Feasibility Study Of Kalabagh Dam Pakistan

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Abstract: Kalabagh Dam is among the proposed dams in Pakistan since 1987. Many consultants worked on the feasibility studies of this dam and have provided much information on the merits and demerits of Kalabagh Dam. But still the dam is not constructed because of many reasons. One main objection by KPK province is that due to construction of Kalabagh dam, Nowshehra region will get flooded. Another main objection by Sindh province is that Kalabagh dam will convert Sindh into desert because of the blockage of water and KBD will increase the sea intrusion problem. In this research, the technical, economical and political study of Kalabagh Dam is done in detail and the final conclusion is provided at the end of this paper. Technically the slope stability analysis of the proposed model is done using latest software namely SLIDE. Moreover, the surface backwater effect of Kalabagh Dam is analyzed by plotting the contour map of the upstream region using Satellite images and Global Mapper software. Economical and political circumstances are also studied and analyzed in detail.

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1. Introduction

The Kalabagh Dam site is located about 194 km d/s of Tarbela dam and 16 km u/s of Kalabagh town. Fig. 1.1 shows its location on the map of Pakistan. The dam site is linked by a railway line and road which are passing near a distance of approximately 13km with the site. Catchment area of River Indus at the Kalabagh dam site is 286, 194 sq. km. The average annual flow of River Indus is 138.69 MAF at the Kalabagh dam site. In kharif season, 83.6% of the discharge occurs and 16.4% occurs at the Rabi season (WAPDA, 2012). Kabul River contributes average annual of 20 MAF of water while Soan river contributes 16 MAF of water. Site exploration and soil investigation started in 1953 by the mutual cooperation of World Bank. Later the construction of KBD project was expected to be started in 1987 and should be completed in 1993. But unfortunately it was not constructed because of many reasons. And one of the main reason is the political criticism. (WAPDA). Finally, in 1980, a team of World Bank finally confirmed that site C (figure 1.1) is best for constructing the dam from both economic and technical point of view. The other two sites i.e. site A and B were rejected because;

(1) The main construction material required at Site A was concrete as the sandstone would not make an adequate aggregate when crushed. Due to this reason, the dam was estimated to be much expensive.

(2) Site B was having a fault line and hence rejected by the other experts.

Figure 1.1: Location of Kalabagh Dam

2. Literature Review

KBD Project was planned in 1984, with the participation of the UNDP administered by the World Bank (WB), for the client, Water And Power Development Authority (WAPDA) of Pakistan. The UNDP project document for the agreement defines the development objectives of the Kalabagh dam project as follows:

"To accelerate the tempo of economic development and increase the growth rate in Pakistan for supporting the fast growing population and raising their standard of living, it is necessary to realize the full hydropower and agricultural potential of available water resources and to regulate the flood peaks of the River Indus. The proposed Kalabagh Dam is an important step towards achieving these objectives"

Objections on KBD

On the construction of KBD, various complaints have been expressed by KPK and Sindh provinces. Main objections by these two provinces are as follows.

Objections by KPK

Below are the main objections of KPK on the construction of KBD.

(1) With the construction of KBD, Nowshehra will get flooded.

(2) Swabi, Mardan and Pibi scarp will be water logged.

(3) Many people of KPK will be displaced.

Objections by Sindh

Below are the main objections of Sindh on KBD:

(1) Construction of Kalabagh Dam will convert Sindh into desert because of non availability of water.

(2) The land of lower Sindh will be affected by the intrusion of salt from sea.

Limit Equilibrium Method

As far as this research is concerned, the slope stability of KBD is checked by using software namely SLIDE. Slide normally use limit equilibrium method. The conventional limit equilibrium methods investigate the equilibrium of the soil mass tending to slide down under the influence of gravity. Transitional or rotational movement is considered on assumed or known potential slip surface below soil or rock mass. In rock slope engineering, methods may be highly significant to simple block failure along distinct discontinuities. All methods are based on comparison of forces (moments or stresses) resisting instability of the mass and those that causing instability (disturbing forces). Two-dimensional sections are analyzed assuming plain strain conditions. These methods assume that the shear strengths of the materials along the potential failure surface are governed by linear (*Mohr-Coulomb*) or non-linear relationships between shear strength and the normal stress on the failure surface. Analysis provides a factor of safety, defined as a ratio of available shear resistance (capacity) to that required for equilibrium. If the value of factor of safety is less than 1.0, slope is unstable. The most common limit equilibrium techniques are methods of slices where soil mass is discretized into vertical slices shown in figure 2.1.

Functional slope design considers calculation with the *critical* slip surface where is the lowest value of factor of safety. Locating failure surface can be made with the help of computer programs using search optimization techniques. Wide variety of slope stability software using limit equilibrium concept is available including search of critical slip surface. The program analyses the stability of generally layered soil slopes, mainly embankments, earth cuts and anchored sheeting structures. Fast optimization of circular and polygonal slip surfaces provides the lowest factor of safety. Earthquake effects, external loading, groundwater conditions can be included. The software uses solution according to various methods of slices (Fig. 2.1), such as Bishop simplified, Janbu etc.

Contouring Using Satellite Imagery and Google Mapper Software

To know the level of ground surface, contouring is done. In this research, contouring of the Kalabagh Dam upstream region is done by taking satellite imagery from USGS website and were processed in a software namely Google mapper.

3. Research Methodology

Surface Backwater Effect on Upstream Region

The surface backwater effect is determined by taking satellite images of the upstream region i.e. Nowshehra, Mardan, Swabi, Charsadda and Pabbi. These images were processed in a software namely Google Mapper to generate contours. Those contours were studied in detail to know weather with the increase of water at Kalabagh Dam upto maximum retention level, that is 915ft, will there be any chance of flooding in the upstream region?

Slope Stability Analysis

The slope stability of Kalabagh dam is checked by using limit equilibrium method. For this purpose, a software namely SLIDE is used. The soil testing results were taken from WAPDA head office and using those parameters, the dam model was designed and following analysis were runned.

Slope Stability

After modeling the dam in the software, its slope stability is checked having no water in it.

Steady State Analysis

The stability of the dam embankment is checked after the steady state was developed.

Rapid Drawdown

The stability of the dam embankment is checked for rapid drawdown condition as well.

Transient State Analysis

The stability of the dam is also checked for transient state.

Seismic Analysis

The seismic analysis is also performed for all the above conditions.

Cost and Benefit Analysis

The cost and benefit analysis of KBD is also included in this research.

Political Analysis

Finally the political background of KBD is studied as well and included in this research. Views and comments of different politicians regarding KBD are mentioned.

4. Results and Discussions

Flooding Problem at Nowshehra Region

Studies on computer proved that the risk of flood to Nowshehra is not having any connection with the construction of KBD. In Nowshehra, 935 ft. is the elevation of lowest point while KBD reservoir peak water level is designed to be kept at 915 feet above mean sea level as clear from figure 4.1. It means clearly that the water level will be 20 ft. lower in the reservoir than the lowest point in Nowshehra region. Extent of maximum reservoir level will remain upto 16 km D/S of Nowshehra region. Hence there is no any chance of flooding in district Nowshehra. In KBD reservoir, the sedimentation will be controlled for 50 days by the sediment sluicing every year at the min. operation level. It will guarantee that in Nowshehra region, there will be no flooding. Previous investigators, Chinese and international experts selected by the WB for the feasibility checking of KBD have concluded this. Names of some of them are given below:

1. Dr. John K. Kennedy (USA)
2. Dr. Khalid Mehmood (USA)
3. Dr. W. Rodney White (USA)
4. Dr. King Lianzhen (China)

This was also checked by plotting the contours of Nowshehra region by using satellite imagery and using a software namely Google Mapper. The image taken from satellite is shown in figure 4.2. This satellite image was imported to Google Mapper and the contour map is generated using that software.

The contour map is shown in figure 4.3. From this contour map, the minimum elevation at Nowshehra region is found to be 285m shown in figure 4.4. From this analysis, it is concluded that there is no any chance of flood in Nowshehra region due to the construction of Kalabagh Dam.

Mardan, Pabbi and Swabi Scarp

Contour map shows the elevation of lowest regions in Mardan is 970 feet, Swabi 1000 feet, Pabbi 960 feet and Nowshehra 935 feet shown in figure 2.2. On the other hand the highest and peak reservoir level of KBD will be kept at 915 feet which is lower than the lowest points at Charsadda, Pabbi, Nowshehra, Mardan and Swabi. The maximum level of Kalabagh dam (915ft) 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 825 ft by early June. This operation pattern of reservoir can neither block the land drainage and nor cause water logging or salinity in Mardan, Pabbi or Swabi area. The drains outlets at Hazara and Mardan scarp have inverts much higher than the highest water level in KBD reservoir. Figure 4.5 shows the minimum elevations of Charsadda, Pabbi, Nowshehra, Mardan and Swabi.

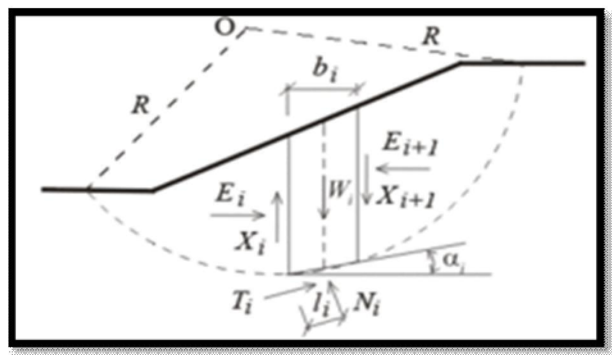

Figure 2.1: Method of slices

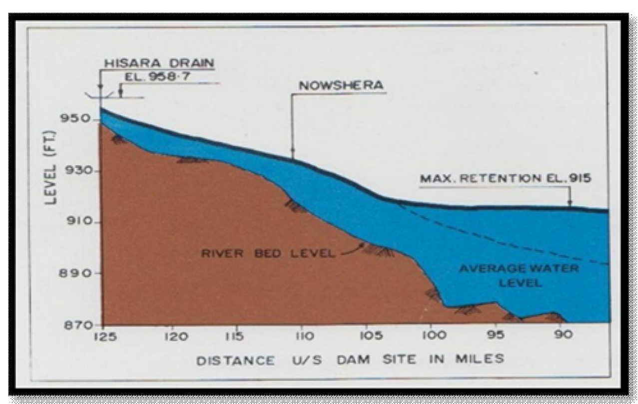

Figure 4.1: Difference of elevations between Nowshehra and KBD Peak reservoir level

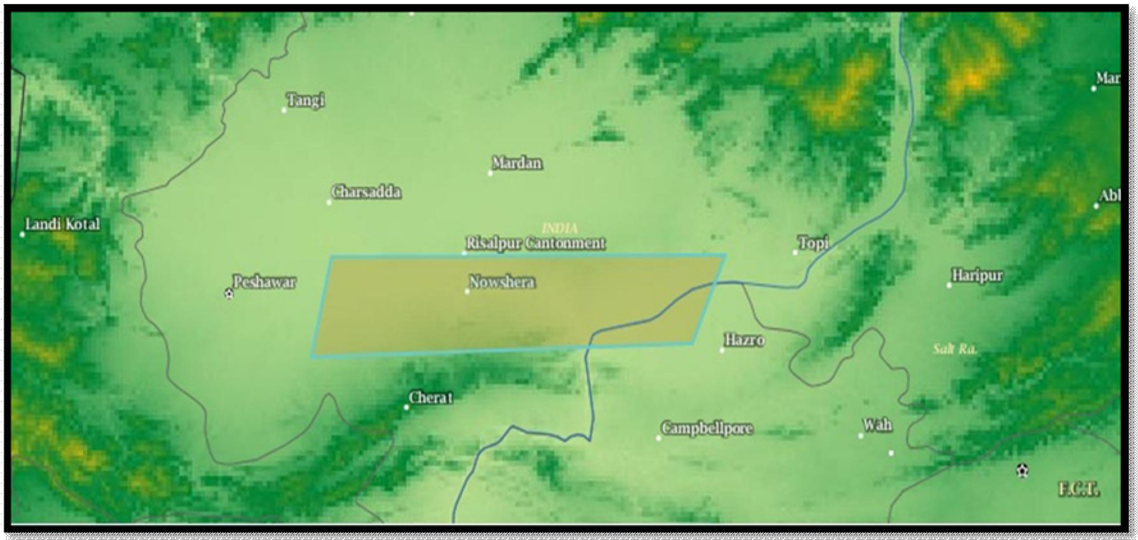

Figure 4.2: Satellite image of the Nowshehra region

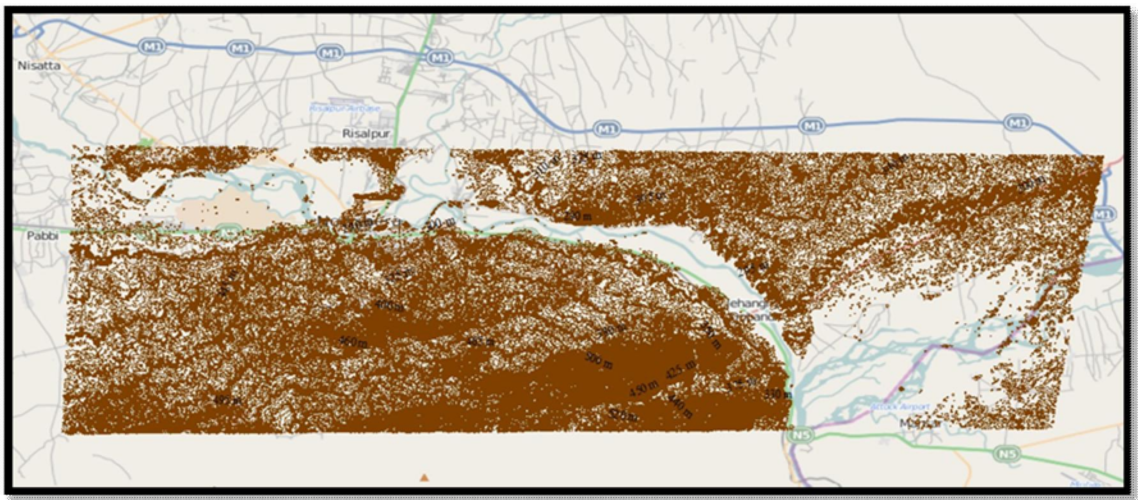

Figure 4.3: Contour map of Nowshehra region

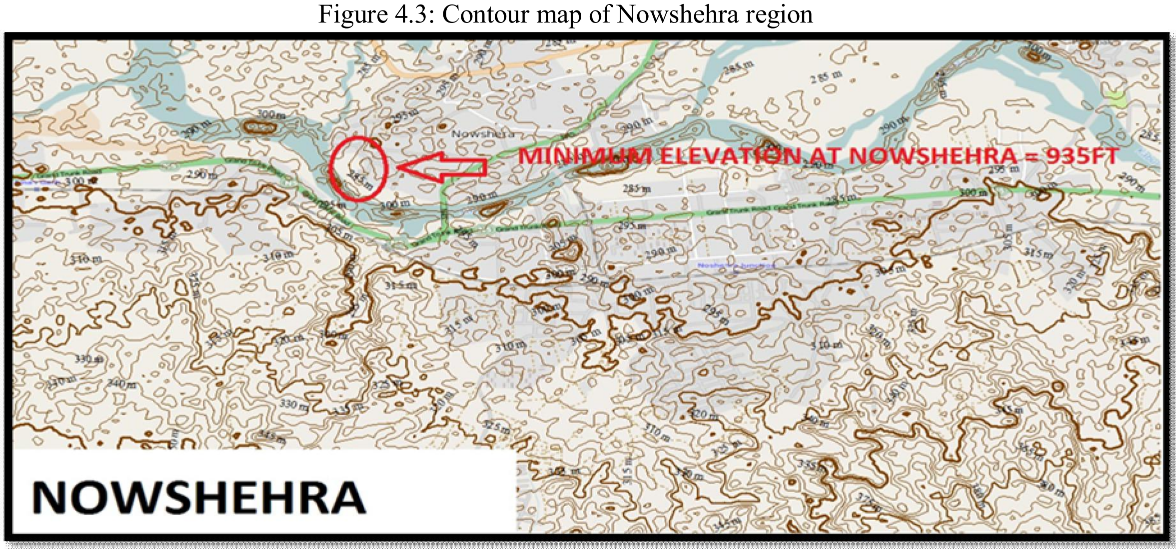

Figure 4.4: Minimum elevation of Nowshehra region = 935ft

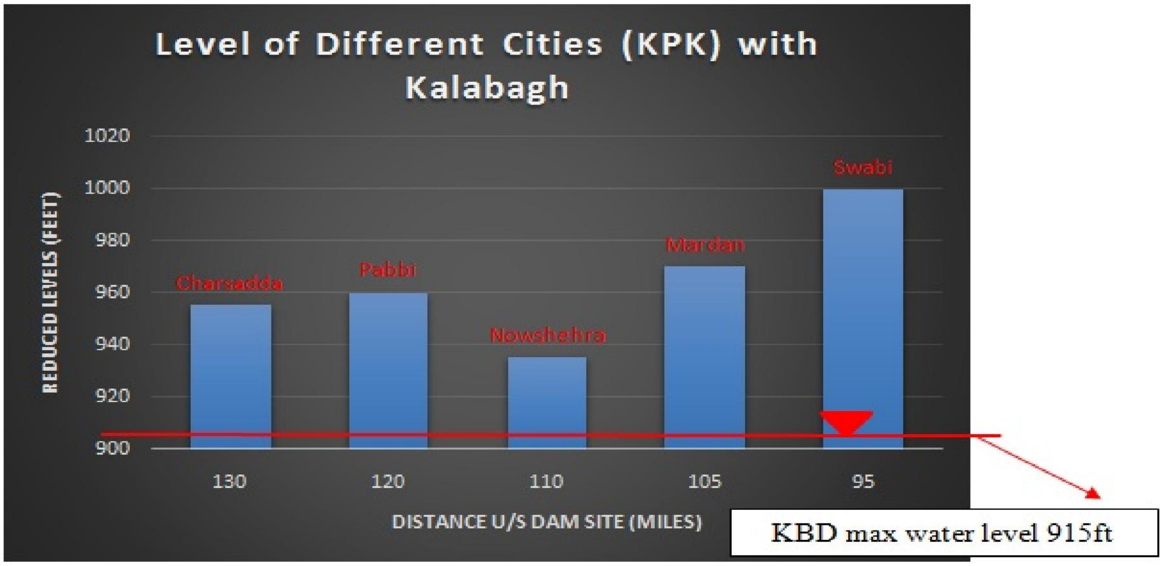

Figure 4.5: Elevations of different regions in the vicinity of KBD

Problem of Displaced People In KPK And Punjab

Every project has some merits and demerits. It is true that due to KBD, some people will be displaced but on the other hand, KBD will solve three main problems of Pakistan upto great extent. That is Load Shedding problem, Irrigation Problem and Flooding Problem from which we are suffering these days.

The estimated population affected by the project would be 83,000 with 48,500 in Punjab and 34,500 in KPK. Government will provide alternate irrigated lands to the affected families. The affected population would be resettled along the reservoir periphery in extended/new model villages with modern facilities of water supply, electricity, roads, dispensaries, school and other civil amenities. (WAPDA, 2012)

Water Availability and Sea Intrusion Problem Of Sindh Province

Before the construction of Mangla and Tarbela dam, Sindh was getting 35 MAF of water while after the two dams were constructed, Sindh is now getting 44.5

MAF water annually. In our rivers, 18% of the annual flow is in winter season while 82% is in summer season. During the flood seasons from July and October, KBD will store the excess water and will run it down during October to July. It means that during the deficiency of water, Sindh will get more water. In months of summer, additional quantity of 6.1 MAF will be available for Sindh which will ensure cultivation of hundreds of acres of barren land as well as it will provide water for the crops. Hence the main beneficiary of water from KBD will be Sindh. KBD will help out in converting the unproductive land of Sindh into cultivable green land.

On the other hand, International Union for Conservation of Nature (IUCN) says in a report (2005) that the mangrove forests below Kotri barrage are decreased due to the shortage of water in River Indus. According to the water apportionment accord 1991, Sindh was supposed to get 48.76MAF of water at annual average rate but it is not so. Table 4.1 shows the summary of water apportionment accord 1991.

Table 4.1: Water Apportionment Accord 1991

In the light of the accepted water distributional principles, the following apportionment was agreed to: (MAF)

Province	Kharif	Rabi	Total
Punjab	37.07	18.87	55.94
Sindh *	33.94	14.82	48.76
NWFP (a)	3.48	2.30	5.78
(b) Civil Canals **	1.80	1.20	3.00
Balochistan	2.85	1.02	3.87
	77.34	37.01	114.35
	+	+	+
	1.80	1.20	3.00

* Including already sanctioned Urban and Industrial uses for Metropolitan Karachi.

** Un-gauged Civil Canals above the rim stations.

Fact is that, Sindh receives only 10MAF of water from 1992 onwards. Table 4.2 shows the decrease rate with time. Due to this decrease, production of Mangrove forests are also decreased, which is shown in table 4.3. The main reason of this decrease is the construction of dams and barrages and diverting the water for irrigation purposes to the upstream regions of Punjab and KPK. According to IUCN report, not even the 10 MAF promised under the 1991 water accord has been released below the Kotri barrage in recent years and in 200-01 the flows were reported to reach the lowest level in Sindh's recorded irrigation history i.e. 0.72MAF. The maximum discharge graph is shown in figure 4.11.

Table 4.2: Decrease water rate with time (Source: Irrigation and Power department, Govt. of Sindh)

Period	Discharge Volume MAF			Percentage Reduction	Construction with Year	Silt Load
	Annual	Kharif	Rabi			
1880-92	150.0	-	-	-	Canal System	400.0 million tonnes
1940-54	84.7	73.8	10.9	10.0	Sukkur Barrage 1933	225.0 million tonnes
1955-65	79.9	69.7	10.2	12.9	Barrages: Kalabagh (Jinnah) 1955 Kotri – 1955 Marala – 1956 Taunsa – 1958 Guddu – 1962	220.0 million tones
1966-76	46.0	44.4	1.6	45.7	Warsak Dam – 1965	133.0 million tones
1977-92	35.2	33.1	2.1	58.4	Tarbela Dam – 1975	100.0 million tonnes
1992 onwards	10.0	-	-	-		30.0 million tonnes

Table 4.3: Decrease of mangrove forests production with time

Mangrove Categories	Year	Area in Hectares
1. Dense, normal and sparse mangroves vegetation	1932	604,870
2. Dense, normal and sparse vegetation	1986	440,000
3. Dense, normal and sparse vegetation	1992	160,000
4. Dense, normal and sparse vegetation (approx.)	2005	86,000

Source: coastal environmental management plan for Pakistan, UNESCAP, GOP, 1996
Mangroves of Pakistan – Status & Management, IUCN Pakistan, 2005

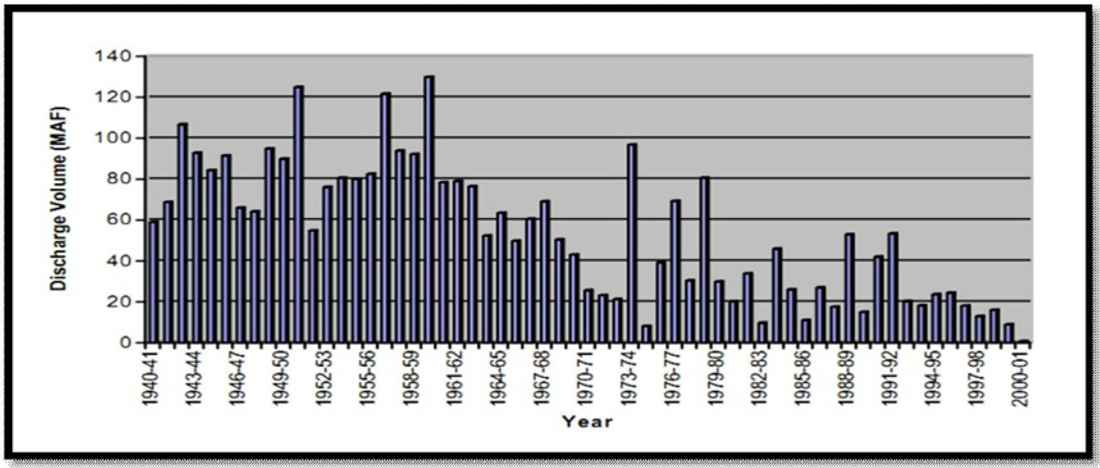

Figure 4.11: Maximum discharge volumes downstream of Kotri barrage

Table 4.4: Land losses due to sea intrusion

Region	District	Land Loss (ha.)
Keti Bunder	Thatta	46,137
Ghorabari	Thatta	12,749
Kharo Chan	Thatta	47,701
Mirpur Sakro	Thatta	24,363
Shah Bunder	Thatta	2,38,866
Jati	Thatta	91,766
Badin	Badin	19,910
Golarchi	Badin	12,398

Source: Board of Revenue, GoS

Table 4.5: Area under selected crops under cultivation

	1995-96	1996-97	1997-98	1998-99	1999-2000
Taluka Keti Bunder					
Rice	486	441	409	399	379
Wheat	130	121	126	91	118
Maize	372	383	329	286	194
Banana	472	449	425	415	365
Total	1,460	1,394	1,289	1,191	1,056
Taluka Kharo Chan					
Rice	156	140	126	123	105
Wheat	140	126	123	113	118
Maize	126	133	109	87	50
Banana	1,098	1,021	935	834	720
Total	1,520	1,420	1,293	1,157	993
Taluka Ghorabari					
Rice	7,500	7,374	7,247	7,131	6,968
Wheat	910	917	913	928	934
Maize	690	657	654	651	655
Banana	1,579	1,555	1,539	1,524	1,494
Total	10,679	10,503	10,353	10,234	10,051

Source: Offices of Mukhtiar Kars of relative talukas

Recently the Irrigation and Power department of Sindh has formally announced statistics of the impact of sea intrusion in the Indus Delta. Tidal infringement has inundated over 486,000 hectares representing 33% of the land in the two coastal districts of Sindh province, namely Thatta and Badin. Almost a quarter million populations have been dislocated causing financial losses of over Rs. 100 billion. The table 4.4 shows losses in Indus riverine and deltic region. With sea intrusion, the affected areas also met with losses in crops production shown in the table 4.5.

Many more losses such as loss in fish production, crops, land, agricultural and forestry are enlisted in the report of IUCN, and this is the main reason that Sindh is not allowing any other dam at the upstream region. The only way to construct any dam is to develop consensus among the provinces. The water of River Indus should be distributed such that sea intrusion problem should be minimized.

Site condition of KBD

Sandstone bedrock

The sandstone bedrock is composed of uniform fine sand and non-plastic silt particles. Most of the sandstone is only weakly cemented. Steep temporary excavation slopes and permanent drained slopes of 1 on 1.75 will be possible but permanent slopes subject to high pore pressures or rapid drawdown conditions will need to be flatter to ensure stability. The design parameters are:

$c^{/} = 0$

$\Phi = 38^0$

Bulk density = 135 pcf

Claystone and Siltstone Bedrock

The siltstone and claystone beds are generally hard and contain many joints. The siltstones have a very low plasticity, but the claystones have a variable plasticity which can be high. The intact strength of the claystone / siltstone beds is moderately high, but there are many fissures within the beds and some shear planes which reduce the strength. Individual design parameters for strength along surfaces parallel to the bedding are derived for each bed, and the preliminary range is:

Parallel to bedding:

c/ = 0

$\Phi = 38^0$

Across the bedding:

c/ = 500 pcf

$\Phi = 26^0$

Bulk Density: 135 pcf

Bedrock Gravels

Bedrock gravels occur as layers or lenses within some sandstone beds, and consist of sandy subrounded to rounded gravel. Parts of the layers are slightly cemented. The design parameters are:

$c^{/} = 0$

$\Phi = 38^0$

Bulk Density: 135 pcf

Apparent mass permeability as found from water absorption tests: 1 x 10^{-3} but generally less than 3 x 10^{-5} cm/sec.

Overburden Gravels

There are three groups of overburden gravels. Terrace deposits nala deposits and river channel deposits. Inspection of samples obtained from boreholes has not revealed any significant difference between them, however. Their appearance is having no significant difference between them. The design parameters are:

$c^{/} = 0$

$\Phi = 38^0$

Bulk Density: 135 pcf

Permeability from 3 x 10^{-2} to 3 x 10^{-5} cm/sec.

The deposits overlying the terrace gravel consists of a layered sequence of silts and silty sands. Some of these deposits fill channels in the underlying gravels. The silts and silty sands have a low insitu density, are non-plastic and are non-dilating. They are not suitable foundation materials and will be excavated and removed from the foundations.

Overburden Silt

Silt deposits and associated fine silty sands are non plastic in nature. Insitu densities were found to be between 80 and 95 lb/cu.ft compared with a laboratory maximum density of 115 lb/cu.ft. Shear strength parameters were $c^{/} = 0$ and $\Phi^{/} = 28^0$, but even the specimens recompacted in the laboratory tended to collapse, rather than dilate, with increasing shear strain. No further tests on undisturbed silt were carried out during this study as it was decided that this material should be removed from any foundation area. Some boreholes and drillholes have been put down through the silt in order to reach lower strata or to define the thickness of the silt and the level of the bedrock surface.

Overburden Sand

Dense overburden sand occurs as lenses within the overburden gravels. It will generally make a strong foundation material for the embankment shoulders, but filters may be required where the sand is subjected to significant seepage flows. It was uniform fine sand with only a small proportion passing the No.200 sieve. The design parameters are:

$c^{/} = 0$

$\Phi = 38^0$

Bulk Density: 135 pcf

Permeability from 1 x 10^{-1} to 1 x 10^{-5} cm/sec

Further standard penetration tests have confirmed the general high density of the sands. Shear strength tests have not been carried out pending the identification of particular lenses during detailed investigations.

90% of the permeability tests in boreholes have given values between 1 x10^{-3} cm/sec (1 x 10^3 ft/year) and 1 x 10^{-4} cm/sec (1 x 10^2 ft/year). No test result was higher than 1 x 10^{-1} cm/sec (1 x 10^5 ft/year) or lower than 1 x 10^{-5} cm/sec (10 ft/year)

Provision Of Toe Drain And Extension Of Core

The proposed model for KBD in 1980's was shown in figure 4.12. Same model was plotted in SLIDE and steady state analysis was performed. The slope factor of safety was OK but phreatic line was established under the drain provided at the downstream side as shown in the figure 4.13. This problem can cause a big problem with the downstream erosion and might cause failure of the dam. To overcome this problem, the core need to be extend as shown in figure 4.14. With this modified model of KBD, the phreatic line will directed towards the drain at the downstream and will be drained out at the toe drain provided at the downstream. The phreatic line is shown in the figure 4.15. Same model was plotted in SLIDE and steady state analysis was performed. The slope factor of safety was OK but phreatic line was established under the drain provided at the downstream side as shown in the figure 4.13. This problem can cause a big problem with the downstream erosion and might cause failure of the dam. To overcome this problem, the core needs to be extend as shown in figure 4.14. With this modified model of KBD, the phreatic line will directed towards the drain at the downstream and will be drained out at the toe drain provided at the downstream. The phreatic line is shown in the figure 4.15.

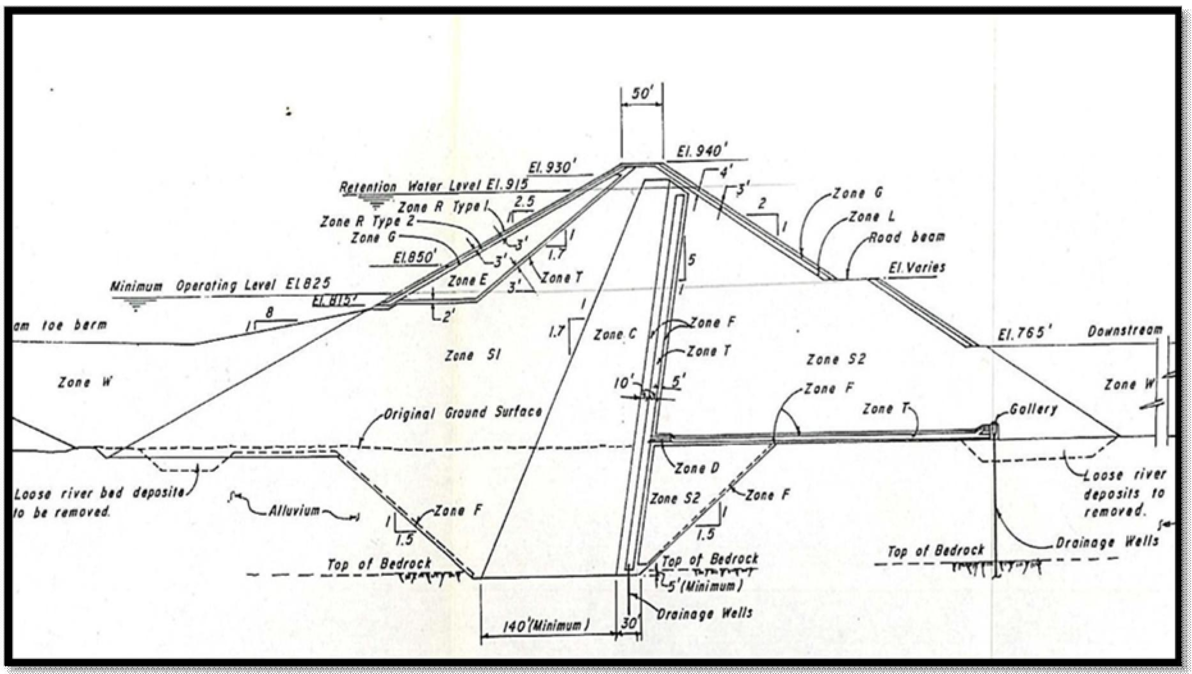

Figure 4.12: KBD proposed model (1980's)

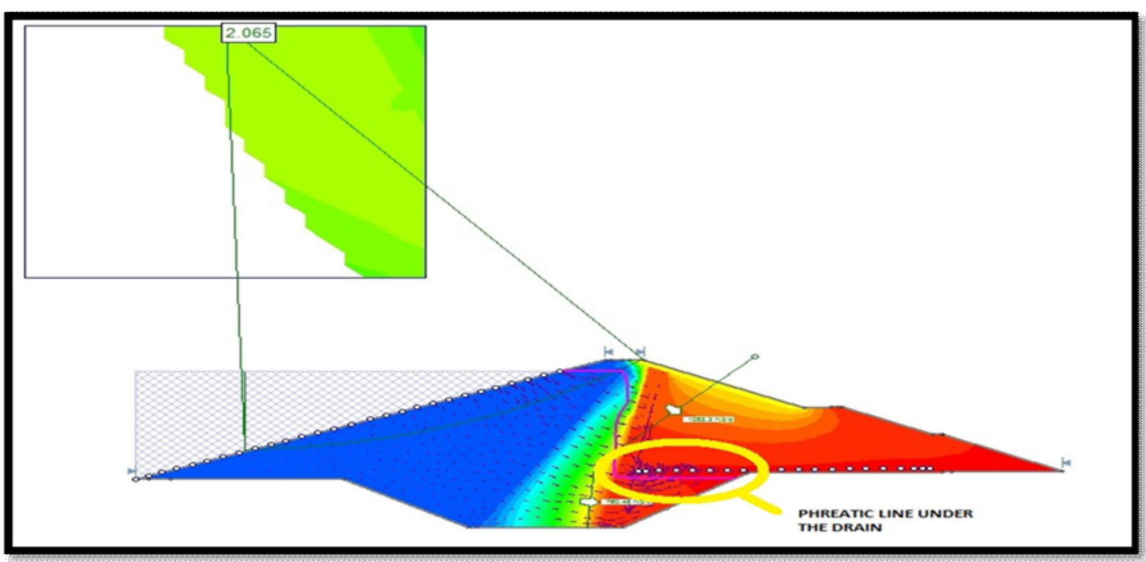

Figure 4.13: Phreatic line under the drain

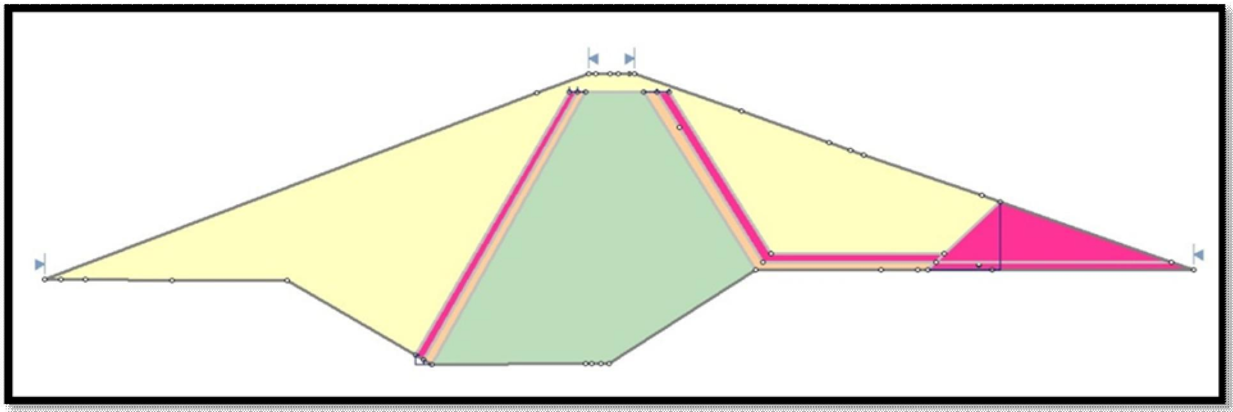

Figure 4.14: Modified model of KBD with toe drain and extended core

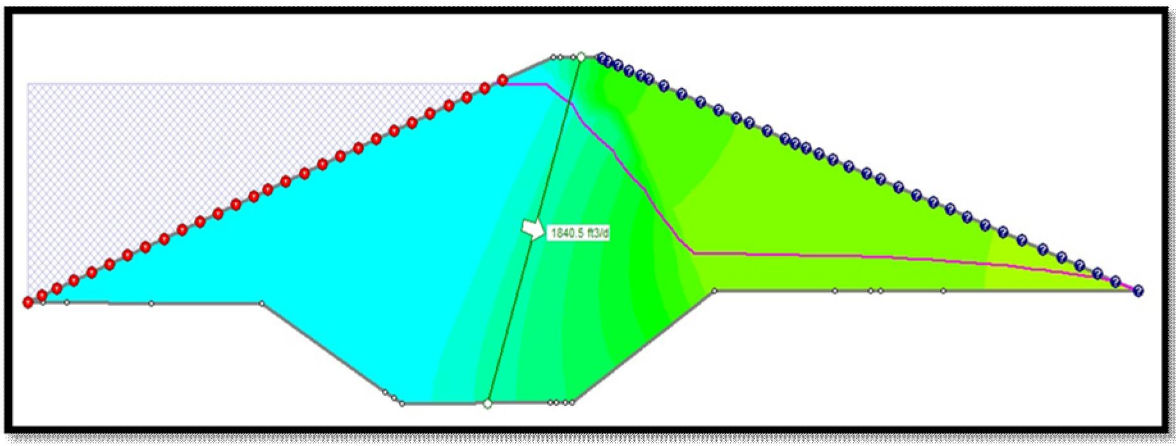

Figure 4.15: Phreatic line directed towards toe drain in modified design

Geotechnical Properties of Fill Material

From the above testing, the consultants specified the following properties for the fill material in the dam:

Rolled Sandstone

Bulk Density = 135 lb/cu.ft

$c^{/} = 0$

$\Phi^{/} = 38^{0}$

Permeability = 1 x 10^{-2} ft/sec

Rolled Clay

Bulk Density = 135 lb/cu.ft

$c^{/}$ = 58 lb/cu.ft

$\Phi^{/} = 32^{0}$

Permeability = 3.3 x 10^{-5} ft/sec

Fine Filter

Bulk Density = 130 lb/cu.ft

$c^{/}$ = 50 lb/cu.ft

$\Phi^{/} = 40^{0}$

Permeability = 1 x 10^{-3} ft/sec

Course Filter

Bulk Density = 145 lb/cu.ft

$c^{/} = 0$

$\Phi^{/} = 40^{0}$

Permeability = 1 x 10^{-2} ft/sec

Toe Drain

Bulk Density = 145 lb/cu.ft

$c^{/} = 0$

$\Phi^{/} = 40^{0}$

Permeability = 1 x 10^{-2} ft/sec

Software Analysis

In this research work, a latest software namely SLIDE is used to analyze the Kalabagh dam for different conditions using limit equilibrium method. Limit equilibrium program **SLIDE** provides 2D stability calculations in rocks or soils using these rigorous analysis methods i.e. Spencer, Morgenstern-Price/General limit equilibrium and non-rigorous methods: Bishop simplified, Corps of Engineers, Janbu simplified/corrected, Lowe-Karafiath and Ordinary/Fellenius. Searching of the critical slip surface is realized with the help of a grid or as a slope search in user-defined area. The analysis done on this software is summarized in table 4.6 (Bishop simplified and Janbu Simplified Methods are shown only).

Table 4.6: Summary of software analysis by Bishop and Janbu simplified methods

S.No.	Description	Side	FOS (Bishop)	FOS (Janbu)	Remarks
1	Slope stability (normal)	Right to left	2.003	1.983	Safe
2	Slope stability (normal)	Left to right	2.231	2.221	Safe
3	Slope stability (seismic)	Right to left	1.387	1.380	Safe
5	Slope stability (seismic)	Left to right	1.496	1.488	Safe
6	Rapid drawdown (normal)	Right to left	2.227	2.196	Safe
7	Rapid drawdown (seismic)	Right to left	1.151	1.133	Safe
8	Transient state zero head (normal)	Right to left	2.032	2.023	Safe
9	Transient state 30ft head (normal)	Right to left	2.030	2.007	Safe
10	Transient state 100ft head (normal)	Right to left	1.921	1.844	Safe
11	Transient state 160ft head (normal)	Right to left	1.919	1.842	Safe
12	Transient state 180ft head (normal)	Right to left	1.927	1.859	Safe
13	Transient state 200ft head (normal)	Right to left	1.952	1.906	Safe
14	Transient state 233ft head (normal)	Right to left	2.010	1.985	Safe
15	Transient state zero head (seismic)	Right to left	1.387	1.380	Safe
16	Transient state 30ft head (seismic)	Right to left	1.380	1.367	Safe
17	Transient state 100ft head (seismic)	Right to left	1.262	1.215	Safe
18	Transient state 160ft head (seismic)	Right to left	1.181	1.143	Safe
19	Transient state 180ft head (seismic)	Right to left	1.155	1.125	Safe
20	Transient state 200ft head (seismic)	Right to left	1.142	1.117	Safe
21	Transient state 233ft head (seismic)	Right to left	1.125	1.113	Safe
22	Steady state (normal)	Right to left	2.003	1.983	Safe
23	Steady state (seismic)	Left to right	2.234	2.224	Safe

Cost of The Project

The estimated cost of KBD project at June 1987 level was USD 2, 650 Million and at July 2005 level, it was USD 6, 124 Million.
(Source: http://www.WAPDA.gov.pk/pdf/KBDam.pdf).

Benefits of the project:

An official meeting of Ministry of Water and Power held on January 14, 2014 regarding the issue of Kalabagh dam. They suggested the government to construct Kalabagh dam as soon as possible because it is having a lot of benefits in which few are given below:

(1) **Electricity:** Kalabagh Dam would guarantee sufficient and cheap electricity. Thermal power costs Rs 16 per unit, where as Hydel power costs Rs 2.5 to Rs 3 per unit. The big dams are needed to overcome the issue and the country would suffer severe water crisis if they were not built. Kalabagh Dam will have the capacity of generating 3,600MW of electricity which will save $4 billion annually for the country, excluding the 30 percent line losses. (The express tribune, January 14, 2014).

Further, as a result of conjunctive operation an additional 336 million MKWh's and upto 600 MW of additional peak power would be generated at Tarbela. To put these figure in perspective, if Kalabagh was in position today, there would have been no load shedding in Pakistan. The energy generated at Kalabagh would be equivalent to 20 million barrels of oil per year. (WAPDA, 2012)

(2) **Irrigation:** About 30 million acre foot water is being wasted into the sea because of absence of big water reservoirs and the dam was causing the country a loss of Rs132 billion annually. Irrigation oriented operation of the project gives the highest overall return. Thus the full live storage of 6.1 MAF would be available for guaranteeing assured irrigation supplies throughout the year including replacement of the storage loss on the three existing reservoirs.

(3) **Flood Alleviation:** The recent floods in Pakistan caused more than $45 billion loss which could have been averted if big dams were operational. Kalabagh would store surplus water in the flood season and make it available for controlled utilization during the low flow season (The express tribune, January 14, 2014).

The water would thus be used for sowing and final maturing of the Kharif crops and entire Rabi crops. Kalabagh would reduce the frequency and severity of flooding along the Indus particularly between the dam site and Indus / Panjinad confluence, 300 miles downstream (WAPDA, 2012).

Overall benefits:

On a conservative basis, the overall direct benefits of Kalabagh Dam would be around Rs. 20 billion per annum. Thus the investment cost of project would be repaid within a very short period of 8-9 years.

Consequences of Not Building Kalabagh Dam (WAPDA, 2012)

(1) Economy will be destabilized because national food security problem would be jeopardized and Pakistan will face additional burden of importing food grains.

(2) Due to sedimentation in the existing storage reservoirs, it will result in shortage of committed irrigation supplies and will cause serious drop in agricultural production as well.

(3) A storage project like KBD is essential for implementing water Apportionment Accord 1991. Otherwise in dry water seasons, it would give rise to inter-provincial disputes and recriminations.

(4) 20 million barrels of oil will be imported by Pakistan for fulfilling the energy demands if they are not constructing KBD. Again, this will be an additional burden on Pakistan's economy.

(5) Recently an agreement with international private sector is signed by the government in which the energy producers agreed to install 300 MW of thermal power units in coming 3-4 years in Pakistan. The power cost will increase with this contract although it may help in overcoming the load shedding problem. Therefore, KBD is better option to overcome the problem by constructing a low cost hydropower plant and hence to keep the cost of electricity within the reach of all consumers.

(6) Due to high power cost, growth of domestic industrial and agriculture sectors would be increased.

Political Study

Some of the political parties are against the construction of Kalabagh dam especially ANP and MQM. Former president Pervez Musharaf was in great favor of constructing Kalabagh dam. While PMLN and PTI seems to be neutral in this case. This could be understood from the statements of some of their key personnel.

ANP and Kalabagh Dam (The express Tribune, December 9, 2012)

Addressing a jam-packed audience at the Nishtar Hall, ANP chief Asfandyar Wali Khan minced no words when it came to his party's opposition to the project.

"They have to make a choice, whether they want Pakistan or Kalabagh Dam," said Asfandyar, adding that his party was not ready to accept Punjab as a commander of the federation.

MQM and Kalabagh Dam (London, 31 August 2001)

Mr Altaf Hussain has strongly condemned the decision of construction of the Kalabagh dam and termed it as Anti-Sindh

PMLN and Kalabagh Dam (The express Tribune, December 5, 2012)

Nawaz Sharif announced on December 5, 2012 that we cannot build Kalabagh dam without consensus among the provinces. If two provinces want Kalabagh dam to be constructed and two are against, then it is not possible to be constructed.

PTI and Kalabagh Dam (The express Tribune, January 4, 2014)

The party chief, Imran Khan said that PTI being a national political party could not consider the construction of all controversial dams including the Kalabagh Dam unless there is a national consensus over them.

PERVEZ MUSHARAF and Kalabagh Dam (Dawn, Mar 03, 2005)

The president, who addressed his first public meeting in the KPK after the May 2002 referendum, spoke at length on the merits of building Kalabagh dam as opposed to the Bhasha dam.

SHAMS UL MULK (Ex-Chairman, WAPDA, Gm KBD, Gm Tarbela Dam)

Views of Shams ul Mulk regarding KBD are as follows:

(1) With construction of KBD, three main problems of Pakistan will be solved; Power, Flood and Irrigation.

(2) There is no problem of flood due to construction of KBD with a normal flow of water in River Indus. Flood of August 1929 and 2010 were exceptional cases.

(3) In 2010, the peak level of flood reached Tarbela at 4:00am. The capacity of that flood was 8, 35,000 cusecs. Tarbela was having very less storage capacity as it was almost at its maximum reservoir level. The capacity left was only 5, 6 feet. Hence, 2, 15,000 cusecs was stored out of 8, 35,000 cusecs and 6, 20,000 cusecs was released. With this storage, the Sukkar barrage gets survived otherwise there were no chances of Sukkar barrage to have safety from that huge flood. If KBD was also constructed on time, the damage would be negligible.

(4) KBD is having no effect on Mardan, Charsadda and Swabi scarp project.

(5) World Bank team having great experts suggested to construct KBD before 1992, then Bhasha dam but KBD was not constructed due to lobbies inside Pakistan, i.e. Oil lobbies and foreign countries to destabilize Pakistan and some other political reasons.

(6) Hydel power from Tarbela and Mangla cost is Rs. 1.2 per unit while from furnace oil it costs Rs. 12.4

per unit. Nowadays we are making more power from furnace oil compare to Hydel power.

(7) In D.I.Khan, there is almost 800 Acre land which is at a height of approximately 150 ft from River Indus. To irrigate this land, we have two options. First option is to pump the water and second is to make KBD. With first option, the cost of irrigation per acre will be Rs. 5000 while with construction of KBD; the cost will be Rs. 400 to 500 per acre.

(8) Pakistan is paying Rs. 132 Arab per year because of not constructing KBD. In this amount, Punjab is paying 68 Arab, Sindh is paying 40 Arab, KPK is paying 18 Arab and Baluchistan is paying 6 Arab.

(9) Before construction of Tarbela and Mangla dams, Sindh was getting 36 MAF water while after construction of these two dams, Sindh is now getting 43 MAF of water. It means with KBD, Sindh will get more water as usual.

(10) China have constructed 85,000 dams and India have constructed 4500 dams (Medium and Large) while Pakistan is having total 153 small, medium and large dams.

(11) We are wasting almost 35 MAF of water and it is going useless in Arabian sea. If India is constructing dams on our water, they have a reason that if Pakistan is wasting their water so why not India get benefit of it. And we Pakistani will be having no reason to object.

(12) ANP government was against the construction of KBD but majority of KPK people are in favor. In KPK, the registered voters are one crore and 8 lac. ANP got 5, 75,000 votes while they came to government in 2008. It means they got only 5.6% of the total votes. 94.4% were not in favor of ANP government. It means that ANP is not representing the view point of KPK people but their own political interests.

(13) The decision makers are having no problem to construct or not construct KBD. Poor people are suffering because of not constructing KBD.

Conclusions

(1) KBD is totally feasible from geotechnical and design point of view.

(2) There is no problem of surface flooding at the upstream region of the dam.

(3) Studies indicate that Sindh province is having sea intrusion problem due to the construction of dams at the upper regions of Punjab and KPK. Before constructing KBD, consensus should be developed among the provinces and the team of workers should contain members from all provinces.

(4) Kalabagh dam is economical and beneficial from power generation and irrigation point of view.

(5) PAK ARMY, PMLN, PTI, WAPDA and majority of the technical experts are in favor of constructing Kalabagh dam to overcome the load shedding problem in Pakistan.

Future Recommendations

(1) From this research, it is recommended that Kalabagh dam should be constructed as soon as possible but the share of water and power should be distributed in all the four provinces in such a manner that all of them get benefit from KBD. For that, proper agreement should be signed among the provinces and that agreement should not be limited to the documents only but should be implemented practically as well. For the implementation of the agreement, the control of KBD should not be given to only one province or federation. But the controlling team and staff should contain experts from all four provinces before as well as after the construction of KBD.

(2) The groundwater effect of KBD on both upstream and downstream should be analyzed.

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