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ROLE OF DIAMER BASHA DAM (DBD) ON FOOD, ENERGY SECURITY AND CLIMATE CHANGE MITIGATION OF PAKISTAN

Zahid Majeed

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By

Engr. Zahid Majeed[1]

Abstract

The Indus River flows through centre of Pakistan like a Yangtze River in China before emptying into the Arabian Sea, southeast of Karachi. The flows of the river are highly variable and depend on snow melting from glaciers in the Himalayas and partly summer monsoons. About two third of the total annual runoff occurs from June to September. The Indus and its tributaries are source of world's largest contiguous irrigation system for agriculture and contributes major share of hydel power generation in Pakistan. Therefore, due its variable annual flows mega dams/ water storage reservoirs are necessary to regulate the flows of Indus River throughout the year for Rabi (October to May) and Kharif season (April to October) crops and flood control to mitigate adverse impacts due to climate change by constructing mega dams in Upper Indus River.

Upper Indus River has a drop of about 690 m in a stretch of 315 km length from DBD (4,500 MW, 10 BCM) to Tarbela Dam (4,888 MW, 14 BCM). After commissioning of Tarbela Dam on Upper Indus about 50 years back, presently Pakistan Water and Power Development Authority (WAPDA) is implementing DBD through Diamer Basha Dam Company (DBDC), constructing Dasu Stage-I (2,160 MW, 1.4 BCM) and finalized feasibility studies of Patan (2,400 MW, 0.27 BCM) and Thakot-I (2,222 MW, 0.18 BCM) run of river hydropower projects at upstream of Tarbela as cascade system. The total installed capacity of cascade system including Tarbela Dam is about 16,000 MW with a gross storage capacity of about 26 BCM. This study is focussed on under construction DBD and its role in food and energy security and climate change mitigation of Pakistan.

Keywords: Indus River, Cascade System, Diamer Basha Dam & Tarbela Dam.

1. Introduction

The Indus River initiates in the Himalayan Mountains of Tibet and flows through Pakistan like a human spine (Fig.1) before falling into the Arabian Sea. The length of the river is 2,900 km with a basin size of about 1 million

[1] Chief Engineer, Diversion Works (DW), Diamer Basha Dam Project (DBDP) WAPDA, Chilas 10144, Pakistan, gm_hpw @ yahoo.com

sq. km. and average annual discharge is about 175 BCM. The river initially flows Northwest for 966 km but then turns South, draining an area that includes the glaciers and high mountains [1]. The river flow depends mostly on snow melting from the Himalayas glaciers and partly on monsoon rains. About two third of the total annual runoff occurs from June to September. The Indus and its tributaries are a source of world's largest contiguous irrigation system for agriculture and contributes major share of hydroelectricity generation in Pakistan.

The river system consists of the main stem Indus after which India is named and five major tributaries (Fig. 1), all of which flow partially or entirely through India before reaching Pakistan. India is therefore the upper riparian nation on virtually every tributary of significance in the basin. The major exception is the Kabul River, which begins in Afghanistan, before converging with the Indus River in Pakistan.

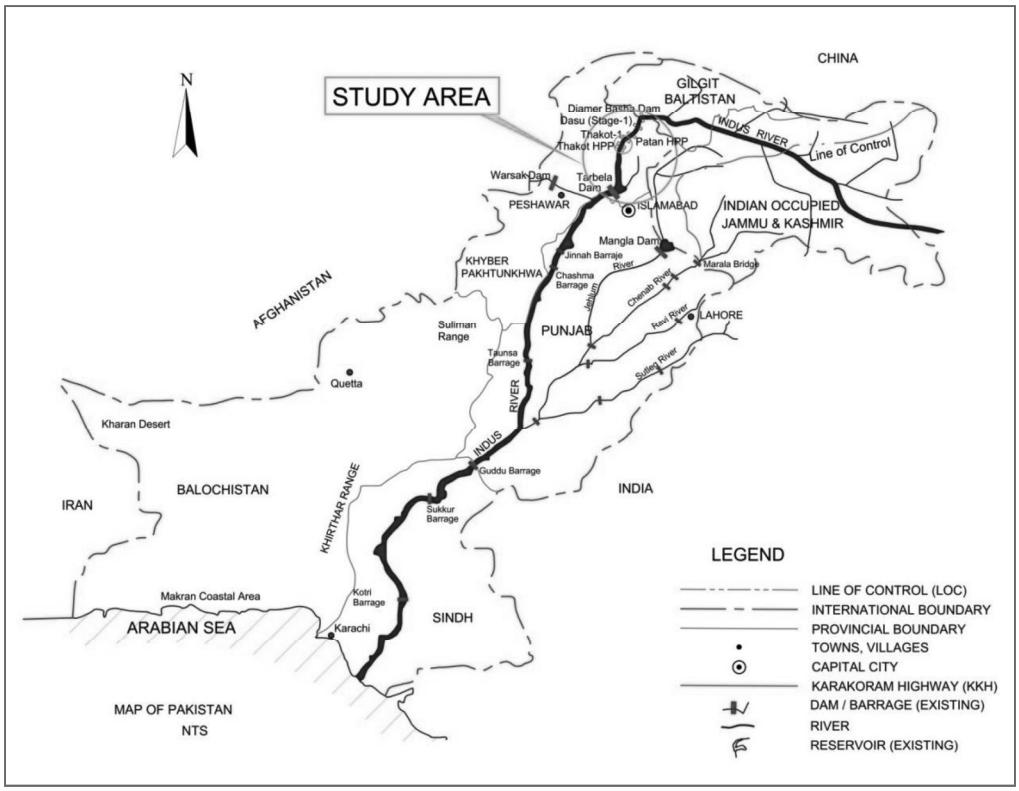


Figure-1: Map of Islamic Republic of Pakistan showing Study Area on Indus River

Upper Indus River has a drop of more than 2200m in a stretch of 700 km length from Line of Control to Kalabagh Dam (Fig. 2) which is ideal for hydroelectric generation and storage reservoirs to regulate the flows of

Indus throughout the year. The Study Area (Figure 1 & 2) comprises of cascade system on Upper Indus between Diamer Basha Dam[2] (DBD) and existing Tarbela Dam (about 315 km reach). Dasu (Stage -I), Patan and Thakot run off river hydropower projects are the part of cascade system of the Study Area.

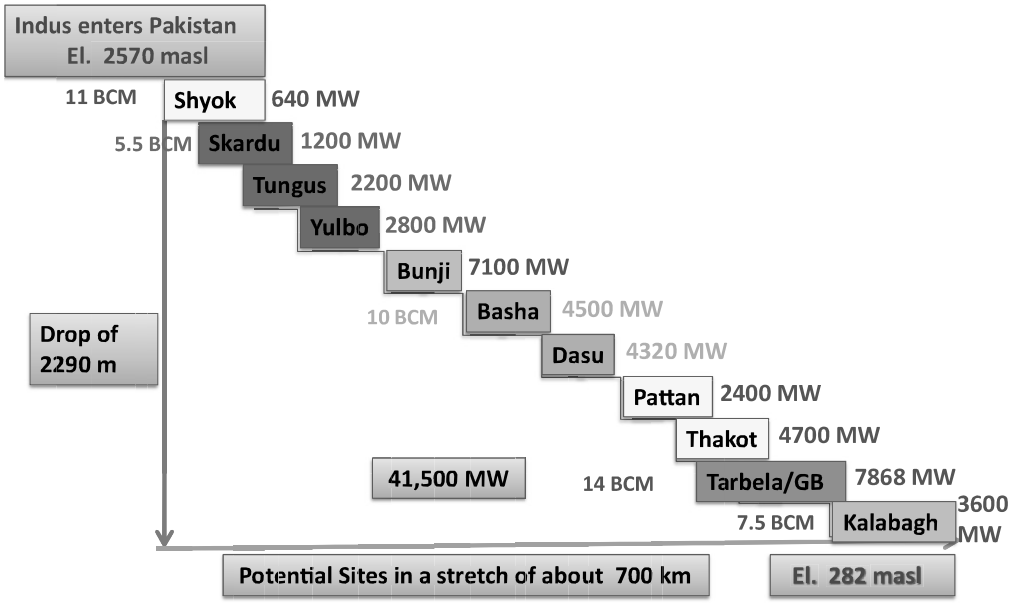


Figure-2: Upper Indus River Cascade Potential

2. Diamer Basha Dam Project (DBD)

Diamer Basha Dam (DBD) is under construction since August 7, 2020 located on the Indus River in Gilgit Baltistan and Khyber Pakhtunkhwa about 420 km from Federal Capital Islamabad (reservoir is of about 109 km at FSL of 1160 masl having gross storage capacity of about 10.0 BCM with an installed capacity of 4,500 MW) and 315 km upstream of existing Tarbela Dam (installed capacity 4,888 MW and gross storage capacity 14.0 BCM) [5].

DBD will be world highest Roller Compacted Concrete Dam having a height of 272 m by using largest quantity of RCC i.e., 200 million m^3 with ungated spillway at the top to pass the Probable Maximum Flood (PMF) of 42,000 m^3/sec, with two underground power houses on each bank and flushing tunnels. The Project is divided into 6 Contract Packages i.e. MW-1, MW-2, HM-1, HM-2, EM-1 and EM-2 [11].

[2] Detailed Engineering Design prepared by DiamerBasha Consultants LI-NDC-BQB-PES, under construction.

Currently MW-1 package has been awarded to Power China and FWO Joint Venture (PFJV) which consists of construction of dam, spillway and permanent bridge. The work has been commenced since August 2020 and will be completed in 102 months with a cost of about US $ 4 Billion [11] with an additional cost of land acquisition, resettlement and Confidence Building Measures (CBM) of about US $ 1 Billion and US $ 0.6 Billion for relocation of Karakorum Highway (KKH). It comprises of preliminary works, diversion works (Fig. 3,4 &5) to divert the flood of 15,000 m^3/sec for 100 year return period, which comprises Diversion Canal (DC) of 15,000 m^3/sec, u/s and d/s cofferdams and a diversion tunnel of 1355 m^3/sec as shown below:

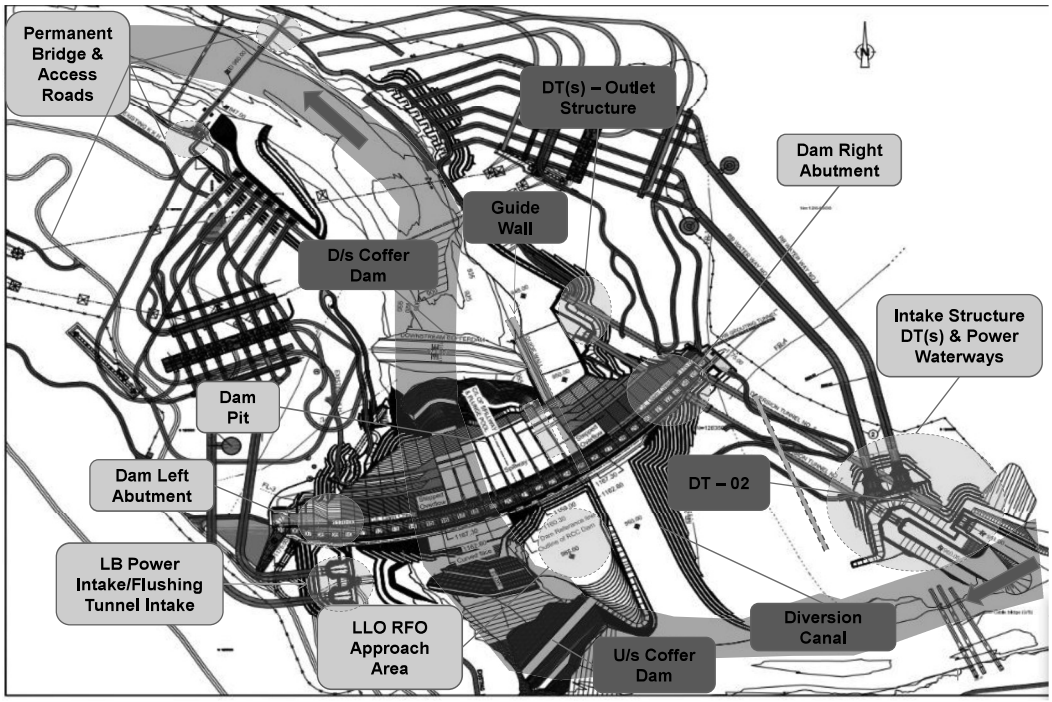


Figure-3: Plan of Dam & Diversion Scheme (In blue boxes) to divert 15,000 m^3/sec discharge

After diversion of Indus flows construction of dam and spillway has been undertaken. Besides, Tender works for other Contract packages are in progress. MW-2 include Civil works for both underground power houses including headrace tunnel, surge shafts and tailrace tunnel. The Package HM-1 includes procurement and installation for hydraulic steel structure including gates for intake tunnels upstream of the dam. While, HM-2 include hydro mechanical equipment and hydraulic steel structures for both power houses (left and right bank) downstream of the dam. At the final stage contracts EM-1 and EM-2 shall be executed which includes power plant

generation and electro-mechanical equipment for both powerhouses (EM-1), High voltage and power plant electrical equipment, Gas Insulated Switchgear (GIS) and transformer cavern equipment (EM-2) for both power houses costing about US $ 5 Billion.



Figure-4: Indus River passing through DC



Figure-5: Diversion System (night view)

Currently, packages MW-1 and HM-1 are being executed under the umbrella of Dam Part, while other four package MW-2, HM-2, EM-1 and EM-2 are part of power generation under process of bidding. The total cost of all package including CBM works and KKH relocation is estimated around US $ 11Billion [11].

2.1 Up to Date Status/Progress of DBD

At present River Diversion for 15,000 m^3/sec discharge has been completed (Fig. 6), out of 25 million m^3rock excavation about 16 million m^3 has been finished and stored in4 stock pile areas near crushing plant(Fig. 7) having capacity of 500 tons/hr during phase I. Installation of ice plant, cooling plants and batching plant (Phase I-1040 m^3/hr)and 5 silos of 3000 tons capacity have been completed (Fig.8). Heavy Fuel Oil plant of 4x 8.4 MW about 34 MW phase- I (Fig.9) will be commissioned during March, 2025. Dam pit

excavation going on in between u/s and d/s cofferdams beside guide wall on right side and left abutment which will be completed by June 2025 and RCC works will be started in Dec 1, 2025.



Figure-6: Indus River Closure done successfully in December, 2023 by Power China.

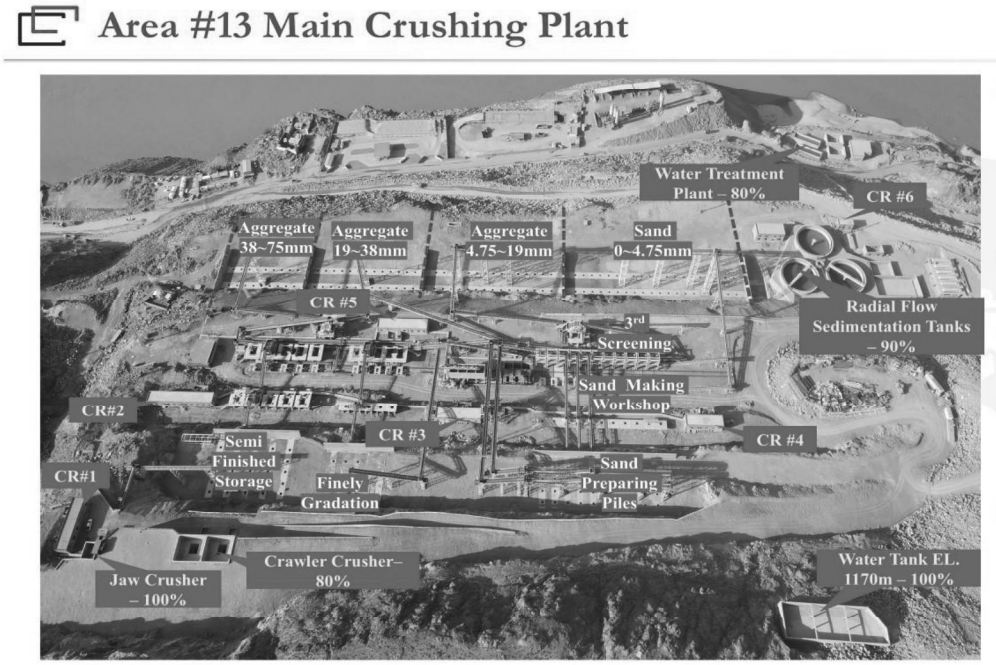


Figure-7: Main Crushing Plant Phase I –500 T/hr in Phase II 2600 T/hr.

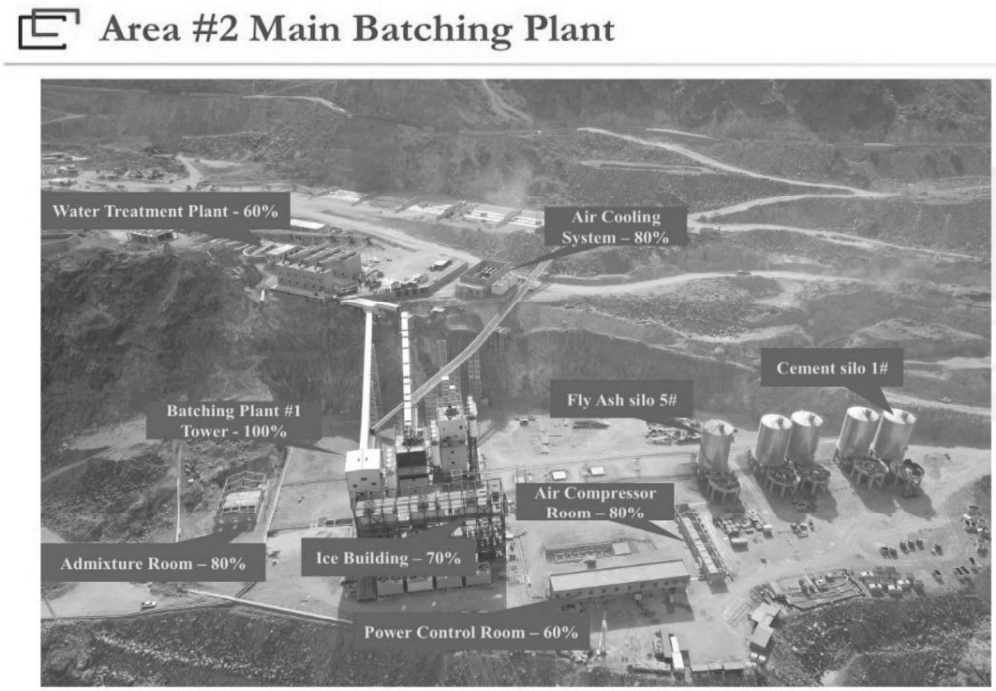


Figure-8: Batching Plant Phase I - nominal capacity 1040 m^3/hr.

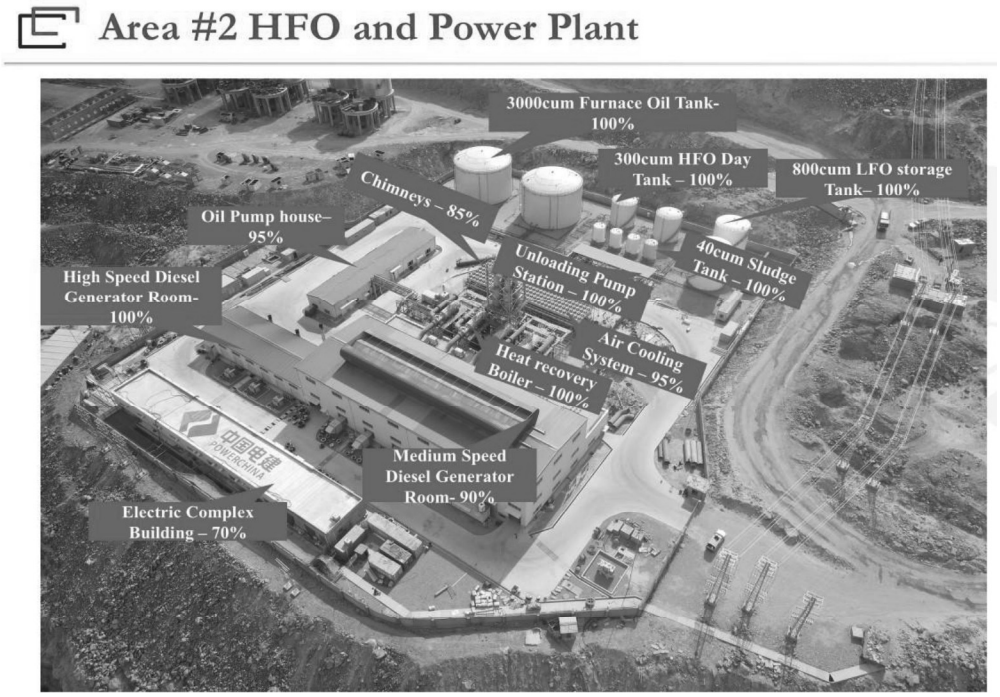


Figure-9: Power Plant of about 34 MW, Heavy Fuel Oil (HFO) will be commissioned in March 2025.

2.2 Role of DBD in Food and Energy Security

Due to variable flows of Indus River explained earlier mega dams (water storage reservoirs) are necessary to regulate the flows of Indus River throughout the year for Rabi (October to May) and Kharif (April to October) crops. However, Tarbela Dam was commissioned in 1976 and had a gross and live storage capacity of 14 and 12 BCM respectively. As Indus is one of the largest sediments producing river in the world. Therefore, presently the gross and live storage capacity of Tarbela Reservoir is 8.0 BCM and 7.0 BCM respectively which shows appreciable reduction in the existing storage of Tarbela Dam by 40% due to sediment deposition. After about 5 decades DBD under construction has gross and live storage capacity of reservoir 10 and 8 BCM respectively this will compensate the 5.0 BCM live storage which has been depleted in Tarbela Reservoir it means additional 3 BCM water will be available for irrigation. With this additional storage of water about 1.23 million acres of land will be irrigated. At the time of commissioning of Tarbela population of Pakistan was about 75 million, however in 2024 the population of Pakistan is 240 million it means DBD will only supplement the food requirement of Pakistani nation.

Primarily the water releases from Tarbela Dam have been used for irrigation and hydroelectricity as by product i.e., 17,500 GWh annually about 1 cent per KWh with an installed capacity of 4,888 MW, which is about 12 % of total generation of the country. Similarly in the case of DBD water will be released according to irrigation demand and as a by-product hydroelectricity i.e. 18,000 GWh annually about 2.5 cent /kWh will be generated with an installed capacity of 4,500 MW. Presently electricity price of energy mix in Pakistan about 10 cents/KWh so electricity generation from DBD will add additional 12% than Tarbela in energy mix and decrease in per unit electricity price of country and affordable to common man. DBD will supplement existing storage and generate inexpensive electricity in the energy mix.

In Post Basha Scenario only with the operation of Basha reservoir without sediment flushing mean annual energy generated of the cascade will be 39,822 GWh (38,771 GWh with additional generation of 1,111 GWh /annum at Tarbela) without considering mean annual energy generated by DBD i.e. about 18,000 GWh. But in Pre Basha-Scenario the mean annual energy with sediment flushing is 24,273 GWh which is the loss of 15,549 GWh (about 15.5 billion units/annum) about 38% loss of mean electricity generation in the absence of DBD [5] as shown in Table 1.

Table-1: Post and Pre Basha Power Generation due to Regulation of flows by DBD

Operating Scenario	Mean Annual Energy GWh			Total GWh
	Dasu (Stage-I) HPP	Patan HPP	Thakot-I HPP	
Post Basha[1] - Power generation without sedimentation flushing	15,712	12,569	10,490	38,771
Pre Basha - Power generation with sedimentation flushing	9,372	7,931	6,970	24,273

2.3 Role of DBD in Climate Change Mitigation

Pakistan is among the top 10 most vulnerable countries to the impact of climate change. As a country the onslaught of extreme climate events has been gradual and incessant since the last 2 decades. In order to tackle the effect of extreme events due to Climate Change and floods structural measures taken by management of major rivers by constructing

dams/reservoirs as per WAPDA's priority list and DBD comes after Kalabagh Dam which could not be constructed due to dispute between provinces. However, DBD will help to mitigate climate change impact by reducing flood peaks. The floods of 2010 and 2022 have made destruction of infrastructure Pakistan more than US $ 70 billion in addition to the loss of human life [6,7,8,9] and more than 60% loss sustained in Sindh Province.

As DBD will play major role in climate mitigation of Pakistan therefore financial support should be provided from the climate finance committed by developed countries of US $ 300 billion upto 2035 for developing countries during COP 29 held at Baku, Azerbaijan because it is difficult to arrange US $ 9 Billion to complete the Project by Pakistan.

3. Increase in Benefits of Existing Tarbela Dam

It is calculated during Detail Engineering Design of DBD [5] that in Post Basha Scenario will result in enhancing the life of Tarbela Reservoir by reducing the sediment entry of about 3.0 BCM of existing reservoir during next 30 years and will result in generation of additional 1,111 GWh/annum [5].

4. Conclusions

a. Diamer Basha Dam (DBD) in addition to supplement and partially ensure food and energy security will mitigate Climate Change Impacts of Pakistan and optimize the hydelgeneration and reservoir life of d/scascade projects at Indus River therefore its construction is of vital importance.

b. As DBD will play major role in climate mitigation of Pakistan by regulating flows of Indus therefore financial support should be provided from the climate finance committed by developed countries of US $ 300 billion up to 2035 for developing countries during COP 29 held at Baku, Azerbaijan at least US $ 6 Billion to complete the Project.

c. In Post Basha Scenario reservoir (10,008 Mm^3) of DBD will act as a huge sediment trap which will significantly reduce the sediment inflows d/s cascade projects i.e., Dasu (Stage-I), Patan, Thakot-I reservoirs can be operated without sediment flushing for the next 3decadesand enhance the life of existing Tarbela Reservoir by reducing the sediment entry of about 3.0 BCM during next 30 years.

d. In Post Basha Scenario only with the operation of Basha reservoir without sediment flushing mean annual energy generated of the cascade will be 39,822 GWh (38,771 GWh with additional generation

of 1,111 GWh /annum at Tarbela) which is about 15,500 GWh more by regulation of flows by DBD to annual generation.

5. Acknowledgements

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