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# ADDRESSING WATER AND POWER NEEDS OF PAKISTAN THROUGH CONSTRUCTION OF MAJOR STORAGE DAMS

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By

**Muhammad Munir Ch.[1], Zia-ul-Hasan[2] and Dr. Allah Bakhsh Sufi[3]**

## Summary

The water and power issues have reached a crucial stage for Pakistan which is already one of the most water-stressed countries in the World. It is apprehended that Pakistan would become water scarce due to high population, 173 million in 2012. The climatic change in Pakistan has slowed down melting of snow from mountains, thus reducing flow of rivers resulting in severe water shortages for the winter crops. Under this scenario, construction of mega multi-purpose storage dams is assuming highest priority to sustain irrigated agriculture which is the backbone of Pakistan's economy and to meet the growing power needs of the country. For meeting these requirements a number of dams are planned for construction on River Indus. These include two major storage dams, Diamer Basha Dam (DBD) upstream and Kalabagh Dam (KBD) downstream Tarbela Dam. However, due to several controversial issues and non-availability of required funding, it has not been possible to undertake construction of any of the two Dams despite urgent national need for additional storage capacity, especially on river Indus.

KBD is a potential water storage and hydropower project. It is closer to the National Grid and has easy access to the project area. It is located 210 km downstream Tarbela Dam on the River Indus and 290 km from Islamabad. The project envisages the construction of 79 m high earth & rock-fill dam, with its maximum pool level at 279m amsl, and usable storage of 7.52 BCM (7% of avg. annual flow). The ultimate generation capacity would be 3,600 MW. The average annual flow at Kalabagh is 109.78 BCM (89.0 MAF) from the Indus, Kabul and Soan rivers. The project will have a useful economic life of over 50 years. Its conjunctive operation with Tarbela will enable enhancement of 600 MW of peaking capability and additional 336 million Kwh of annual generation at Tarbela. The overall direct benefits of KBD would be around Rs.121 billion per annum as escalated upto 2012-13, thus the investment cost of project would be recovered within a period of 9-10 years. KBD will augment irrigation supplies, generate cheaper hydropower and mitigate floods besides increase in industrial production, employment generation and agricultural boost.

The Khyber Pakhtunkhwa (KP) and Sindh provinces reservations on KBD construction have been respected and duly considered. With revised specifications, the project would not affect Nowshera even in the worst scenario. As for as, Sindh's apprehension that the water availability would be reduced after the dam construction, the fact remains that the dam would store billions m³ of water from going waste during floods. The confidence building measures among provinces is the real need of the time. For this purpose it could be suggested to declare KBD project land as federal territory and vesting the operation of the dam with some independent regulatory body. The royalty on power generation may be distributed in accordance

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with the most recent National Finance Commission Award. Such efforts may facilitate to secure the required consensus to build the KBD project in the national interest.

## 1. BACKGROUND

The principal water resources of Pakistan are represented by surface flows of river Indus and its tributaries which are fed by snow and glacier melt from the Himalayan and Hindu Kush Mountains and the rainfall in the catchments. The major surface water development in the country has been based on the use of water of these rivers.

About 14.16 mha (35 ma) land is irrigated by canals and tubewells. Water availability for canal withdrawals has progressively increased from 82.65 to 130.76 BCM(67 to 106 MAF) between the years 1947 and 1976 to meet population growth demand. This increase was achieved with the construction of water storages at Chashma, Mangla and Tarbela. Apart from providing additional irrigation water, both Mangla and Tarbela Dams are also used for hydel power generation with installed capacity of 1,000 MW and 3,478 MW respectively. After completion of Tarbela Dam Project in 1976, there has not been any further increase in canal withdrawals although the population has continued to grow and reached 173 million in 2012.

With increasing population and depleting water resources, Pakistan is heading towards a situation of water shortage and threat of famine (Figure .1). Per capita surface water availability was 5,260m³ per year in 1951 which has reduced to 1036m³ in 2012. The position is worsening and with rapidly increasing population, this may further drop to about 860 m³ by 2025 representing acute water short conditions. The minimum water requirement to avoid food and health constraints due to being a “water short country” is 1,000 m³per capita per year. Pakistan hasthus reached the stage of “acute water shortage”,where, people fight for every drop of water. In addition, the storage capacity of existing reservoirs is being reduced rapidly due to sedimentation. Additional storages, therefore, have to be created by building major storage dams to replenish the lost capacity and save Pakistan’s agricultural economy from total disaster and produce food grains for rapidly increasing population.

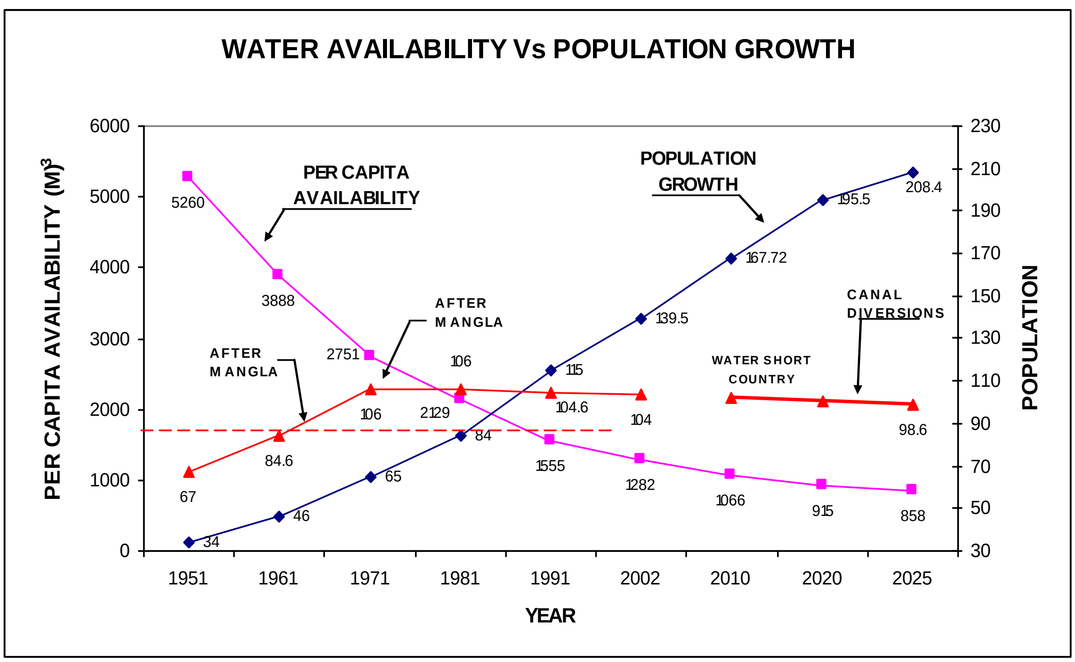



Figure-1: Canal Water Diversion v/s Population Growth & Water Availability

According to Water Sector Investment Planning Study (WSIP, 1990), carried out by WAPDA, Pakistan will face a deficit of 12 million tons in total grain production in the year 2012-13. Such a large scale deficit cannot be bridged simply by improving farming practices and technology. The irrigation supplies scenario in the year 2012-13 has reached a critical stage which will further deteriorate year-by-year thereafter indicating an urgent need for more storage dams.

## 2. SEDIMENTATION OF RESERVOIRS

Pakistan has three major reservoirs, which have original storage capacity of 19.42 BCM (15.74 MAF). The storage capacity of Tarbela,Mangla and Chashma reservoirs has depleted by 5.40BCM (4.37 MAF) or 28% by the year 2012 due to sedimentation. It is estimated that the gross storage would reduce by 7.2 BCM(5.83 MAF) or 37% by the year 2025 as shown in Table-1.

Table-1: Storage Loss Due To Sedimentation

| Reservoir | Storage capacity* | | | Storage loss | |
|---|---|---|---|---|---|
| | Original | Year 2012 | Year 2025 | Year 2012 | Year 2025 |
| | BCM (MAF) | BCM (MAF) | BCM (MAF) | BCM (MAF) | BCM (MAF) |
| Tarbela (1976) | 11.94 (9.68) | 8.02 (6.5) (67%) | 6.63 (5.37) (56%) | 3.92 (3.18) (33%) | 5.31 (4.3) (44%) |
| Mangla (1967) | 6.6 (5.34) | 5.49 (4.45) (83%) | 5.19 (4.20) (79%) | 1.11 (0.9) (17%) | 1.41 (1.14) (21%) |
| Chasma (1971) | 0.88 (0.72) | 0.52 (0.42) (59%) | 0.41 (0.33) (.47%) | 0.36 (0.29) (41%) | 0.47 (0.38) (53%) |
| Total | 19.42 (15.74) | 14.03 (11.37) (72%) | 12.23 (9.92) (63%) | 5.39 (4.37) (28%) | 7.18 (5.82) (37%) |

Source: WRM Directorate, WAPDA

* The storages shown are without raised Mangla Dam storage of 3.6 BCM (2.9 MAF)

## 3. WATER RESOURCES OF PAKISTAN

The water resources available to the country are the natural precipitation, the surface water and the groundwater.In the arid to the sub-tropical climate of the country, the natural precipitation is scanty. Over half of the country receives less than 200 mm of annual rainfall, and rainfall in excess of 400 mm occurs only in about 20 percent of the northern areas. Apart from being scanty, the precipitation is distributed quite unevenly over the seasons and in a major part of the country this is concentrated in the 3 to 4 months of the summer monsoon. Despite its meager amount, rainfall is utilized for rain-fed agriculture and for meeting the drinking water needs of the people and livestock.

The sources of surface water available to Pakistan are its rivers. Most of these rivers, in the western half of the country, are ephemeral streams that remain dry for most of the year. It is the Indus River and its tributaries with perennial flows, that constitute the main source of water supply.The Indus and its tributaries, have their sources in the Himalayan and the Hindu Kush mountains, with a total drainage area of 944,569 sq. km, which extends beyond the country's territorial limits. The inflow to these rivers is mainly derived from snow and glacier melt and rainfall in the catchment areas. The tributaries of the Indus, originating in India but flowing into Pakistan are Jhelum, Chenab, Ravi and Sutlej (with a major tributary Beas). Originating in Afghanistan, the other major tributary is the Kabul river.

Under the Indus Waters Treaty 1960, the flows of the three Eastern Rivers, (Sutlej, Beas and Ravi) have been allocated to India, whereas, with minor exceptions, Pakistan is entitled to all the waters of the Western Rivers (Indus, Jhelum and Chenab). The average annual inflow of the Western Rivers at the rim stations (the most important gauging stations: Indus at Kalabagh, Jhelum at Mangla and Chenab at Marala), as they enter the Indus Plain is 172.70 BCM (140 MAF). This constitutes the main source of water supply for the country.

Although the surface flows of the Indus river and its tributaries available to Pakistan are quite significant, these are highly variable seasonally and yearly. Against the average annual inflow of 172.70 BCM (140 MAF), the long term historic data indicates a high of 230.42 BCM (186.79 MAF) or 34% above the average in 1959-60 and a low of 120.57 BCM (97.74 MAF) or 30% below average in 1974-75.The inflows during the six months of the summer cropping season of Kharif and during remaining six months of the Rabi season are 84% and 16% of the average annual inflow respectively. The high variability indicates a compelling need for conserving and regulating the high and surplus summer flows for use during low flow season to meet irrigation water needs and to generate cheaper hydel power. It will also greatly help to minimize flood damages.

Groundwater is another important source of water supply. Investigations have established the existence of a vast aquifer with an areal extent of 194,000 sq. km (74,904 sq mi) underlying the Indus Plain which has been recharged in the geologic times from natural precipitation and river flows, and more recently by the seepage from the canal systems. Although the quality of the groundwater in the Indus Basin aquifer is highly variable, both areally and with depth, it is estimated that 67.85 BCM (55 MAF) of groundwater, representing the safe yield, could be withdrawn annually for beneficial uses. About 61.68 BCM (50 MAF) is pumped presently for irrigation and domestic uses.

## 4. CLIMATE CHANGE

### 4.1 Temperature

The 4th Assessment Report (AR4) by the three working groups of the Intergovernmental Panel on Climate Change (IPCC) has projected that average global surface temperature will increase by approximately 3°C during the 21st century. The following information is derived for Pakistan for two IPCC scenarios, A1B (very rapid economic growth, population growth peaking mid-century and balanced use of energy sources), and A2 (fragmented and slow economic growth and continuous population growth).

- The temperature increase in Northern Pakistan is larger than that in Southern Pakistan, in line with the IPCC global scenarios which shows higher temperature increase over Central Asia than that over South Asia.
- The temperature increase in both Northern and Southern Pakistan in each scenario is higher than the corresponding globally averaged temperature increase (for A2 scenario, the projected temperature increases in 2080s in Northern and Southern Pakistan are 4.67°C and 4.22°C, respectively (Figure 2).
- The current annual average temperatures for Northern and Southern Pakistan are about 19°C and 24°C respectively.

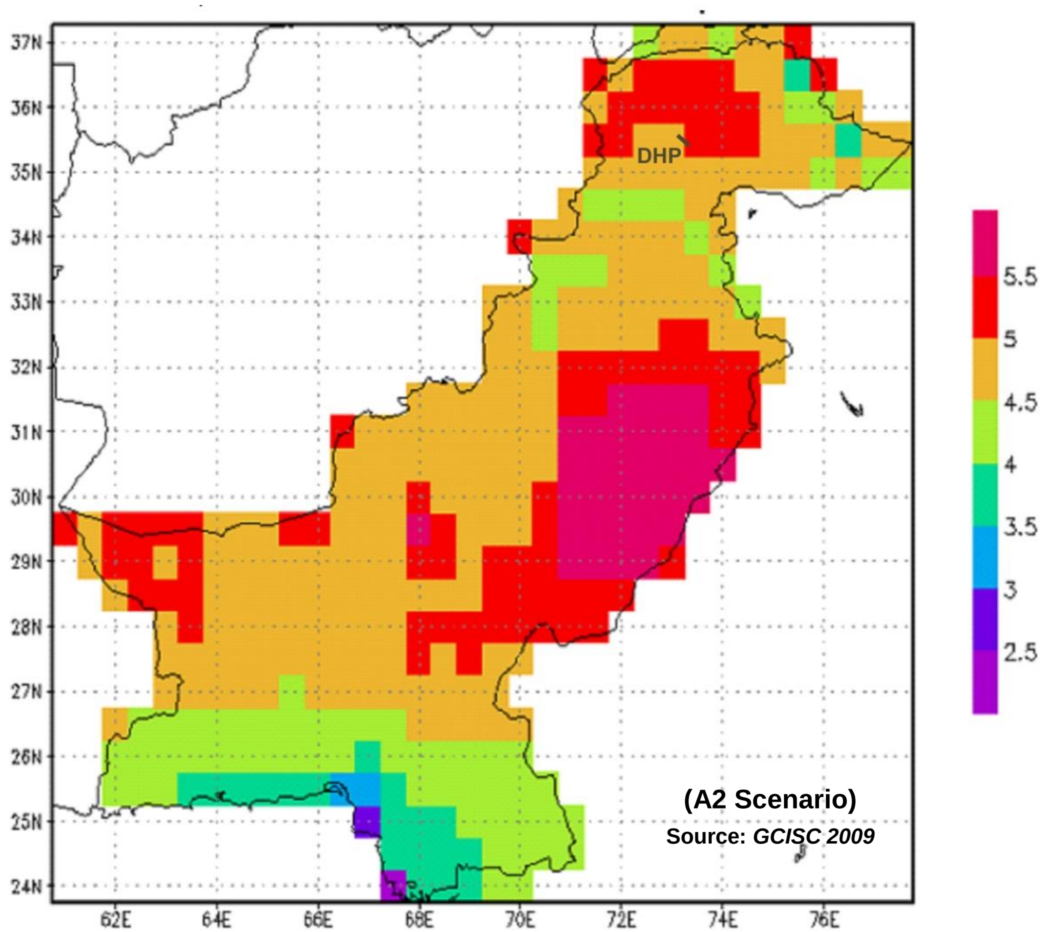



Figure-2: Projected Temperature Change (°C) for 2080s

## 4.2 Melting of Glaciers

About 50-80% of the average river inflows in the Indus River System (IRS) is fed by snow and glacier melt in the Hindu Kush-Karakoram (HK) part of the Hindu Kush-Karakoram-Himalayan (HKH) mountain ranges. After the Arctic/Greenland and Antarctic glaciers, the HKH represent the third largest ice mass on earth. These glaciers constitute about 2,700 cubic km of stored volume of ice (Roohi, 2005), equivalent to about 14 years of average IRS inflows.

Over the past century, glaciers worldwide have exhibited a receding trend; the HKH glaciers are receding faster than in any other part of the world and it is expected that if the present rate of recession continues, the HKH glaciers might disappear by 2035 (Rees, G. and D.N. Collins, 2004). The thermal regime of HKH glaciated region has in general warmed up and the frequency of occurrence of moderate as well as severe heat waves have also increased significantly (PMD, 2009). Preliminary analysis of the time series data on flows of the Indus and its tributary rivers has not indicated any large melting of glaciers so far (GCISC, 2009). Based on the studies available, it looks likely that the HKH glaciers are receding under the influence of global warming and that melting will increase with increase in summer temperature.

Recent simulation modeling conducted by Global Change Impact Studies Center(GCISC) on Indus flows for a scenario where temperature will rise by **3°C** and glaciers shrink to half their present size, indicates overall annual flow would reduce by about 15% and the monthly flow pattern would also change considerably, with more water coming in spring and early summer and less water in the later part of summer (Figure 3).

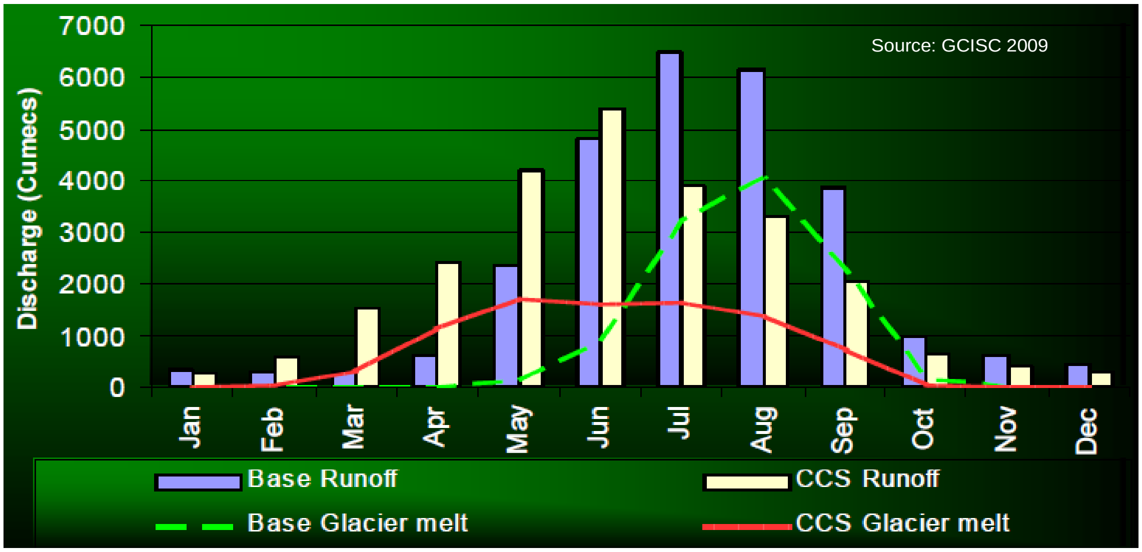



Figure-3: Present Base Flows (1995-2004) and Future Flows in Indus at Besham Qila (for a scenario of 50% glacier recession and 3°C of temperature increase).

As a major climate change related concerns, it is projected that it will increase variability of monsoon rains and enhance the frequency and severity of extreme events of floods and droughts.

## 5. PRESENT SITUATION OF POWER SUPPLY AND DEMAND

The power demand has increased at about 10.3% per annum during the period of last 10 years from 2001 to 2010 alongwith economic growth rate of the country. However, the power supply did not catch up with the power demand which continues to increase year by year. About 6,105 MW power supply-demand gap occurred in the summer of 2011. Under such a situation, the people of the country had to face the planned power outages for about eight hours daily on the average. The planned power outages has caused difficulties in people's lives and constrained the development of irrigated agriculture. The industrial sector also suffered great economic losses due to power outages causing unemployment in the country and high production cost. Therefore, minimizing the supply-demand gap in power sector is urgently required.

As of December 31, 2010, the total installed capacity of Pakistan through all resources was around 21,420 MW. However, rapid demand growth and insufficient generation development created a gap between supply and demand resulting in significant load shedding.Table 2 below shows the level of power shortages in recent years from zero power shortage in 2003 to almost 23% in 2010.

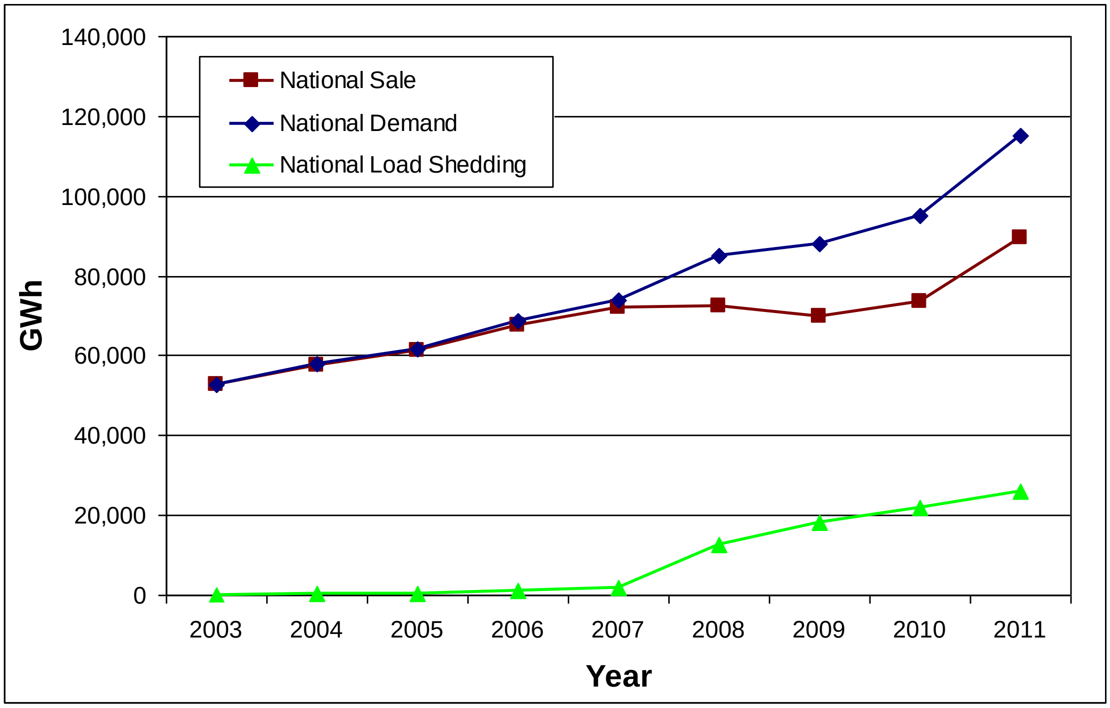
Table-2: Power Shortage Level between National Sale and National Demand

| Year | National Sale [GWh] | National Demand [GWh] | National Power Shortage [GWh] | Power Shortage Rate [%] |
|---|---|---|---|---|
| 2003 | 52,661 | 52,661 | - | 0.0 |
| 2004 | 57,467 | 57,986 | 520 | 0.9 |
| 2005 | 61,247 | 61,512 | 265 | 0.4 |

| Year | National Sale [GWh] | National Demand [GWh] | National Power Shortage [GWh] | Power Shortage Rate [%] |
|---|---|---|---|---|
| 2006 | 67,608 | 68,815 | 1,208 | 1.8 |
| 2007 | 71,947 | 73,982 | 2,040 | 2.8 |
| 2008 | 72,518 | 85,096 | 12,578 | 14.8 |
| 2009 | 69,668 | 87,890 | 18,222 | 20.7 |
| 2010 | 73,595 | 95,238 | 21,821 | 22.9 |
| 2011 | 89,402 | 115,247 | 25,845 | 22.4 |

Source: Power System Statistic 35th Edition and National Power Control Center

The annual power demand and supply gap which started in 2004 created a slight increase up to 2.8% in 2007. The gap then abruptly increased to 14.8% in 2008 and further increased to 22.9% in 2010.The trend graph for the national sale and national demand are shown in Figure 4.




Source: Prepared by Nippon Koei, Japan Survey Team based on the data in Table 2.

Figure-4: Trend Graph for National Sale and National Demand

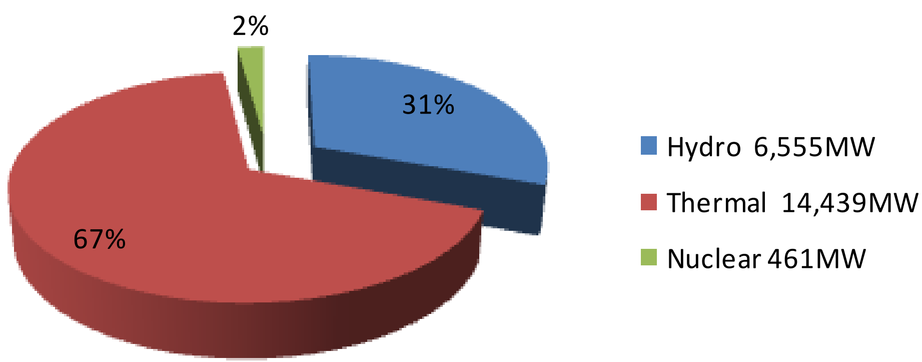
## 5.1 Existing Installed Capacity Of Power Generation Plants

The total installed capacity of existing hydro and thermal generation plants in the country including the Karachi Electric Supply Company (KESC) and independent power producers (IPPs), was 21,527 MW, as of March 2012. However, due to seasonal variation of water inflow for hydro plants and the capacity de-rating for thermal units, the dependable capacity for the systems was estimated at 15,259 MW during winter. The installed capacity of hydro plants was about 31%, thermal capacity was 67% and nuclear capacity was about 2%. The total installed capacity from IPPs was about 38% of the total installed capacity. The breakdown is shown in Table-3 and Figure-5.

Table-3: Summary of Existing Power Plants

| Type of Plant | Owner | Installed Capacity (MW) A | Capacity in Winter (MW) B | Ratio B / A |
|---|---|---|---|---|
| Hydro Plant | WAPDA | 6,516 | 2,308 | 35.4% |
| | IPPs | 111 | 111 | 100% |
| | *Sub-Total Hydro* | *6,627* | *2,419* | *(36.5%)* |
| **Thermal Plant** | - | - | **De-rated Capacity (MW) B** | - |
| | PEPCO | 4,829 | 3,580 | 74.1% |
| | IPPs for PEPCO | 7,475 | 6,909 | 92.4% |
| | Rental for PEPCO | 113 | 113 | 100% |
| | KESCO | 1,655 | 1,463 | 88,4% |
| | IPPs for KESCO | 367 | 353 | 96.2% |
| | *Sub-Total Thermal* | *14,439* | *12,418* | *(86.0%)* |
| Nuclear Plant | for PEPCO | 325 | 300 | 92.3% |
| | for KESC | 136 | 122 | 89.7% |
| | *Sub-Total Nuclear* | *461* | *422* | *(91.5%)* |
| **Total** | | **21,527** | **15,259** | **70.9%** |

Source: National Power System Expansion Plan 2011-2030




Source: National Power System Expansion Plan 2011-2030
Figure-5: Installed Capacity of Power Plants

### 5.2 Hydropower Potential and WAPDA Vision 2025

Pakistan is endowed with a very large renewable energy resource in the form of hydropower with a conservatively estimated potential of around 60,000 MW. Out of this, only about 6,627 MW has been exploited to date.

Hydro energy has grown at an average annual rate of 3.96% over the period 1980-2010.This growth dampened to 1.85% in the last 10 years and to 1.05% during the last 5 years. Hydro energy as percent of total energy declined from about 67% in 1980 to about 31% in 2010. To cope with the increasing water and power demands of the country, WAPDA prepared, “Water Resources and Hydropower Development - Vision 2025 Program”, which was approved by the Government in 2001. This program is a US$25 to 33 billion development program with projects that could generate up to 16,000 MW of additional hydel power. It was focused on the development of additional water storage projects to strengthen the economy by reinforcing agriculture by optimizing water resources and by enhancing hydropower generation.

## 6. NEED FOR LARGE STORAGES IN PAKISTAN

In view of anticipated severe water shortages, the construction of large multi-purpose storage dams has assumed highest priority to sustain irrigated agriculture and to meet the growing power needs of the country. The storages would also enable affective river regulation. If nothing is done, there would be significant shortfall in irrigation water supplies and sustainability of irrigated agriculture would face serious problems. In the context of this situation several dams are planned for construction on River Indus and its tributaries.

Another relevant, though newly emerging, factor will be the need to harness the increased Indus River inflows during the first half of 21st century as a result of deglaciation due to global warming. This situation may be further aggravated through recurrence of catastrophic floods similar to 2010. Sometimes it is debated that, as the large dams in Pakistan have become controversial, we may instead construct small dams. It may be pointed out that small dams may be constructed wherever feasible to boost local economy, but from national point of view these are not at all substitute for large multi-purpose storage dams.

## 7. FLOOD CONTROL THROUGH LARGE DAMS

A record flood (about 1 in 500 year interval) was generated in Swat River towards end of July 2010 due to unprecedented rains in the upper catchment. If at this time, Munda Dam was there, it would have effectively regulated the flood in Swat River; thus avoiding widespread devastation lower down in KP province particularly around Nowshera. Similarly, if KBD was there, it would have controlled the unprecedented floods in Indus River and helped to avoid widespread devastation in the downstream areas of Punjab, Sindh and Balochistan provinces. Thus, the presence of these large dams would have substantially reduced the devastation caused by 2010 floods. During 2012 raised Mangla Dam helped to store floods consequently saving flood losses in River Jehlum command. Global history of 20th century contains similar examples of successful control of floods. During 2010 floods, the adjacent areas of India were spared from the devastation similar to Pakistan, basically due to sizeable storage capacity on the Eastern Rivers. As reported in the ICOLD World Register of Dams, by 1998 India had 4,291 Large Dams (9% of World Dam Population). Of these, 2,256 dams were built in the peak period from 1971 to 1990. However, Pakistan suffered considerable flood damages for not having required storage capacity besides wasting precious water resource.

## 8. MINIMUM ADDITIONAL STORAGE REQUIREMENT BY 2025

To sustain the agricultural economy as well as ensure national food security through the mainstay of Indus Basin Irrigation System (IBIS), it is estimated that a minimum additional storage requirements by 2025.(over and above 3.6 BCM - 2.9 MAF of Raised Mangla) would be 22 BCM (18 MAF) comprising; 7.4 BCM (6 MAF) for replacement of on-line storage loss, and 22 BCM (18 MAF) for bridging the gap between supply and projected irrigation demand and anticipated canal withdrawals.

## 9. RECENT WATER RESOURCES DEVELOPMENT STUDIES AND POLICY INITIATIVES

Since the start of 21st Century, a number of water resources development studies, with primary emphasis on storages, have been carried out by the concerned national agencies and foreign donors. The notable amongst these are:

- WAPDA Vision 2025 Programme (2001);
- ADB's Water Strategy Study (2002);
- World Bank's Water Policy Study (2002);
- Report by GoP, Technical Committee on Water Resources (2005); and
- World Bank's Report on Pakistan, Country Water Resources Assistance Strategy (2005).
- World Bank’s Report on Pakistan Water Resources Economy Running Dry (2005).

The relevant recommendations were also reflected in GOP, 'Medium Term Development Framework' (2005). In particular, WAPDA's Vision 2025 Programme' envisaged development of 32 BCM (26 MAF) of storages to ensure national water security.In 2005, the Federal Government took a policy decision to pursue implementation of five dams. These dams with an aggregate live storage capacity of over 25 BCM (20 MAF) comprised: Diamer Basha (7.9 BCM - 6.4 MAF); Kurram Tangi (1.5 BCM - 1.2 MAF); Munda (0.8 BCM - 0.67 MAF); Akhori (7.4 BCM - 6.0 MAF); and Kalabagh (7.5 BCM - 6.1 MAF). However, in 2008, the then Federal Government decided to defer KBD Project due to objections by some provinces and instead assign priority to implementation of DBD Project which is still awaited due to certain contentious issues and lack of funding.

## 10. STATUS OF LARGE DAMS IN PAKISTAN

After commissioning of Tarbela Dam in 1976, Pakistan has failed to undertake implementation of any long term programme to harness the beneficial potential of Indus river and tributaries through construction of large storage dams, except raised Mangla in 2011-12. The main impediment in this regard has been lack of 'National Consensus'. The signing of interprovincial Water Apportionment Accord in 1991, provided a ray of hope for construction of storage dams, wherever feasible. Consequently, it was hoped that efforts will be made to reactivate the KBD. However, this dream could not materialize due to inter-provincial controversy and mistrust.

WAPDA again tried to pursue the objective through its Vision 2025 Programme. In 2004, the Government approved construction of five large dams comprising: Kalabagh, Diamer Basha, Munda, Kurram Tangi and Akhori Dams. Among these, Kalabagh was assigned priority. However, due to failure to achieve national consensus, the priority was instead assigned to implement DBD. Notwithstanding this, the Government tried to keep alive the issue of KBD which has been awaiting go ahead after completion of prolonged engineering studies; establishment of techno-economic viability, and preparation of tender designs and documents. But in 2008 the then elected government again deferred KBD Project under the pretext of lacking national consensus. Priority was again assigned to construction of DBD which could not be started due to certain technical concerns and lack of funding from donor agencies in view of objections raised by India.

With 2010 event of catastrophic floods, a totally new dimension has been added to the urgent need for constructing large storage dams to control this menace of unimaginable proportion. Therefore, a welcome national debate has started for effective flood control through construction of dams on Indus river and its tributaries. Front runner in this regard is again KBD with storage capacity of 7.5 BCM (6.1 MAF) and power potential of 3,600 MW. Similarly, Munda Dam with its installed capacity of 700 MW could provide effective regulation of Swat River floods with ameliorating effect on the downstream Nowshera Valley.

Although construction of DBD Project is being considered, it may take at least 10 years for completion. On the other hand, recurrence of floods have brought into sharp focus the urgency for flood control measures through construction of large storage dams. In this context, KBD Project with construction period of 6-7 years seems to be a preferable choice.

## 11. PROPOSED PLAN OF ACTION

As already mentioned, in 2005 the Federal Cabinet took policy initiative to construct above mentioned five large dams. Based on the current status of 'Engineering Preparedness', these dams with live storage capacity of over 25 BCM (20 MAF) could be implemented by 2025 subject to availability of funding. Proposed sequencing of these dams is: Diamer Basha with live storage of 7.9 BCM already approved by GoP (2010-20 but still awaited); Kalabagh having live storage of 7.5 BCM with special focus on its flood regulating capability (2015-22); and Akhori with live storage of 7.4 BCM (2020-25).

## 12. DIAMER BASHA DAM PROJECT

The DBD Project, which is ready for implementation, is proposed to be located on Indus river about 40 km downstream of Chilas, the district headquarter of Diamer in Northern Areas (now Gilgit-Baltistan) and 400 km from Islamabad. The dam will be 272 m (892 ft.) high roller compacted concrete (RCC) structure with two 2,250 MW each underground powerhouses on both banks of the river. It will have a live storage capacity of 7.9 BCM to provide for the direly needed supplemental water for IBIS. The installed capacity of 4,500 MW would yield an annual generation of 18,100 GWh. In addition, Tarbela Dam would generate extra 1,100 GWh through conjunctive operation with DBD. The environmental impacts would also be relatively moderate. These would comprise: total land acquisition of 15,149 ha (37,419 acres) with agricultural land of 1,138ha (2,811 acres) only; directly affecting a population of about 28,650 in 31 villages to be resettled in the Model Villages around reservoir periphery; and submergence of about 94 km (59 miles) of existing Karakoram Highway (KKH).

However, as per recent development, the World Bank has conditionally agreed to finance the project. The Bank has proposed to undertake feasibility of the project through its experts to shape up the plan for formal funding which would take period of about three years. This conditional financing offer by the Bank tentamounts to delaying the project, as its “feasibility study” and “detailed engineering design” have already been carried out by two separate international consortiums of foreign and local consulting engineering firms in 2004 and 2009 respectively. Both these studies are of international standard and there seems to be no need for undertaking fresh feasibility study. In the background of Indian objection regarding the project, it is apprehended that the project would be delayed significantly and there is no hope for its implementation in the near future.

It is estimated that the Basha Dam Project would cost about US$ 12 Billion with construction period of 12 years. In view of this scenario it is imperative to consider and implement other viable and relatively cheaper project(s) to meet the urgent national need of creating additional storages.

## 13. KALABAGH DAM PROJECT

The major objectives of this multi-purpose project of vital national interest inter alia include:

- To compensate for the storage lost due to silting up of existing reservoirs and to provide additional storage and regulation on the Indus for management and timely supplies of water for the crops;
- To generate large amount of low cost hydro-electrical power near major load centers;
- To increase the energy and power output of Tarbela Power Station as a result of conjunctive operation of Tarbela and Kalabagh reservoirs; and
- To regulate and control the extreme flood peaks of the Indus to alleviate flood damages downstream.

The KBD site is located 210 km downstream Tarbela Dam on the River Indus and 290 km from Islamabad (Figure 6). The project envisages the construction of 79 m high rock-fill dam, with its maximum pool level at 279 m amsl, and usable storage capacity of 7.52 BCM (7% of avg. annual flow). The ultimate generation capacity would be 3,600 MW. The average flow at Kalabagh is estimated as 109.78 BCM from the Indus, Kabul and Soan rivers. The project will have a useful economic life of over 50 years. The project is also essentially required to secure and establish the water rights of Pakistan on Kabul river flows.

Figure-6: Location Map of Proposed KBD and DBD Sites

- **Salient Features of the Project**

**a) Indus River at site**

| | | |
|---|---|---|
| Catchment area | 286194 $km^2$ (110,500 sq. mile) | |
| Maximum observed flood | 33980 $m^3$/sec (1,200,000 cfs) | |

**b) Reservoir**

| | | |
|---|---|---|
| Gross storage | 9.75 BCM | (7.9 MAF) |
| Live storage | 7.52 BCM | (6.1 MAF) |
| Dead storage | 2.22 BCM | (1.8 MAF) |
| Retention level | 279 m | (915 ft. SPD*) |
| Minimum reservoir level | 251 m | (825 ft. SPD*) |
| Area at retention level | 425 $km^2$ | (164 sq. mile) |

**c) Main Dam**

| | | |
|---|---|---|
| Crest elevation | 287 m | (940 ft. SPD*) |
| Crest width | 15 m | (50 ft.) |
| Maximum height (above river bed) | 79 m | (260 ft.) |
| Length | 1,334 m | (4,375 ft) |

**d) Overflow Spillway**

| | | |
|---|---|---|
| Sill level | 262 m | (860 ft. SPD*) |
| PMF Discharge | 30,299 $m^3$/sec | (1,070,000 cfs) |

**e) Orifice Spillway**

| | | |
|---|---|---|
| Sill level | 239 m | (785 ft. SPD*) |
| **PMF Discharge | 22,751 $m^3$/sec | (980,000 cfs) |

**f) Installed Capacity** 3,600 MW

* Survey of Pakistan datum, based on mean sea level at Karachi.

** Probable Maximum Flood.

## 13.1 Project Cost

The total project cost is estimated at US$ 8.0 billion. Implementation of the project would take about 6 years for the first power unit to come in operation.

## 13.2 Project Benefits

KBD will yield direct annual benefit of about Rs. 121 billion from irrigation supplies, power generation and flood alleviation. Additionally, indirect benefits like more industrial and food production, employment and agricultural boost will accrue.

**a) Irrigation Water Supplies**

Due to non-availability of enough fresh water, secondary salinization of lands will seriously affect our crop yields and production. KBD will augment about 7.5 BCM of irrigation supplies annually. The additional water will be made available mostly during Rabi season from October to March and for sowing of Kharif crops, like Cotton, Sugarcane and Rice during April and May. Average benefits of additional irrigation supplies of the project are estimated as Rs. 40 billion per annum.

**b) Power Generation**

KBD will generate, on an average, 11,400 million Kwh annually. The conjunctive operation of Kalabagh and Tarbela will enable Tarbela to generate 336 million Kwh of electricity in addition to its existing power production. Average power benefits are estimated as Rs. 80.0 billion per annum as per the most conservative estimate. KBD, on its completion will add 3,600 MW to the system which will be 20% of the peak demand. This will improve the hydel - thermal ratio. About 11.4 billion units of low cost hydel electricity will be produced annually and transmitted on the national grid for supply to all provinces. This addition of cheaper power, will help stabilize the tariff, a benefit for the entire nation.

The annual energy generated at Kalabagh would be equivalent to 20 million barrels of oil otherwise needed to produce thermal power. This annual import of fuel would require augmentation of transportation infrastructure, an additional burden of Rs. 100 billion per annum to the economy. Thermal generation in the absence of low cost hydel generation would further upset the thermal-hydel mix in the system causing prohibitive rise in the power tariff. Growth of domestic industrial and agricultural sectors would be impeded due to high power cost.

### c) Flood Alleviation

KBD will reduce the frequency and severity of flood damages in downstream areas. Kalabagh reservoir will be drawn down at the start of the monsoon flood season and will not be refilled until late in the season. Some floods will be absorbed by the reservoir and others significantly abated by it while refilling the reservoir. Average flood control benefits are estimated as Rs. 1.50 billion per annum. In 2012 raised Mangla Dam accommodated significant flood water in river Jhelum.

### d) Benefits to Provinces in Water Share

KBD would store water during flood season and release the same during the low flow periods of the year in accordance with provincial shares in the Water Apportionment Accord (1991) as shown in Table-4. The additional water availability to the farmers will result in more cropped area.

Table-4: Provincial Flood Water Shares as per WAA, 1991

| Province | Percentage | Supply BCM (MAF) | |
|---|---|---|---|
| KP | 14 | 1.053 | (0.854) |
| Punjab | 37 | 2.784 | (2.257) |
| Sindh | 37 | 2.784 | (2.257) |
| Balochistan | 12 | 0.903 | (0.732) |
| Total | 100 | 7.524 | (6.100) |

## 14. APPREHENSIONS OF KP AND SINDH PROVINCES REGARDING KBD PROJECT

The KP and Sindh provinces have been expressing their concerns about KBD Project as they consider against their interests. There have been several debates and discussions at various forums regarding the merits and demerits of KBD project, but unfortunately the controversy regarding the project could not be resolved. As a result, it has not been possible to undertake this project of great National interest. The apprehensions of KP and Sindh provinces and the factual position are discussed in the following sections.

### 14.1 Apprehensions of KP Province

- **Historic flooding of Peshawar Valley including Nowshera town would be aggravated in the event of recurrence of 1929 record flood**

The apprehension is not based on facts. Backwater effect of KBD Lake would end about 16 km downstream of Nowshera. A state-of-the-art computer model study, backed by physical modeling in Pakistan, has established that recurrence of record flood would not affect the water level at Nowshera even after 100 years of sedimentation in reservoir. The computer model did not include the effect of Tarbela reservoir which is now factually providing relief by attenuating flood peaks. These studies were reviewed by Chinese Expert (Dr. Lianzhen) and later by an international panel of experts (POE) headed by Dr. Kennedy of USA who was nominated by Government of KP. Both reviewers are highly supportive of the studies. The POE has stated in their report that the results of this study are conservative.

- **Drainage of surrounding area of Mardan, Pabbi and Swabi plains would be adversely affected by the reservoir thus creating waterlogging and salinity**

Lowest ground levels at Mardan, Pabbi and Swabi areas are 296 m (970 ft), 293 m (960 ft) and 305 m (1000 ft.) amsl respectively, as compared to the maximum conservation level of 279 m (915 ft.) for Kalabagh (Figure7). This maximum level of Kalabagh reservoir would be maintained only for 3 to 4 weeks during September and October after which it would deplete as water is released for Rabi crops and power generation. Ultimately it would go down to dead storage level of 252 m (825 ft) by early June. This operation pattern of reservoir cannot block the land drainage and cause waterlogging or salinity in Mardan, Pabbi or Swabi area.

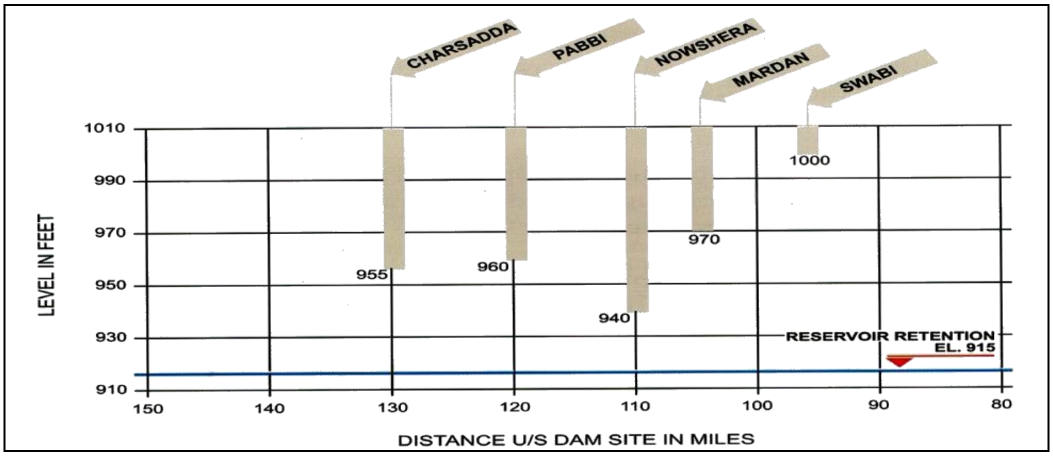



Figure-7: Levels of Different Cities (KP) with Kalabagh

- **Operation of Mardan SCARP would be adversely affected**

The invert levels of main drains of Mardan SCARP are higher than reservoir elevation of 279 m (915 ft) and the back water level in Kabul river and Kalpani Khwar. These drains would therefore, keep on functioning without any obstruction.

- **Fertile cultivable land would be submerged**

Kalabagh reservoir will extend 147 km up the Indus river from the dam site and 57 km up the Soan river, and about 16 km up the Kabul river from the Kabul-Indus confluence (Figure 8).The reservoir area at maximum pool level of 279 m (915 ft.)amsl would be 425 $km^2$ (164 square miles).

Total cultivable land to be affected by the project is only 14,164 ha. Cultivable land to be submerged under the reservoir elevation of 279 m (915 ft.) and to be acquired permanently, would be 11,129 ha ---9,115 ha in Punjab and 1,214 ha in KP. of this irrigated land would be only 1,214 ha ---1,174 ha in Punjab and 40 ha in KP. The balance 3,035 ha is the land that will be temporarily submerged by flood with recurrence interval of 1 in 5 years. Full compensation for this land will be paid to the owners, leaving title with them so that they can cultivate the land as before---2,428 ha of such land is in Punjab and 607 ha in KP. In addition, the drawdown of the reservoir level every year would provide one season cropping in about 5,666 ha lying above elevation 271 m (890 ft.).

It may be worth mentioning that about 405 ha of irrigated land was acquired for Mardan SCARP alone, and compared to this, Kalabagh asks for a much smaller sacrifice.

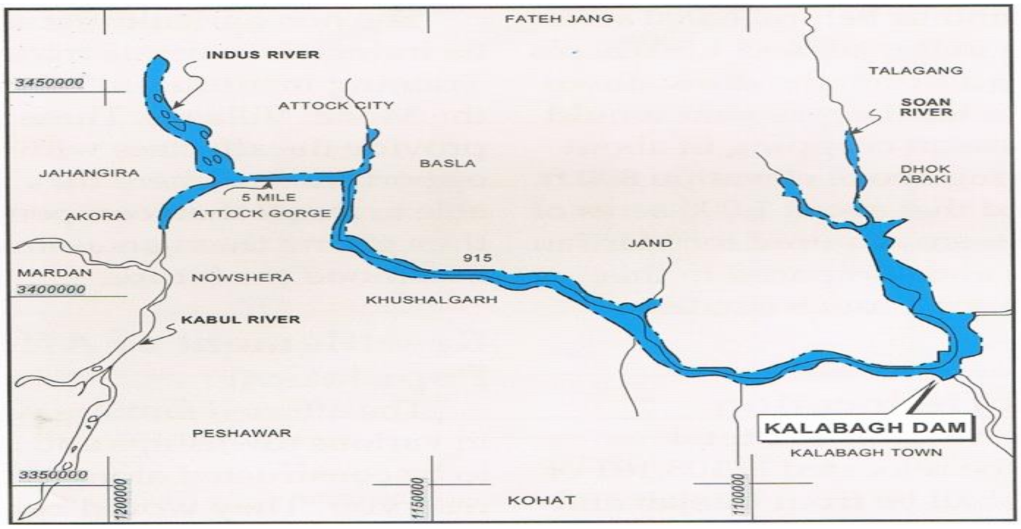



Figure-8: Kalabagh Dam Reservoir Area (EL. 915 ft.)

## 14.2 Apprehensions of Sindh Province

- **There would be no surplus water to fill Kalabagh reservoir**

  The Indus river flows are highly variable both annually and seasonally, with 84% of inflows occurring during six summer months and remaining 16% during six winter months. It provides an opportunity to conserve surplus summer flows for use during low period and to avert flood damages.

  In post Tarbela years, an annual average of about 43.2 BCM have escaped below Kotri to Sea. During July to September period, flood surplus is always available. Kalabagh reservoir will be filled up by only 7.5 BCM, and nearly 36 BCM would still be going downstream of Kotri Barrage. On the direction of Senate Standing Committee on Water & Power, Indus River System Authority (IRSA) carried out a study and confirmed that sufficient water is available for further storage.

- **The anxiety that the project would render Sindh into a desert**

  The main objective of constructing major storage dam(s) on Indus river and its major tributaries, is to store surplus water during flood season and make it available on crop demand basis during the remaining dry periods of the year. This has been practically demonstrated after full commissioning of Tarbela Dam Project in 1976. During pre-storage years of 1960-67, average annual canal withdrawals of Sindh were 44 BCM. After construction of Mangla and Tarbela, the corresponding figure rose to 52 BCM indicating an increase of over 24 percent. The Rabi diversions alone increased from 13.2 to 18.6 BCM. It is estimated that after Kalabagh, the canal withdrawals for Sindh would further increase by about 2.8 BCM. Thus the often repeated apprehension regarding desertification of Sindh defies even the basic logic of a storage reservoir.

- **High level outlets would be used to divert water from the reservoir**

  A telemetric system employing modern electronic technology has recently been installed at each barrage and other flow control points to monitor discharges in various canal commands on real time basis under the auspices of IRSA. This system shall also be extended to KBD Project to further ensure fair water distribution among the provinces as per Water Apportionment Accord, 1991.

- **Cultivation in riverain (Sailaba) areas would be adversely affected**

  Sailaba crops are grown on the land adjacent to the main river and the creeks. Though crops are sown on the soil moisture soon after the floods, these need more than one watering to mature. As a result Sailaba lands give poor yields. Consequently, farmers generally provide irrigation to their crops through shallow tubewells or lift pumps. Prime movers on these tubewells have to be removed during the flood season to avoid damage. Sindh has presently 267,098 ha of Sailaba cultivation land from Guddu Barrage to sea. Majority area has tubewell facility for supplemental irrigation. This area is initially sown due to the moisture provided by flooding with river stage upto 8,495 $m^3$/sec (300,000 cusec) and above (Figure 9). Flood peak above 8,495 $m^3$/sec would still be coming after construction of KBD without detriment to the present agricultural practices, while larger floods would be effectively controlled. This would, in fact, be conducive to installation of permanent tubewells to provide perennial irrigation facility in the riverain areas. The local farmers can look forward to have two crops annually instead of the present one crop.

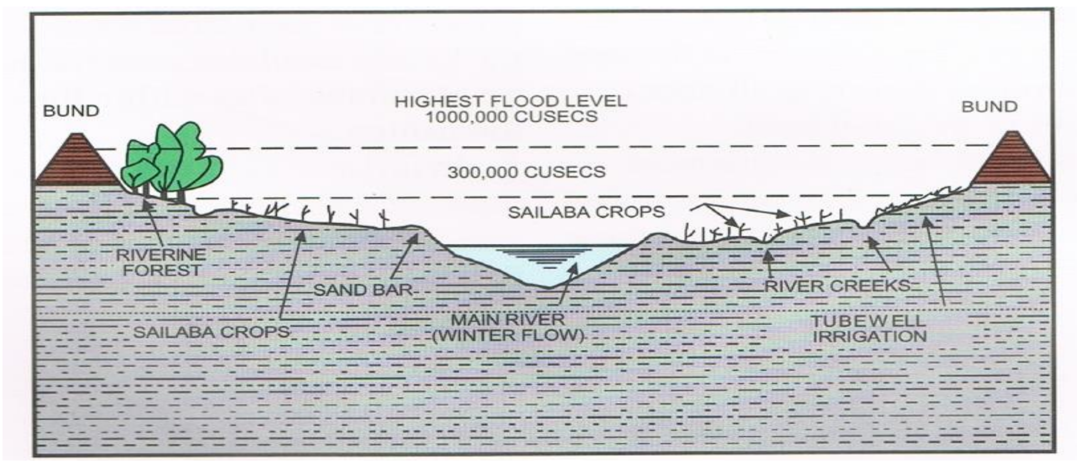



Figure-9: Sindh Province Riverain Area (Typical X-Section)

- **Sea Water intrusion in Indus estuary would accentuate**

  The fear that present extent of the sea water intrusion in the Indus Delta would be further aggravated by Kalabagh is not substantiated by factual data. Studies indicate that presently the total effect of Indus estuary is only limited to the lower parts of Delta and gets dissipated below Aghimani gauge (Figure-10). Data shows that sea water intrusion seems to be at its maximum even now, and it is unlikely to be further aggravated by KBD.

  Another apprehension is that sea water intrusion would cause serious quality deterioration of the existing aquifer system. The groundwater contained in the aquifer is highly saline north of Hyderabad. Intrusion of sea water along shore of delta is of little consequence. This is further supported by the fact that there is southward oriented groundwater gradient throughout this aquifer. Considering the very low transmissivities of the aquifer in Delta region, upward sea water intrusion can be almost ruled out. Despite all this, it could still be considered to improve conditions by building some engineering structures.

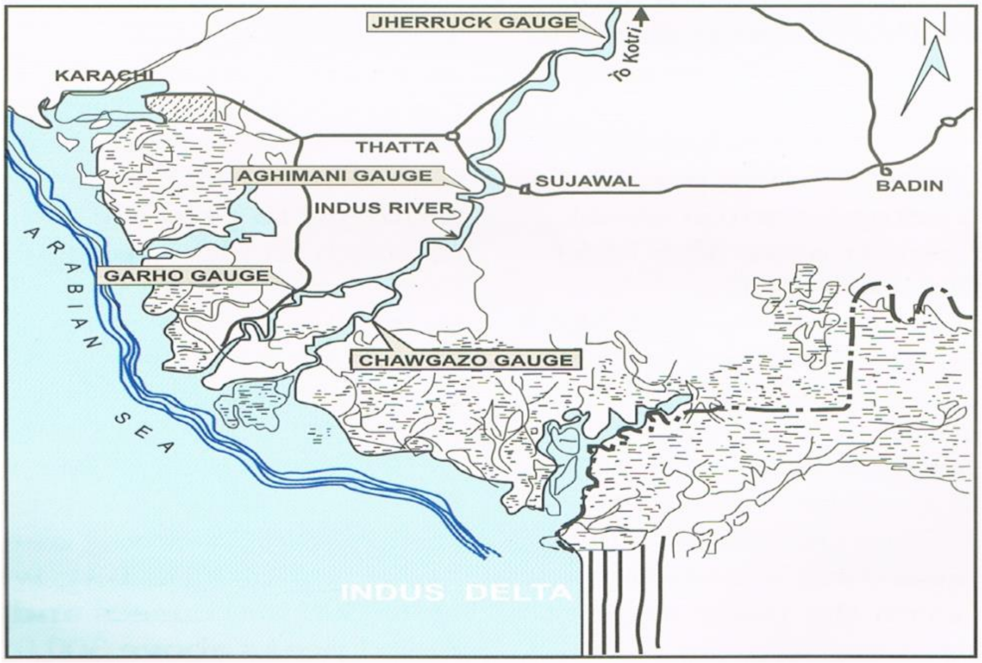



Figure-10: Sea Water Intrusion limits upto Aghimani Gauge

- **Mangrove forests, which are already threatened, would be further affected adversely**

The concern that construction of KBD would adversely effect the mangrove forests is not substantiated by facts. According to available data, out of the total tidally inundated historic Indus Delta area of 0.62 million ha,the mangrove forest area is only about0.13 million ha. Further, in these forests which spread from Karachi in the west to Rann of Kutch in the east, about 95% of the plantation comprises salt tolerant species. The other species are found only in small areas near canal escapes and in the active delta areas. The active delta area (as distinct from the historic delta area described above) is about 118,280 ha. The mangroves cover only 2,995 ha or 2.5% of this area,while the remaining area is mostly in the form of mud-flats.

According to a study carried out by NED University of Engineering and Technology Karachi, titled “What really threatens us and our Mangroves”, the reduction of mangroves is essentially due to frequency of tidal inundation being too small instead of a fresh water reduction caused by upstream abstractions, which started with the construction of Sukkur Barrage in 1932. Other causes include uncontrolled overgrazing and cutting of trees due to extreme population pressure. Therefore, in order to revive the mangroves, the real need is for replanting salt tolerant varieties with provision for controlled doses of fresh water. Such a possibility can be further enhanced through creation of upstream storage facility like Kalabagh. It will help to regulate the river flows for providing appropriately designed scheduled releases downstream Kotri Barrage.

- **Fish production and drinking water supply below Kotri would be adversely affected**

The apprehension that marine fish production would decrease is not correct. The statistics of Ministry of Agriculture & Livestock, Government of Pakistan as given in

Table-5, reveals that fish production infact, increased in the downstream area after construction of Tarbela Dam.

Table-5: Marine Fish Production

| **Year** | 1975 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|
| **Fish Production (000 Tons)** | 113 | 283 | 270 | 292 | 303 | 351 | 308 | 315 |

Although the above statistical data negates the apprehension, it is certainly possible that production of Pallah fish can be increased with the use of modern technology. In the Riverain area downstream of Kotri Barrage, groundwater is predominantly brackish and as such unsuitable for either irrigation or drinking water supply. With the construction of KBD, the winter flows in the river would improve thus assuring more fresh water supplies.

## 15. CONCLUSIONS AND RECOMMENDATIONS

### 15.1 Conclusions

The authors highly respect the rights of all the provinces and have full regard for their interests without any prejudice. In light of the factual position as described and discussed in the paper, it may be concluded that construction of KBD is essential in the larger national interest. It will greatly help to address the urgent needs of water and power of the country and shall accrue the following benefits in a relatively shorter period:

(i) About 28% loss of storage capacity due to sedimentation of the on-line reservoirs upto 2012, would result in shortage of committed irrigation supplies causing serious drop in existing agricultural production. The storage loss will further increase every year to the extent of 37% by the year 2025. The KBD shall be an appropriate and timely replacement of this storage loss.

(ii) For implementation of Water Apportionment Accord 1991, new storages are essential. If new storage(s) are not created, the resulting situation may lead to bitter interprovincial water distribution disputes, particularly during dry water years.

(iii) The annual energy generated at Kalabagh would be equivalent to 20 million barrels of oil otherwise needed to produce thermal power. This annual import of fuel would require augmentation of transportation infrastructure, an additional tentatively estimated burden of Rs. 100 billion per annum on the economy.

(iv) Thermal generation, in the absence of low cost hydel generation, would further upset the thermal–hydel mix in the system causing prohibitive rise in the power tariff. The power contribution of 3,600 MW by KBD shall help to offset power tariff rise.

(v) Growth of domestic, industrial and agricultural sectors would be enhanced with the availability of cheaper hydropower from KBD. The dam will generate direct annual benefit of about Rs. 121 billion per year and recover its cost within a period of about 10 years.

(vi) It may be emphasized that if KBD was constructed as per its original plan and completed in 1996, it would have contributed from irrigation and power more than three times of its construction cost so far, besides continuing long lasting benefits. In addition, it could have saved over Rs. 1.60 trillion required for import of oil for equivalent thermal power. Thus the construction of KBD is required to support the national economy.

## 15.2 Recommendations:

(i) The KP and Sindh provinces reservations on KBD construction have been adequately considered and discussed in the paper. Accordingly it is recommended that construction of KBD may be taken up in the best national interest. It is further recommended that confidence and trust building measures among provinces, which are the real need of the time, may be initiated at appropriate level to facilitate the consensus required for construction of the project at the earliest possible. For this purpose, it is suggested to declare KBD project land as “federal territory” and vesting the operation of the dam with some “independent regulatory body” for ensuring water distribution as per Water Apportionment Accord, 1991.

(ii) The royalty on power generation may be distributed in accordance with the most recent National Finance Commission Award. This shall help to secure National Consensus regarding construction of KBD which is required for economic development of the country.

(iii) A wide dissemination of the conclusions and recommendations is required for consideration of the policy makers and masses at large for early construction of KBD in the best national interest.

## REFERENCES


- ADB Power Sector Rehabilitation Project, 2012.
- ADB's Water Strategy Study (2002).
- Economic and financial analysis of DHP, Basic Design Report, 2012
- Feasibility Report of KBDproject, 1989.
- GCISC (2009): Ali, G., S. Hassan, and A.M. Khan, Climate Change: Implications and Adaptation of Water Resources in Pakistan, Research Report No.GCISC-RR-13, Global Change Impact Studies Centre, Islamabad.
- GCISC (2009): Islam, S., N. Rehman, M. M. Sheikh and Arshad M. Khan, Climate Change Projections for Pakistan, Nepal and Bangladesh for A2 and A1B Scenarios used in IPCC-AR4, Research Report No.RR-03, GCISC, Islamabad.
- Hydro Planning Organization, WAPDA, Sunny View Lahore (2009).
- IPCC – UN, Intergovernmental Panel on Climate Change, Fourth Assessment Report: Climate Change 2007 (AR4)
- Mangla Hydropower Station Rehabilitation and Enhancement Project –Preparatory Survey Report, August 2012 ---prepared by Nippon Koei Co. Ltd Japan with Development & Management Consultants (DMC) Lahore Pakistan, as Associate.
- National Water Policy, 2003 –draft, prepared by the office of Chief Engineering Advisor, MW&P, GOP, Islamabad.

- NTDC Electricity Marketing Data. 2012
- Pakistan Water Partnership (PWP) – The Framework For Action (FFA) For Achievement of Pakistan Water Vision 2025, Feb. 2000 prepared by Development and Management Consultants (DMC), Lahore, Pakistan.
- PEPCO Power statistics of Pakistan 2011
- Provincial Water Apportionment Accord 1991.
- Rees, G. and D.N. Collins (2004), Snow and Glacier Aspects of Water Resources Management in the Himalayas, Centre for Ecology and Hydrology, Oxford shire, UK
- Report by GoP, Technical Committee on Water Resources (2005);
- Riaz. N. Tarar, 2011, Medium and Large Dams Construction for Water and Food Security in Pakistan, World Water Day, 2011 held at Pakistan Engineering Congress, Lahore.
- Roohi/ICIMOD (2005): Roohi, Rakhshan, A. Ashraf, R. Naz, S.A. Hussain, M.H. Chaudhry, S.R. Bajracharya, B. Shreshtha and S.P. Joshi. Inventory of Glaciers and Glacial Lakes and the Identification of Potential a Glacial Lake Outburst Floods (GLOFs) affected by Global Warming in the Mountains of Himalayan, PARC, ICIMOD, APN, START & UNEP.
- WAPDA, Water Sector Invest Planning Study 9WSIP), 1990.
- WAPDA's Vision 2025 Programme (2001).
- World Bank's Report on Pakistan, Country Water Resources Assistance Strategy (2005). The relevant recommendations were also reflected in GoP, 'Medium Term Development Framework' (2005).
- World Bank’s Report on Pakistan Water Resources Economy Running Dry (2005).
- World Bank's Water Policy Study (2002).
- WRM – Publication No. 385,2009, Indus Basin Irrigation System, Historic Rivers and Canals Discharge Data 2008 – 2009, WRMD Directorate, WAPDA, WAPDA House Lahore.