood mitigation downstream of Munda Headworks. Feasibility study (Draft) submitted by M/S AMZO in May 2006.

5.2.10 Kurram Tangi Dam Project (NWFP)

Kurram Tangi Dam project is planned to be constructed on Kurram River in North Waziristan Agency about 14.5 km upstream of Khurram Garhi Headworks and 305.7 km north of Bannu city in NWFP. The project includes construction of 90 m high dam to create a reservoir 0.914 MAF (Gross) and 0.614 MAF (Live). The power generation would be 83 MW. The Feasibility study of the project has been completed.

5.2.11 Winder Dam Project (Balochistan)

Winder Dam Project is proposed across Winder River about 125 km from Lasbela city about 66 km from Uthal in Balochistan. Brief Scope of the project includes to irrigation of agriculture development of 10,000 acres, drinking water and groundwater recharge. The project includes construction of a dam with height of 92 ft to create a reservoir of storage capacity 40,500 AF (Gross) and Live Storage 36,500 AF.

5.2.12 Naulong Dam Project (Balochistan)

Naulong Dam Project is planned across Mula River at Sunt about 30 km from Gandawa City in Tehsil and District Jhal Maagsi of Balochistan. Brief scope of the project is to irrigate 25,000 acres of land and flood mitigation. The project includes construction of a dam with a height of 138 ft to create a reservoir of 124,000 AF (Gross) and 99,000 AF (Live). The consultants for the detailed engineering design and tender document have been appointed in November 2006.

5.2.13 Sukleji Dam Project (Balochistan)

The Sukleji Dam project is planned on Sukleji River to store 56,200 acre feet of inflow for irrigation of about 10,000 acres of land and to generate 100 – 150 KW of hydropower at a cst of Rs. 1.96 billion.

5.2.14 Hingol Dam Project (Balochistan)

The proposed Hingol Dam is planned on the Hingol River and project area lies in Lasbela District of Balochistan. The culturable command area of the project is about 49,950 acres to be irrigated by network of gravity canals supplying 276 cusecs of water in addition of generation of 300 KW hydropower.

5.2.15 Nai Gaj Dam Project (Sindh)

Nai Gaj Dam Project is planned on Nai Gaj River at the terminal ridge of Kirther Range and lies in district Dadu Sindh. The scheme is meant to irrigate cultivable lands available in the vicinity of the Nai Gaj Dam Project for irrigated agriculture development of agro forestry. The project includes construction of a dam with a height of 45.71 m to create a reservoir of 174,000 AF Gross) and 130,000 AF Live).

5.3 Conservation/System Improvement/Technological Innovations

There is a need to reduce the water losses from the water supply systems. Conservation measures will include following areas of activities at the National, Regional and Farm levels as narrated hereunder:

5.3.1 Lining of Main Branch Canals

Lining is considered expensive and is even questioned for its effectiveness. However, in those reaches, where the canals pass through lands underlain with saline ground water, the seepage for the canal to ground water is not recoverable and is a total loss. This gets more pronounced if water does not carry sediments and the silt lining eventually gets eroded. For instance, Lower Jhelum canal carries clean water of Mangla Lake and generally commands lands underlain by saline ground water. Lining of this canal is proposed to be taken up as a pilot national programme for water conservation.

5.3.2 Lining of Distributary and Minor Canals

Properly designed and constructed lined channels at Distributary and minor level will not only help save substantial amount of precious water, but would also ensure better command, equitable distribution of water and allow for increased capacities of channel for demand based operation of the system.

5.3.3 Farm Level

Most of the water loss is taking place at farm level – principally as seepage from the bed and sides of watercourses and as deep percolation below the root zone from the fields. Evaporation loss is largely unavoidable although micro irrigation techniques or a piped water distribution system at the farm level will significantly reduce this loss. The On-Farm Water Management Program aims at reducing conveyance losses and field losses by improving watercourse, precision land leveling, organizing WUAs and establishing demonstration plots. In addition, water storage tanks are constructed and lifting devices installed on streams so as to provide irrigation water to barani agricultural land.

Government has launched National Programme for Improvement of Watercourses in Pakistan during 2004. The project aims at improvement/construction of 86,999 watercourses at the cost of Rs. 66 billion. These watercourses have been proposed to be improved during the five years. In addition, about 184,740 acres of agricultural land will be precisely leveled. The implementation of watercourse improvement programme shall improve the availability of water at farmgate, which is estimated to be between 6.0 to 8.0 MAF. This water is, however, available to only the existing users and not transferable to other users or areas for bringing additional areas under cultivation.

5.3.4 Irrigation System Rehabilitation Programme

This programme is already being implemented by the provinces with the financial assistance of international donor agencies. The need for this programme would have not arisen, had the O&M been adequately funded and properly executed. The huge cost and effort which is being consumed by rehabilitation programme could have been directed towards modernization of irrigation system. The conservation aspect in rehabilitation is only marginal whereas substantial water savings can be achieved if rehabilitation is substituted by remodeling and modernization.

5.3.5 Flood Water / Hill Torrents Conservation

The active flood plains of the Indus River and its major tributaries total some five million acres. Within this area, about 1.7 million acres are under crops, about 3,50,000 acres are in woodland and grazing is done on much of the cropped and non-cropped land. Agriculture is dependent primarily on residual soil moisture and high water table after flooding, although, in some more elevated area pumps and tubewells are utilized.

Lands under torrent sailaba area are cropped using residual moisture from hill torrent flooding. Many techniques have been developed over time for conservation and utilization in Sindh, NWFP and Balochistan. The flood flow of all rivers and hill torrents of Balochistan has been assessed as 10 MAF which almost go waste rather causing damage to land and population. To utilize the flood water for agriculture development and other purposes the flood water could be stored diverted to lands after preparing proper feasible projects.

5.3.6 Remodeling and Modernization of Irrigation System

Remodeling and modernization should take care of inequitable distribution of water. At present 60 percent of irrigation areas at the tail commands are either getting no water or the supplies are far below the authorized supplies. The irrigation system should now begin moving towards a demand based supply system. This may involve huge expenses and may not be economical as a large scale measure. Pilot schemes can be implemented at strategic locations in all the provinces. Further expansion can take place after monitoring the results of completed schemes. Barrages constructed on Indus and its tributaries play a pivotal role in diverting irrigation water to the command areas. With the passage of time these key components have developed a number of defects. Besides rehabilitation and strengthening of most vulnerable barrages and associated structures, it is also necessary to upgrade and modernize the electro-mechanical features and improve O&M capabilities.

5.3.7 Improvement of Communication and Canal System

For the efficient regulation and operation of the irrigation systems, it is important that data from the gauging stations installed all over Indus Basin Irrigation System (IBIS) are communicated to provincial and federal agencies concerned with the management of the system. It is also not possible to make quick adjustment in response to rainfall in the far stretched command areas. These problems can be overcome by adopting modern communication technology, based on automatic telemetric system. Availability of accurate and timely data will improve regulation which in turn will result in equitable distribution of water. Now automatic telemetric system is in place and let us hope for improving water distribution system by IRSA.

5.3.8 Introduction of Sprinkler and Drip Irrigation

There is a great potential for reducing water use through introducing Sprinkler and Drip Irrigation for many crops, while it is true that capital investment can be intensive for modern mechanized irrigation such as these, consideration should be given to their introduction and means of financing them, given the increasing scarcity of water in Pakistan.

6. CONCLUSIONS AND RECOMMENDATIONS

Pakistan water-resources have been diminishing at an alarming rate, as can be concluded from the stated facts in this paper. The quality of water is also deteriorating with time. To improve the situation, the Vision-2025 Programme need to be implemented in an organized and coordinated way, through concerted efforts including better water management at the field level and good-governance and institutional arrangements. It is concluded and recommended that:

- Surplus surface water of at least 21 MAF is available for immediate development of big storages on the Indus;
- Sedimentation of existing reservoir is enhancing with time thereby reducing the water availability;
- Country is likely to face serious water, food and power shortages after 2010;

- If cheep hydropower is not added to the system the electricity would become more expensive.
- It is strongly recommended that construction of storage of ready projects of reservoir and hydropower should be started immediately;
- The provincial governments and its various Research and Development departments and agencies, like the On-Farm Water Management Project, the extension directorates of the Agricultural Department, will play a major role in the execution of the activities related with high-efficiency irrigation systems and lining of minors and watercourses in saline zones. The Irrigation Department will look after the execution of water development projects of local and regional level like small dams and reservoirs, karez management, harnessing spring-water, groundwater regulation, etc and
- The high irrigation systems like drip and sprinkler need to be developed at appropriate sites for popularizing such technologies among farmers. The ultimate solution of water scarcity lies in adoption of such technologies depending upon economic feasibilities and in attaining more production per drop of water.

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COMBATING WATER SCARCITY

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GENERAL

The valleys of the River Indus and it tributaries, called “Indus River Basin” constitute the heart land of Pakistan. It includes the mountain basins of the north and the west, the Indus Plains, the Kachhi Plain, Desert areas of Sindh and the Rann of Kach. Population density is the highest in the canal irrigated areas in the north east of Indus Plains. The arid Plateaus and barren mountains, on the other hand, are least inhabited. The increasing population and the associated social, technical and economic activities all depend, directly or indirectly, on the exploitation of water as a resource.

The total area of Pakistan is 196 million acres(MA). Out of which about 103 MA comprise rugged mountains, narrow valleys and foot hills, the remaining area of 93 MA consists of flat aggradational plains and sand deserts. About 77MA can be used for cultivation, but only about 54.4 MA is currently cultivated. Remaining 22.5 MA is lying barren for lack of water. Fig. 1 presents the land use of Pakistan.

An annual average of over 35 MAF water escapes below Kotri barrage However, this surplus water in the river system is available in about 70-100 days of summer only. To save and utilize this water, construction of additional storage facilities is essential.

PAKISTAN’S WATER RESOURCES

Per capita availability of water has been gradually dwindling in Pakistan from 5260 cubic metres in 1951 to 1100 cubic metres in 2006. It is projected that by 2010 per capita availability of surface water may hit 1000 cubic metres, which is a threshold for defining 'a water short country' Fig.2.

Pakistan's economy mainly depends upon Agriculture. It is the single largest sector and accounts for 24 per cent of the GDP and employs 50 per cent of the total workforce. About 68 per cent of country’s population lives in rural areas and is directly or indirectly linked with agriculture for its livelihood. Over 70 per cent of our exports rely upon agricultural-based products. Water is the mainstay of agriculture. Irrigated agriculture provides 90 per cent of food and fibre requirements from about 42.5 million acres which is around 80 per cent of the cultivated area, while the remaining is contributed by over 10 million acres of barani (rain-fed) land.

About 1/3rd of the agricultural potential of Pakistan remains untapped because of non-development of water resources and associated infrastructure.

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Irrigated area of Pakistan has enhanced from 20.7 MA in 1947 to 54.5 MA due to construction of a large number of irrigation works since independence. As a result, Pakistan now has the largest contiguous irrigated area of the world. The Indus River Basin System has three (3) multipurpose dams / reservoirs, nineteen (19) barrages, twelve (12) link canals and forty-five (45) independent main canal commands.

Population growth, rapid urbanization and industrialization are imposing growing demands and pressures on water. The rising imbalance between supply and demand has led to shortages and unhealthy competition leading to inter-provincial tension. Its misuse has led to environmental degradation in the form of persistent water logging in certain areas and rapid decline of groundwater levels in other areas. Intrusion of saline water into fresh groundwater aquifer is another problem caused by excessive pumping.

The growing shortage of water which reaches alarming proportions during the drought years requires that a concerted effort be made to conserve water, develop available water resources to the optimum and adopt modern technologies for more efficient irrigation techniques. Unless this is done, self-sufficiency in food, socio-economic amelioration, alleviating poverty and conservation of environment would not be possible. Eventually food shortages and even famine-like conditions may arise in the country.

Besides irrigated-agriculture usages, - water plays an intrinsic role in many other sectors such as domestic, industrial, mining, livestock, fisheries development, etc. Hydropower is the cheapest and environmentally the cleanest way of generating electricity. Its abundant potential in Pakistan has to be developed on a priority basis if the current trend of rising power tariff is to be reversed. In order to meet the needs of growing population for water supply and sanitation, food and fibre, industry and environment, the conservation of this precious resource and development of water resource projects would be essential. Achieving sustainable development will, thus, be a major challenge in the 21 st century.The major exploitable water resources of Pakistan are:

Surface Water

Snow melt and Rainfall

Monsoon and Westerly currents are the two main weather systems that contribute to rainfall over Pakistan. Average annual rainfall over Pakistan is 11.4 inches.

A major portion of hill torrent flows not only goes waste but also causes damages in the areas which are already underdeveloped. The total development potential of hill torrents is estimated as approximately 10 MAF of which 5 MAF has already been conserved through the construction of more than 500 structural interventions such as delay action dams, dispersion structures, retaining walls, etc. Approximately 3 MAF is considered a reasonable quantum for further harnessing by the year 2025.

River Flows

Pakistan has three (3) major river basins with the following average annual flows:

	MAF (Million Acre Feet)
Indus Basin	144.0 to 151.0
Mekran Coastal Basin	3.0
Kharan Closed Desert Basin	0.8
Total	147.8 to 154.8 MAF

Of the total available annual flow in the Indus Basin, 105 MAF is already being used through a system of storages and distribution network.

The total surface water available is 154.88 MAF. By subtracting the 105.00 MAF water required for canal diversion and 15.00 MAF for system losses, the net available surface water is 34.88 MAF.

Fig-3 Shows that the average escapages below Kotri is 35 MAF. Subtracting from the water flowing d/s of Kotri, the requirement for the ongoing projects and the below Kotri requirement, 21.5 MAF is still available for future development.

Groundwater Resources

The vast and readily available groundwater resources *of* Pakistan have played an increasingly important role in meeting the country's food and fibre requirements. Groundwater now supplies around 45 per cent *of* crop water requirements in the country since it permits the farmers to exercise greater control over available water in its timely application for crops. Crop yields have nearly doubled due to use *of* groundwater in addition to rotational canal water supplies. It is, therefore, imperative that long-term sustainability *of* groundwater, as a resource, is maintained.

The aggregate groundwater potential is estimated to be approximately 50 MAF *of* which 42 MAF is being currently used annually through more than 700,000 tube wells installed and operated by the farmers themselves, and about 5,000 public sector operating tube wells. Fig.4.shows growth of tubewells with time.

The pace at which the groundwater exploitation has unfolded has also added to the complexity *of* its management. In some regions, water extraction impact on the groundwater is alarming; groundwater levels are declining rapidly to unfeasible pumping depths, and there is intrusion *of* saline water in the fresh groundwater areas through lateral or upward movement *of* the former. At the same time, there are some areas especially saline water area where water logging still persists due to inadequate pumping and/or drainage. It has been estimated that a further potential *of* some 6 to 8MAF exists in the development *of* Pakistan's groundwater resources. In some areas it is being overmind.

Projected Water Requirements

Population of Pakistan stands at 158 million and is likely to increase to about 220 million by the year 2025.

Projected food requirements have been estimated based upon population growth and the requisite caloric needs. The per capita consumption *of* food and fibre, thus, calculated, indicates the projected water requirements at the farm gate which is 142 MA, as depicted in Fig. 5.

Wastage of water in the irrigation system

Pakistan has the largest contiguous irrigation system in the world. It is estimated that 40 to 50 per cent of water is lost between the canal headworks to the farm gate. Lining of Canals is considered a good solution to this problem. But lining of canals is a great issue as canals will need to be closed long enough to deprive the farmers of at least one crop and the farmers are not willing to pay this price for Canal Lining. The irrigation application rates within the farms are also high because of reliance on the conventional flood irrigation. With the passage of time, water as a commodity is becoming more and more precious. Above all it is a finite source. This high percentage of wastage, therefore, can. not be afforded for long. Wastage of water through poor infrastructure or poor water management constitutes a major issue related to the water resources of Pakistan. Another aspect of this issue is the productivity of the farms against per cusec of irrigation water. Pakistan has a much lower rate of production as shown in Fig.-6. The irrigation efficiency, therefore, needs to be enhanced.

In view of the huge (around 45 to 50 per cent) losses of irrigation water between canal-heads and the farm gate, water conservation should be accorded a high priority. Lining of Canals and Water courses should be taken in hand more vigorously.

Measures Required for Water Conservation

Water resources can be conserved by employing a number of interventions including the following:

Surplus river flows can be conserved by constructing storages/dams at suitable locations on the river system or as off-channel storages.

Rainwater harvesting techniques can be used to conserve rainfall run off. The primary methods are by constructing the following types of interventions.

Delay action/storages dams

Diversion/dispersion structures

Flood walls

Construction of ponds

Constructing leading/feeding channels to the fields

Spreading chemicals to seal the catchment areas and inducing more run off

Lining of channels in saline groundwater areas

Laser leveling of farms

High-tech irrigation methodologies

Use of sprinkler irrigation system

Use of drip

Fig.7 and Fig-8 shows model forms using sprinkler and drip irrigation system at Mirani Dam area.

Use of skimming/radial well technology to skim off fresh water overlying saline water
Use of bio technology for improving the chemistry of saline water for plant growth

Need for Development of new Storage Reservoirs

The development of river water resources has remained stagnated since 1976 and no new storage or irrigation project could be constructed after the completion of the Tarbela Dam. This was originally thought to be due to continuation of the age-old dispute between the Provinces over sharing of Indus Waters. Signing the Water Accord between the four Provinces and its ratification by the Federal Government in 1991 should thus have paved the way towards further irrigation development in the country. The salient features of the Accord includes clear definition of provincial shares in the existing river diversions, as well as for future development projects, the establishment of an authority for regulation and distribution of river waters to the provinces, and the recognition of the need to construct storages for planned future agricultural development.

The perceived benefits of the Accord, however, have not materialized so far in the shape of any new storage. The existing river supplies are totally committed to the existing projects. Therefore, in order for the Accord to be really meaningful and for it to play an enabling role in irrigation development, there is a need to initiate immediate steps to manage surplus river flows, which are currently going waste into sea.

The growing food and fiber requirements of the country as projected category-wise over the next 25 years, with a nominal export growth element of 2 percent per year indicate the need for 44 MAF of additional water.

Furthermore, the element of additional water availability of river flows of 23 MAF at canal heads, can contribute towards meeting the requirements only if additional storages are built without which flood water utilization will not be possible . An additional storage capacity of 18 MAF would be necessary while remaining 5 MAF would be the corresponding direct use of river flood flows.

Besides non-exploitation of available surplus water in Pakistan, combined with rising population pressure on existing irrigated areas, the fact is that with passage of time, the quantum of irrigation water presently available will go on declining even further. This is so because sedimentation of Tarbela, Mangla and Chashma Reservoirs is resulting in a gradual depletion of the storage capacity of the system. With some 3 MAF of storage water already lost, it is becoming an impossible task to even sustain the present level of irrigation supplies. Another disturbing factor is that the sediment delta, for instance in the Tarbela lake, is heading rapidly towards the dam; at a pace of approximately a kilometre each year. The 200 feet high delta close to the dam and its structures will pose many serious dangers to the safety of the Project.

The country also passes through periodic calamities caused by the phenomenon of recurring floods. Floods of such magnitude are detrimental, not only in financial terms, but also in terms of severe undermining of a productive system which should logically be free from uncertainties and frequent dislocations. One economical way of mitigating floods is through multi-purpose carryover storages which permit beneficial use of stored flood waters spread over more than one (1) year. Such carryover storages, are also of enormous help in riding over drought-year calamities.

Finally, an accelerated economic growth of Pakistan depends upon adequate and assured input of electric supply at a reasonable cost. The demand of electricity has been growing rapidly which is typical of developing countries. Input of hydropower on a large scale is the only answer if cheap and environmentally clean electricity is to be added to the current blend which is heavily dominated by expensive thermal generation.

Surplus stored flows of the Indus River System can be utilized either by remodeling of existing irrigation system and improving canal supplies for increasing cropping intensities or by constructing new canals to irrigate new areas.

It is planned to supply surplus water of Indus River during Kharif season for about 60 to 100 days. After the construction of storage dams, the supplies to these canals can be improved. This demonstrates that it is more expedient to provide surplus water to new areas to improve the socio-economic conditions of these areas and to help to meet the adverse effects of droughts.

If nothing is done about the depletion of reservoir storages as a result of sedimentation of reservoirs, then the water availability for irrigation and other uses will continue to decline. This is a significant issue to be addressed under the policies and strategies and, perhaps the most controversial issue in Pakistan.

CONCLUSIONS & RECOMMENDATIONS

Country is likely to face serious water, food and Power shortages after 2010.

Surplus surface water of at least 25 MAF is available for immediate development of three big storages on the Indus.

It is strongly recommended that construction of a large reservoir and Hydropower Project on river Indus should be started immediately.

Concurrently small storage dams and run of river hydropower stations should be built where feasible

Modern Irrigation Technology should be adopted.

Conservation of Hill Torrent Flow to transform the concept of uncertain crop yields to secure crop production.

Regulation of Ground Water usage.

If cheap hydropower is not added to the system the electricity would become more expensive.

ROLE OF GROUNDWATER IN COPING WITH SCARCITY OF WATER

By

Dr. Muhammad Nawaz Bhutta[3]

ABSTRACT

Water scarcity is among the main problems to be faced by many societies and the world in the 21st century. 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. Major supply sources for water in Pakistan are rivers flows, groundwater and rainfall. Average annual canal diversions from rivers are 106 MAF out of which 58 MAF reaches at the farm gate. Total annual groundwater potential is 65 MAF out of which 59 MAF reaches the farm gate. The rainfall is concentrated in monsoon period and that too not reliable. Therefore total availability of water for use is 117 MAF. Per capita availability of water has decreased from 5651 m^3 in 1951 to 1350 m^3 in 2002. The requirements for domestic water supply and sanitation, industry, environment and agriculture are 5.2, 2.2, 1.3 1.6 and 140 MAF respectively. Therefore, total present water requirements are 150 MAF. There is a gap between requirements and demand which will increase with the passage of time. The scarcity of water is adversely affecting agricultural production and living of people. In the past the gap was partially filled with groundwater use. But unfortunately use of groundwater has reached its maximum limits. Although growth of private tubewells have increased over the years but the utilization factor have gradually decreased. The groundwater table in the Indus Basin has started falling. Therefore, it is recommended that recharge to groundwater should be given highest priority for its sustainable use. In addition the canal diversions should be increased to reduce dependence on groundwater. Deterioration of groundwater quality and pollution are also serious issues. Therefore institution needs to be strengthened for protection of groundwater quality.

1. INTRODUCTION

Water is essential to the survival of all living things-plant, animal and human. About 70 percent of earth is covered with water, and 97 percent of that is part of salty Oceans. Remaining 3 percent is the fresh water out of which, less than one percent of

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fresh water is useable, amounting to only 0.01 percent of the Earth total water. This includes sources like rivers, lakes and groundwater (Figure 1).

Water scarcity is among the main problems to be faced by many societies and the world in the 21st century. The threshold of 2000 m^3 per year per person is considered to indicate that a region is water stressed since under these conditions population face large problems when a drought occurs or when men made shortages are created. Water scarcity is commonly defined as the situation where water availability in a country or a region is below 1000 m^3 per person per year. However many regions in the world experience much more sever scarcity living with less than 500 m^3 per person per year which would be considered sever water scarcity.

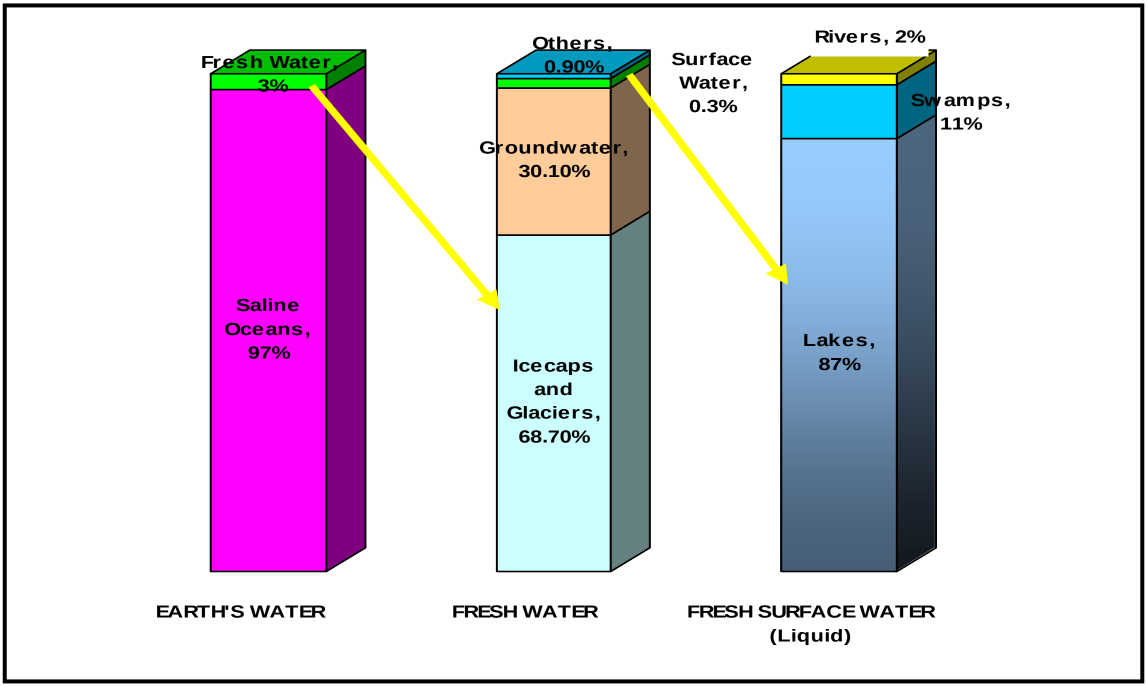

Figure 1 Distribution of Earth Water

Water scarcity causes enormous problems for societies and population. The available water is not sufficient for the production of food and for alleviating hunger and poverty in these regions, where quite often population growth is larger than the capability for sustainable use of natural resources. 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.

1.1 Objectives

The main objectives of the paper are to:

i) Evaluate the importance of groundwater in meeting water demands;
ii) Assess the sustainability of groundwater use; and
iii) Prepare recommendations for groundwater management.

2. AVAILABILITY OF WATER

Water is a critical resource for sustainable economic development of Pakistan. The growing imbalance between supply and demand has led to the shortages and competition. Main source of water in Pakistan are rivers, groundwater and rainfall.

2.1 Rivers

Indus Basin flows are highly variable on seasonal and yearly basis. Advent of high variability dictates that river flows be conserved and managed to optimally meet agricultural requirements. The analysis of inflow record of the three Western Rivers from the year 1976-77 to 2003-04 indicates that annual flow varies from 172.1 MAF (1991-92) to 97.17 MAF (2001-02). Kharif flow variation is from 157.24 MAF (1978-79) to 84.7 MAF (1974-75). Average annual availability of river flows in Kharif is nearly 85 percent, while balance water is available during Rabi season as against requirements of nearly 60 percent and 40 percent during Kharif and Rabi respectively. Magnitude of variation between maximum and minimum Kharif flow is over 75 MAF. Existing storage capacity is about 18.75 MAF, while reservoirs transfer 15.12 MAF on an average annual basis. Thus, in order to optimally, utilize and transfer surplus Kharif flows to Rabi, the additional storage capacity of dams should be around 60 MAF. Figure 2 indicates the historic canal diversions and population growth in Pakistan. At present average annual canal diversions are 106 MAF. Per capita availability of water has decreased from 5651 m^3 in 1951 to 1350 m^3 in 2002 (Figure 2). Reduction in per capita water was due to increased population and lack of storage facilities.

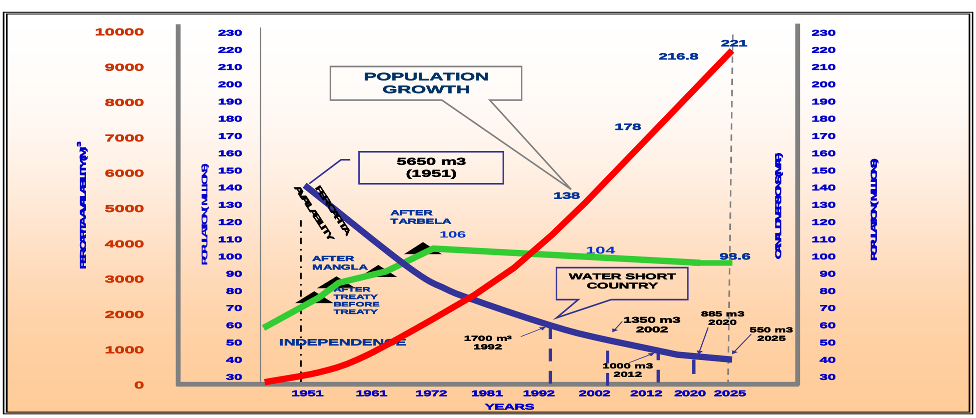

Figure 2 Historic Canal Diversions and Population Growth

2.2 Groundwater

Groundwater is not an independent source but has been developed by recharge from irrigation system during the past one century. Indus Basin has one of the largest under ground water reservoir. The watertable in the canal commands had continued to rise since the introduction of irrigation system. This was due to positive groundwater balance in these areas. However, the watertable has started depleting in almost the entire Indus Basin. This suggests that the groundwater pumpage has reached to its maximum limits and groundwater discharge is more than the recharge. It also raises a question about sustainability of groundwater use.

2.3 Rainfall

The annual average effective rainfall over most of the agricultural area of the Indus Basin Plains is about 9 inches but is un-reliable. Therefore dependence of agriculture on rainfall is not possible.

3. WATER USE BY DIFFERENT SECTORS

Starting from customary and religious law and individual ownership to communal rights and public regulations, there have been evolutionary changes in water management since time unmemorable. The changes brought about covered various aspects of institutional, legal and conceptual frameworks. Over hundred years ago, it was simple case of diversion of river water and maintaining supplies through the canal system. Forty years ago, groundwater element joined the surface water requiring for conjunctive use management.

Water using sectors are agriculture, domestic water supply and sanitation, industry, environment and recreation. At global level, the withdrawal for agriculture is 67%, industry uses 19% and municipal and domestic uses account for 9% and 5% is for other uses including recreation and environment. In more developed regions of Europe and North America, industry is the major water consumer. Pakistan’s population in year 2002 was 140 millions and in the year 2025 it is estimated to be 220 millions. There will be greater demand for food, fiber and increased economic activity. Economic activity and development affect income, its distribution and life styles. Development, technological changes, income distribution and life style affect the level of water demand. Water uses by different sectors in the year 2000 are given in Table 1. These uses are much lower than the actual requirements. A growing population and a rising level of economic activity increase demand for water. Water analysts foresee increased competition among water users in meeting the growing demand. They predict that competition will increase among the three largest users.

Table 1 Water Use by Different Sectors in year 2000

(MAF)

Uses	Total
Agriculture	99.0
Water supply and sanitation	4.5
Industry	3.5
Environmental/Recreation	1.3
Total	108.3

Source: National Water Policy – ACE – Halcrow, December 2002.

3.1 Agriculture

Crop water requirements have been calculated based on cropped area of 2004-05 and are given in Table 2. Crop water consumptive use is 105 MAF. If field application efficiency is taken as 75 percent, the requirement at farm gate will be 140 MAF. Table 1 indicates that present water use or available for agriculture is 99 MAF. This shows a great gap between crop requirements and availability of water for crops. This is the major reason for low yields of crops in Pakistan. Scarcity of water also discourages farmers for investment in non-water inputs for increasing crop production.

Table 2 Total Crop Water Consumptive Use in 2004-05 (MAF)

Crop	Punjab	Sindh	NWFP	Balochistan	Pakistan	% of Total
Wheat	20.69	3.24	2.55	1.00	27.47	26.1
Rice	14.22	4.85	0.44	1.44	20.95	19.9
Cotton	13.26	3.35	0.00	0.21	16.82	16.0
Sugarcane	6.27	2.09	0.86	0.00	9.22	8.8
Maize	1.45	0.01	1.63	0.03	3.11	3.0
Coarse grain	1.56	0.21	0.13	0.10	2.00	1.9
Oilseeds	0.90	0.64	0.08	0.06	1.68	1.6
Pulses	2.67	0.29	0.17	0.11	3.44	3.3
Fruits	3.29	1.11	0.33	0.22	4.95	4.7
Vegetables	1.09	0.14	0.20	0.16	1.60	1.5
Fodders	5.31	0.72	0.30	0.20	6.52	6.2
Others Crops	7.23	0.06	0.18	0.01	7.49	7.1
Total	78.14	16.70	6.86	3.55	105.26	100

3.2 Domestic Needs Including Sanitation

Per capita water consumption varies greatly in urban and rural areas. In urban areas, more water is used due to easy access to infrastructural network and better socio-economic conditions. Besides wasteful life styles that are typical of urban societies. In case of rural water supply, there is far lesser wastage in domestic use. Yet added quantities are required inter alia, for rearing of live stock in villages. The total existing water use for domestic and municipal purposes both urban and rural is estimated as 4.5 MAF (Table 1). A major portion of population has no access to pipe water supply. Sanitation is also provided to a small portion of society. Therefore a lot more water is required to fulfill the needs of water supply and sanitation.

3.3 Industry

Many industrial units have been established near major cities and in industrial estates. In addition to large industrial enterprises, numerous small industries have been developed all over the country to meet the need of big industries and to work as secondary and tertiary downstream units. The total existing water use for industries is estimated as 3.5 MAF (Table 1). A rapid growth in industries will need more water.

4. GROUNDWATER EXPLOITATION

Existing abstraction of groundwater is 51 MAF (Table 3). In Punjab province, the groundwater is primarily instrumental in increasing cropping intensity from 80% to 130% in the last four decades. Canal diversions at the barrages provide on the average 55 MAF of water for irrigation to Punjab each year. Of this amount, approximately 40% recharges to the groundwater reservoir up to the farm gate. Groundwater resources to the tune of about 36 MAF are being used to supplement irrigation supplies. Additional groundwater of 4 MAF is extracted for domestic, industrial and other uses (Table 4). Groundwater extraction has reached to its maximum. Optimizing the use of existing water combined with the latest state-of-art technology for skimming, some additional potential can be developed bearing in mind environmental and water quality constraints.

In Sindh province, presently only a small component of groundwater is being exploited by public and private sector. Total groundwater extraction was 7.5 MAF (Table 3) during year 2000 when numbers of tubewells were 33661. The number of tubewells in Sindh during year 2005 became 91472 which included 14022 public tubewells. In saline groundwater areas skimming wells have been installed. If proper skimming and radial well technology can be used to exploit groundwater from all saline areas, there is still a significant development potential which is currently being lost to non-beneficial evapotranspiration losses.

In NWFP, the existing groundwater abstraction through 13000 private and 491 public tubewells is 2.0 MAF (Table 4). However, total development potential for entire Province is estimated as 2.4 MAF indicating a relatively limited sustainable groundwater development potential for future.

Table 3 Groundwater Availability During 2000 (MAF)

Province	Abstraction	ET-losses Non-beneficial	Base flow to Rivers and Nallas	Total
Pakistan	50.6	14.56	1.78	66.94
Punjab	40.0	3.21	0	43.21
Sindh	7.5	9.75	1.15	18.4
NWFP	2.0	0.47	0.63	3.1
Balochistan	1.1	1.13	0	2.23

Source: ACE-HALCROW, 2002

Table 4 Groundwater Uses for Different Purposes (MAF)

Province	Irrigation	Water supply	Industry	Misc	Total	Sustainable Potential
Punjab	35.8	2.5	1.2	0.5	40.0	41.0
Sindh	4.6	1.5	0.7	0.7	7.5	11.5
NWFP	1.4	0.3	0.2	0.1	2.0	2.4
Balochistan	0.8	0.2	0.1	0	1.1	1.8
Pakistan	42.6	4.5	2.2	1.3	50.6	56.7

In Balochistan Province, the present groundwater abstraction has been reported as 1.1 MAF through about 24000 private water supply tubewells, open wells, Karazes etc, while total potential has been estimated to be 1.8 MAF. Recently Mirani Dam has been completed. Subakzai Dam is expected to be completed in this year. Kachi Canal is also being constructed. Upon completion of these projects water availability in the province will improve.

5. GROUNDWATER QUALITY

The quality of groundwater is potable to twice the salinity of sea water in the Indus Basin. Groundwater quality based on agricultural use criteria in various provinces is shown in Figure 3. About 22 percent area of Punjab and 78 percent in Sindh is underlain by saline groundwater. Tubewells have been installed in useable marginal and hazardous quality area. About 70 percent of tubewells pump saline water for irrigation. This is causing secondary salinization. Problems are not only of salinity but also of sodicity. Groundwater quality surveys were done during 1960's and then during 2000-03. Figure 4 indicates changes of water quality in different Doabs of Punjab Province over this period. It indicates that deterioration of groundwater quality is on-going in major parts of Punjab Province.

6. TUBEWELL GROWTH, INTENSITY AND UTILIZATION

The volume of groundwater use can be determined by number of tubewells, their percent time utilization and discharge.

6.1 Growth of Tubewells

Initially installation of tubewells was started in public sector. But about 40 years before installation of private tubewells also started. The growth of tubewells was at exponential rate (Figure 5). Up to now more than 19000 tubewells have been installed in public sector and about a million tubewells have been installed in private sector.

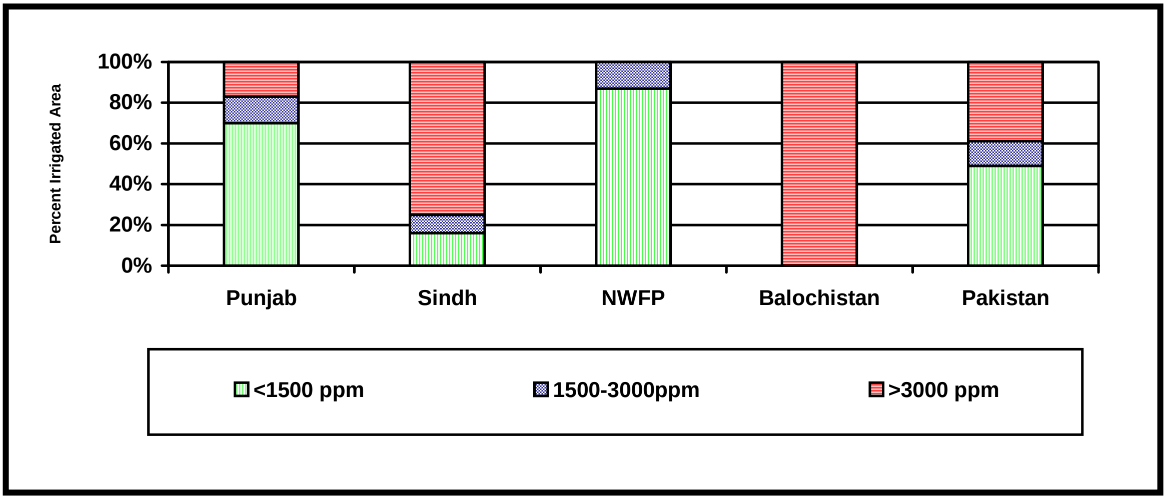

Figure 3 Groundwater Quality in Various Provinces.

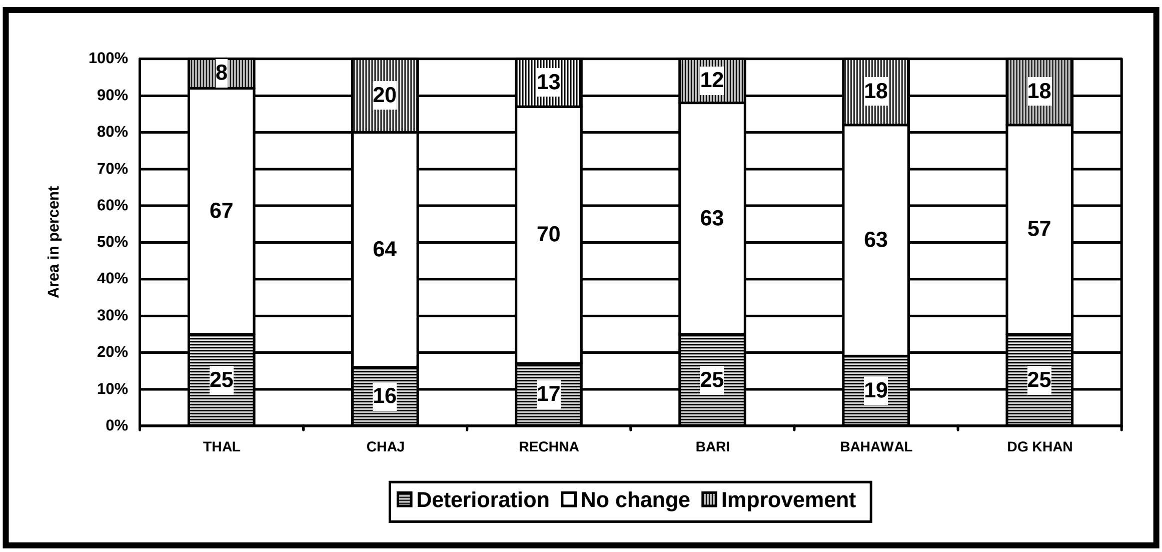

Figure 4 Changes in Groundwater Quality of Doabs in Pungab

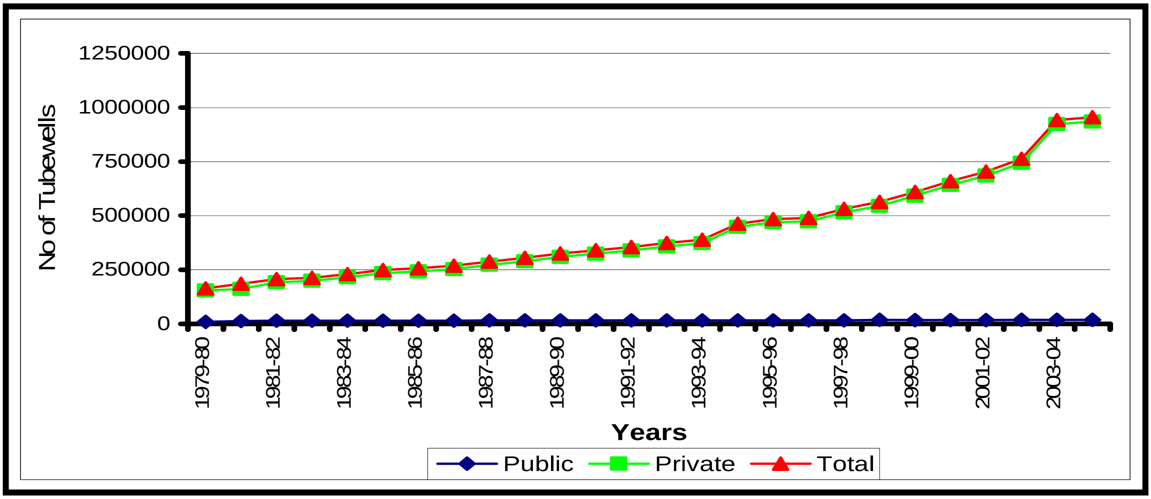

Figure 5. Growth of Tubewells

6.2 Tubewell Intensity

Intuitively one would expect the dependence on groundwater to be higher at the tail of the irrigation systems, where surface supplies are generally low. There are however, no systematic trends. In several command areas densities are high both at the head of the canal, where they may sustain the cultivation of paddy, the centre where they make up deficiencies and at the tail where groundwater is used a substitute for the sometimes altogether missing surface supplies. It appears that tubewell densities in areas with marginal groundwater quality do not substantially differ from those in areas with fresh groundwater. Tubewell density for Punjab in different studies are shown in Figure 6.

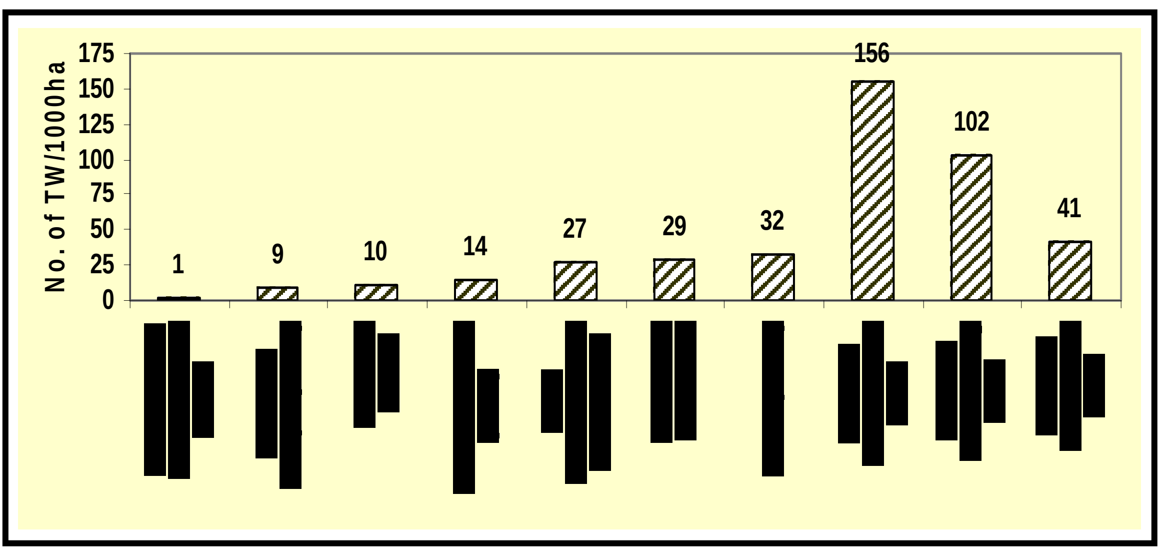

Figure 6. Tubewell Density in Punjab

Data from the Punjab Private Groundwater Project indicated that even in saline groundwater areas as much as 19% of the on farm water supplies come from tube wells.

6.3 Utilization Factor

Utilization factor for different studies are given in Figure 8. It is clear that with the passage of time utilization factor has decreased. This means that increase in pumpage has been limited due to lower utilization factor.

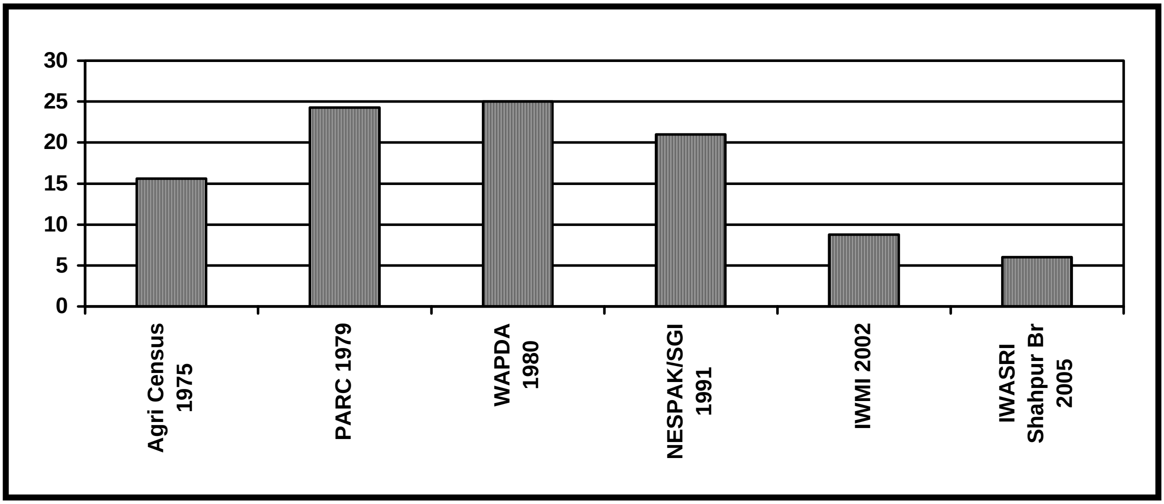

Figure 7. Utilization Factor in Punjab Province.

7. GROUNDWATER TABLE

Because of the intense use of groundwater in the irrigation commands, the waterlogged area having water tables less than 1.5 meter has been reduced (Figure 8 and 9).

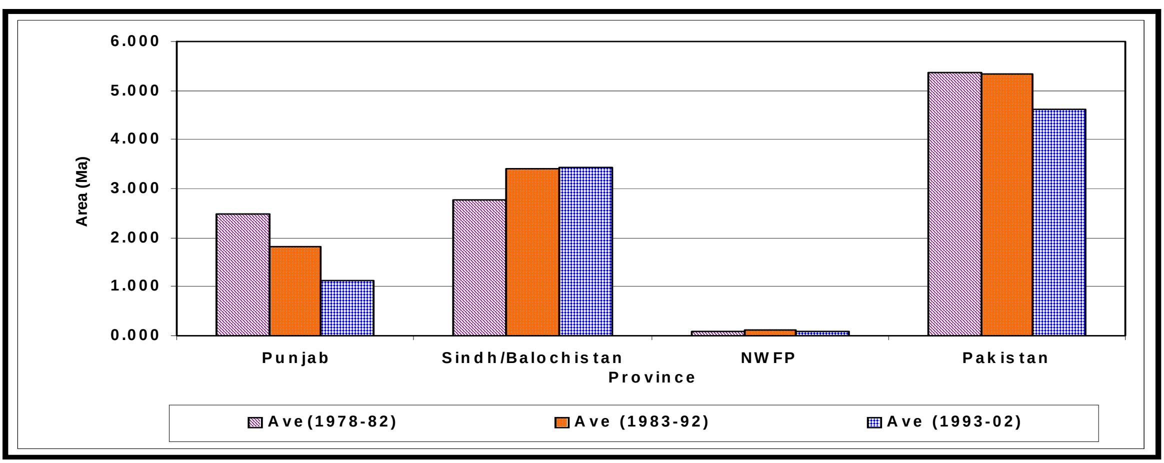

Figure 8 Average Waterlogged Area (0-150cm).
Source: WAPDA 2005

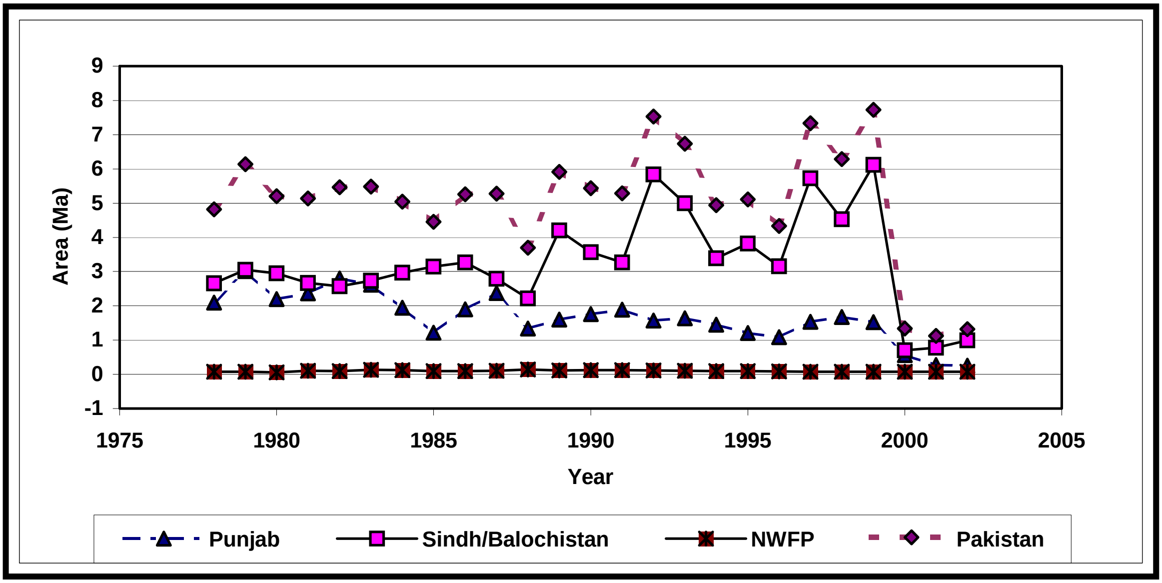

Figure 9 Waterlogged Area (0-150 cm).
Source: WAPDA 2005

8. GROUNDWATER INSTITUTIONS

Pakistan has a large groundwater aquifer but no groundwater institute exists in the country. WAPDA, Provincial Irrigation Departments, Environmental Protection Agencies and Water and Sanitation Agencies and R&D Institutes etc. are mainly involved in groundwater management. These institutions lack in capacity. No mechanism of coordination exists. There is an urgent need to build the capacity of these Institutes. Sharing of information and close collaboration among all the stakeholders is also required.

9. CONCLUSIONS AND RECOMMENDATIONS

Based on the above discussions the following conclusions and recommendations are made:

9.1 Conclusions

(i) Groundwater use was increased over past four decades but have reached to its maximum in Punjab, NWFP and Balochistan provinces

(ii) Mining of groundwater is happening in many parts of the country;

(iii) Excessive use of groundwater has resulted in deterioration of groundwater quality;

(iv) Pollution of groundwater have been identified near major cities and towns;

(v) There is no mechanism of coordination among the institutes/organization working for groundwater management.

9.2 Recommendations

(i) A regulatory framework for groundwater should be prepared;

(ii) Canal diversions should be increased through additional storages to reduce dependence upon groundwater;

(iii) Recharging of groundwater should be given high priority;

(iv) Monitoring of watertable and quality of groundwater should be done systematically and regularly;

(v) Capacity building of groundwater institutes should be given high priority; and

(vi) Involvement of stakeholders in water management should be ensured.

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COPING WITH WATER SCARCITY AND INDUS WATERS TREATY VISION

By

Engr. Usman-e-Ghani•

A. ABSTRACT

1. At the time of independence, the boundary line between the two newly created independent countries, i.e. Pakistan and India was drawn right across the Indus Basin, leaving Pakistan as the lower riparian.

2. Two important irrigation head works, one at Madhopur on River Ravi, and the other at Ferozepur on River Sutlej, upon which the irrigation canal supplies in Punjab (Pakistan) were completely dependent, were awarded India. Dispute thus arose between the two countries regarding the utilization of irrigation waters from existing facilities.

3. Pursuant to the aforementioned dispute, the negotiations between the two countries were held under the World Bank, which culminated in signing of the Indus Water Treaty in 1960. The Treaty was signed in Karachi by Mohammad Ayub Khan, the then President of Pakistan, and Jawaharlal Nehru, the then Indian Prime Minister on 19 September 1960.

4. Under Indus Waters Treaty, the waters of the Eastern Rivers (Sutlej, Beas and Ravi) have been allocated to India and those of the Western Rivers (Indus, Jhelum and Chenab) have been allocated to Pakistan.

B. INTRODUCTION AND THE BACKGROUND

5. The Indus System of Rivers in the Indus Basin comprises of River Indus and its five main tributaries i.e. Jhelum, Chenab, Ravi, Beas and Sutlej. They all combine into one river near Mithan Kot in Pakistan, which outfalls into Arabian Sea at the south of Karachi. The boundary of the Indus Basin is clearly defined in the west, the north and the northeast by mountain ridges (watersheds).

6. The total area of the Indus Basin is roughly 350,000 square miles. Most of it lies in Pakistan and the rest in Occupied Jammu and Kashmir, India, China and Afghanistan. The climate in the plains downstream of the rim stations ranges from semi arid to arid. Annual rainfall ranges from about 2 inches to about 30 inches. The total annual average discharge of these rivers at the rim stations is about 170 MAF (Million Acre Feet).

7. On 14 August 1947, when South Asia was divided into two independent countries, there existed in the region one of the most highly developed Irrigation System in the world and approximately 37 Million Acres of area used to receive irrigation supplies from the waters of the Indus System of Rivers. The available water supplies

• Joint Commissioner for Indus Waters

were allocated to the various princely States and Provinces in conformity with the principle of equitable apportionment of the waters with preferential right to existing users. At the time of independence, major portion of the Indus Basin formed a part of Pakistan and out of 37 Million Acres of total area getting irrigation waters 31 Million Acres was in Pakistan. The boundary line between the two countries was drawn without any respect to the related irrigational works. It was, however, affirmed by the Boundary Commission and expressly agreed by the representatives of the affected zones before the Arbitral Tribunal that the authorized shares of the two zones in the common water supply would be continued to be honoured.

C. THE FIRST INDIAN AGGRESSION

8. The water dispute between Pakistan and India came up soon after the ceasure of the Arbitral Tribunal on 31 March 1948. On 1 April 1948, India taking advantage of being an upper riparian on all rivers, stopped the waters of all the irrigation canals (irrigating about 1.6 Million Acres in Pakistan), which cross the India-Pakistan border and demanded that Pakistan should recognize that the proprietary rights on the waters of the Rivers in Punjab (India) wholly vest with that Government and the Punjab in Pakistan could not claim any share of these waters as a right.

9. The claim forwarded thereupon by Pakistan was based upon the time honoured formula that existing uses are sacrosanct and only excess water, not previously committed, could be divided amongst the riparians according to the area, population, etc. This principle had the support of several treaties between the nations, or states, or even the provinces in the same country.

10. The Indians in return put forward a principle under which the upper riparian has an absolute right to the water and the lower riparian can only get it under an agreement or treaty entered between the parties.

D. ROAD TO THE TREATY

11. India agreed to restore some of the supplies to Pakistan in May 1948, when quite a pro-Indian temporary agreement was signed. It was, however, generally realized that Pakistan could not live without restoration of the full supplies and on this question there could be no compromise. The issue started getting a heed even from international community and substantial awareness was developed that there could be a war on the issue.

12. Direct negotiations between the Parties failed to resolve the dispute. Negotiations under the World Bank commenced in May 1952, wherein it was agreed that specific engineering measures be worked out by which the supplies available to each country would substantially be increased, beyond what they have ever been.

13. The working party set up under the Bank failed to agree on a plan for effective utilization of the waters of the Indus System. The World Bank, in its proposal of 5 February 1954, listed three basic difficulties (given hereafter), which prevented the working party from reaching the heart of the problem, i.e. a fair diversion of the waters between the two countries.

E. DIFFICULTIES IN RESOLUTION

14. The three basic difficulties noted by the World Bank in resolution of the dispute were the following:

(i) The first difficulty lies in the fact that the water supplies and storage potentialities are inadequate to the needs of the basin;

The second difficulty is that although the working party is planning on the basis of the development of the Indus Basin as an economic unit, two sovereign states are involved, which greatly limits the practical aspects of planning. The countries would be reluctant to have works regulating the water supplies on which they depend, constructed in territory controlled by the other country. The prospects of establishing a smooth and efficient joint administration would also not be favourable.

(iii) The third difficulty, and the most serious of all, arose in the course of discussions. The plans put forward by the two sides differ fundamentally in concept. An essential part of Pakistan's concept was that the existing uses of water must be continued from existing sources and the corresponding concept of the Indian plan, on the other hand, is that although the existing uses (here defined to include only actual historic withdrawals) may be continued, they need not necessarily be continued from existing sources.

F. INDUS WATERS TREATY - 1960

15. The Engineers of the Bank worked out their initial proposals on averages ignoring the special seasonal needs for sowing and maturing of the crops, when the demands of water is maximum and the flows are minimum. It took Pakistan two years to convince the Bank that Pakistan's contentions were correct that the division of the waters put forward by the Bank would not accomplish the result visualized in the actual proposal.

16. After protracted negotiations, under the World Bank, when the Bank was convinced that the existing uses in Pakistan could not be met by transferring the waters from the Western Rivers, and that Storages on the Western Rivers would be required for the purpose, the Indus Waters Treaty was signed in 1960.

17. The Treaty consists of 12 Articles and 8 Annexures. It is based on the division of the Rivers between the two countries. The waters of the Sutlej, Beas and Ravi rivers named in the Treaty as "Eastern Rivers", are for the unrestricted use for India; and the waters of Indus, Jhelum and Chenab rivers, named in the Treaty as "Western Rivers", are for the exclusive use of Pakistan; except for certain specified uses allowed to India in upper catchments.

G. REPLACEMENT WORKS

18. Under the Treaty, Pakistan was required to construct and bring into operation a system of works on the Western Rivers in order to accomplish the replacement of water supplies in irrigation canals in Pakistan, which at the time of partition were dependent on water supplies from the Eastern Rivers. The replacement works comprised of two storages dams (one on Indus River and one on Jhelum River), six new barrages (diversion dams), remodeling of two existing barrages, seven new inter-rivers link canals and

remodeling of two existing link canals. This only became possible through the generous assistance (grants and loans) by the friendly countries like USA, Canada, UK, Netherlands, Germany, France, Italy, Australia, Newzeland, etc. The fund was called the Indus Basin Development Fund and was set up and administered by the World Bank with the assistance of Indus Basin Development Board, constituted by the Government of Pakistan. India made a fixed contribution £ 62.060 million towards this Fund, which was payable in ten years in equal installments. Thus India got 24.00 MAF of perpetual flow of the Rivers for this amount. The estimated cost of replacement works (1964 estimates) was US $ 1208.50 million. There was a transition period of 10 years during which Pakistan was to receive waters from the "Eastern Rivers" for use in the aforementioned canals.

19. Such a division of Rivers was a distinct departure from the concept of international law of upper and lower riparian rights (protection of existing uses from the same source). In this way Pakistan had to forgo the entire perpetual flow of fresh waters of the three Eastern Rivers (24.00 MAF), which it used to receive historically for irrigation.

H. INSTITUTIONAL ARRANGEMENTS

20. Under the provisions of Article VIII(1) of the Indus Waters Treaty 1960, both India and Pakistan appointed Commissioners for Indus Waters. Each Commissioner, unless either Government decides to take up any particular question directly with the other Government, is the representative of his Government for all the matters arising-out of the Treaty and serves as the regular channel of communication on all the matters related to the implementation of the Treaty. The two Commissioners together form the *PERMANENT INDUS COMMISSION.* The functions of the Commission are:

i. to establish and maintain co-operative arrangements for the implementation of the Treaty;

ii. to promote co-operation between the Parties in the development of the waters of the Rivers;

iii. to make every effort to settle promptly any question arising between the Parties; and

iv. to undertake tours of inspection of the Rivers to ascertain facts.

21. Under the Treaty, restrictions have been placed on the design and the operation of hydroelectric plants, storage works and other river works to be constructed by India on the Western Rivers. India is required to supply to Pakistan certain specified information related to these works at least 6 months in advance of undertaking the works so as to enable Pakistan to satisfy itself that the design conforms to criteria set out in the Treaty. Within a specified period, ranging from two to three months, Pakistan has the right to communicate to India, in writing, its objections that it may have regarding the proposed design on the ground that it does not conform to certain criteria specified in the Treaty.

22. Under the Treaty, restrictions have also been placed on the irrigated cropped area to be raised by India in the basins of Western Rivers. The Treaty also provides for a

regular exchange of the daily hydrological data and other data under Articles VI and VII(2) of the Treaty.

23. The Treaty provides for a self-generating procedure for the settlement of differences and disputes. Any question which arises between the Parties concerning the interpretation or application of the Treaty or the existence of any fact, which, if established, might constitute a breach of the Treaty, is to be first examined by the Commission, which endeavours to resolve the question by agreement.

I. MAJOR ISSUES WITH INDIA

(i) Baglihar Hydroelectric Plant

Baglihar Hydroelectric Plant is a Run-of-River Project being constructed by India on river Chenab. Under the Indus Waters Treaty 1960, India is allowed to construct Run-of-River Hydroelectric Plants on Western Rivers, subject to the provisions of the Treaty. The design of the Plant should be in accordance with the criteria provided in Paragraph 8 of Annexure D to the Treaty.

India supplied information about the Plant in May 1992 under the relevant provision of the Indus Waters Treaty 1960. The Plant is located on river Chenab about 147 kilometers upstream of Marala Headworks.

Pakistan, under the provisions of the Treaty, raised objections on excessive freeboard provided in the design of the Plant, higher water seal at the intake of the power tunnel, excessive pondage in the operating pool behind the dam and the design of orifice type gated spillway.

Since the Permanent Indus Commission could not resolve the objections, Pakistan invoked the relevant provisions of the Treaty and in order to resolve the issue under the provisions of the Treaty, the World Bank appointed a Neutral Expert on 10 May 2005. The Neutral Expert called both the Parties to Paris in June 2005, and formulated modalities in the form of Protocol. The written and oral part of arguments between the Parties were undertaken in a series of five meetings of the Parties with the Neutral Expert, and one visit to the site of the Plant. The Neutral Expert gave his Final Determination on 12 February 2007.

The decision of the Neutral Expert upheld Pakistan’s contention that the design by India is not in conformity with the design criteria of all the four designs features of the dam as laid down in the Treaty. The Neutral Expert recommended changes in three parameters of the design of the Plant as given hereunder:

a.	Freeboard	The Neutral Expert did not accept India’s calculation for the freeboard and reduced the freeboard from 4.5 meter to 3.0 meter.
b.	Location of Power Intake	As India had wrongly located the power intakes, the Neutral Expert directed to raise the location of power intake by 3 meters.

c.	Pondage	The Neutral Expert determined that the calculations and methodology applied by India to calculate the Pondage is not correct and accordingly reduced the Pondage from 34.722 Million Cubic Meters (MCM) to 32.56 MCM.
d.	Location and Size of Spillway	With respect to this parameter, the Neutral Expert agreed that in accordance with the provisions of the Treaty the analysis provided by India to support their design is not correct and the model test done by India is not "representative of reality". However, the Neutral Expert supported the provision of sluice spillway based on the "international practice".

(ii) Kishenganga Hydroelectric Plant

The proposed Kishenganga Project is located in Occupied Jammu and Kashmir on river Neelum. The original design envisaged the construction of 268 meter long and 75.48 meter high concrete dam with reservoir capacity of 0.18 MAF and power storage of 0.14 MAF. The stored water of River Kishenganga is to be diverted through a 21 km long tunnel to produce power of 330 MW. The water after production of power is to join Wullar Lake.

Pakistan raised objections on the diversion of flow and design of the project. The issue was formally taken up through the meetings of the Commission from May 2003 to November 2005. On failure of the Commission to resolve the issue, Pakistan Commissioner for Indus Waters initiated proceedings for reference of the case to the Court of Arbitration. However, Indian Commissioner intimated vide his letter dated 19 June 2006, that under Paragraph 15(a) of Annexure E, the Kishenganga Storage-cum-Hydroelectric Project has now been revised as a Run-of-River Plant. Revised information, as specified in Appendix-II to Annexure D to the Treaty was also supplied. Pakistan Commissioner after examining the information supplied by India raised following objections:-

i. The proposed design of the Plant in respect of freeboard, pondage, spillway and intake is in violation of the provisions of the Treaty.

ii. India is not authorized to divert waters of river Kishenganga (Neelum) in view of Article III, Article IV(6) and Paragraph 15(iii) of Annexure D.

India has so far not responded to Pakistan's objections. However, the issue is proposed to be discussed during the next meeting of the Commission scheduled to be held late in 2007.

(iii) Wullar Barrage

Under the provisions of Indus Waters Treat 1960, the waters of three Western River, namely Indus, Jhelum and Chenab, have been allocated to Pakistan for un-restricted use, except for certain uses by India in the areas located in the Occupied Jammu and Kashmir and in India. Except for 0.75 Million Acre Feet (MAF) of storage on the tributaries of river Jhelum and 0.01 MAF incidental to a barrage, India is not allowed to build any storage on the main river (Jhelum).

In February 1985, Pakistan learnt through reports that India is planning to construct a Barrage, namely “Tulbul Navigation Project”, at the downstream end of Wullar Lake on River Jhelum. In March 1985, Pakistan conveyed its concerns to India and sought details of the scheme for its examination. India supplied some details of the scheme in March 1986. According to the information supplied by India, the Wullar Barrage, located at the out fall of Wullar Lake on Jhelum Main, would be 439 feet in length, with a gated weir and under sluices, and a 12 meter wide navigation lock. It would have a maximum discharge capacity of 50,000 cusecs and would enable pond level in the lake to be raised and maintained at elevation 5178 feet. Thus it might be possible to manipulate additional storage of approximately 0.336 MAF of water in the Lake.

The matter was accordingly taken up by the Permanent Indus Commission for resolution under Article IX(1) of the Treaty but the Commission was failed to resolve the issue. The construction of works, which India executed for the piers/abutment of barrage and navigation lock was, however, got suspended by Pakistan in September 1987.

Later, on the request of the Government of India, bilateral negotiations started at the level of the Secretary, Ministry of Water and Power, Government of Pakistan and the Secretary, Ministry of Water Resources, Government of India. So far, 13 rounds of talks have been held.

J. CONCLUSION

24. The crux of the Indus Waters Treaty 1960, is the division of rivers of Indus System between Pakistan and India. Waters of Western Rivers (Indus, Jhelum and Chenab) were allocated to Pakistan with certain restricted uses allowed to India in Occupied Jammu and Kashmir, whereas the water of Eastern Rivers (Ravi, Beas and Sutlej) available for unrestricted uses by India.

25. In view of the intent and the spirit of the Treaty, Pakistan expects that regarding the projects and usage from the Western Rivers, the Indian design of the works would fall strictly in accordance with the provisions of the Indus Waters Treaty 1960 so that the water rights as envisaged through the Treaty would appropriately be honoured.

26. Besides above, it would also be worthwhile to mention that Pakistan should strive for optimal development of its water resources available through the Western Rivers. This would probably be the only solution available to Pakistan to effectively cope with the possibilities of water scarcity.

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