ANATOMY OF KALABAGH DAM

ENGINEER ABDUL RASOOL MEMON
Former General Manager Wapda
&
Former Chief Engineer Irrigation

PAKISTAN STUDY CENTRE
UNIVERSITY OF SINDH
ALLAMA I.I.KAZI CAMPUS
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PUBLISHER'S NOTE:

The author of the book Engineer Abdul Rasool Memon is an eminent Engineer from Irrigation and Power Department where he served for about four decades. He retired as Chief Engineer (Irrigation) and has also served as General Manager Wapda (South) and General Manager Planning. As General Manager Planning, he was Incharge of Planning and investigation of Projects entrusted to Wapda. During this period he had the opportunity to oversee the feasibility of Kala Bagh Dam. In his capacity as General Manager South, he has constructed Hub Dam which is 151 feet high and is presently supplying water to Karachi. He has contributed number of articles to the Institute of Engineers, Pakistan Engineering Congress and a number of research reports are also to his credit. While writing the Anatomy of Kala Bagh Dam, the author has referred to the latest available record and has tried to present the factual position to the laymen as well as scholars who want in-depth study and the public at large so that the controversy could be seen in proper perspective.

In this connection he had delievered a lecture on Kalabagh Dam in Mehran University of Engineering and Technology, Jamshoro and sindh Education Academy, Hyderabad which has now been elaborated. Besides, he was also associated with the Indus Basin works, under which big dams like Mangla Dam, Tarbela Dam and number of barrages were planned and executed during the early sixties.

Pakistan Study Centre, University of Sindh had previously published a brochure on Kalabagh Dam written by the present author. The present book is the enlarged version of the booklet already published by the Centre. In this book the learned Engineer, who is an expert, has analysed the impact of "Water Accord". He has also included a copy of Sindh Punjab Agreement for those who want to make their own analysis of the Water Availability in the Indus System. This research work will be beneficial to those who are interested to continue further research on

the Project. The Centre will be glad to publish any further work related to this Project.

August,1992
Jamshoro

Prof.Dr.M.Yakub Mughul
Director
Pakistan Study Centre
University of Sindh

PREAFACE

It was during early 1988 that while working as Engineering Advisor to the University of Sindh, some friends in Mehran Engineering University persuaded me to address the Engineering Staff and Students on the subject of Kalabagh Dam Project. Accordingly a lecture was arranged and Professors of both. The Sindh as well as Mehran University were invited. Hurriedly a note was written pinpointing the obviously insoluble problems connected with the construction of the dam vis-a-vis Sindh and Pakistan economy. This note was subsequently printed and published trhough the courtsey of Dr.Muhammad Yakub Mughul Pakistan Study Centre's Director.

As it appeared, Kalabagh Dam's tempo was dampened due to strong protest from North West Frontier Province although Sindh also raised the voice mildly that the Project should not be undertaken until water apportionment was made between the provinces. The status quo contined till award on "Water Accord" was given by the council of common interests on 21st of March 1991 with complete subservience of course by the representatives of Sindh.

"ڪاتيءَ ڪونهي ڏوهہ ، ڪُنُ وڏيندوَ هٿ ۾"

Meanwhile Wapda has also issued 4 more supplementary volumes to make the Project acceptable to the Provinces. It was therefore considered necessary to revise the previous brochure, uptodate the data and also reflect the impact of Water Accord on the Project.

With the signing of Water Accord and the apparent sofenting of the reistance from N.W.F.P, dark omens of desertification have already appeared on the horizan of Sindh. It was the fear of unknown and uncertain future of the posterity that promoted me to revise and elaborate the previous matter in the light of latest information available fulfil my professional duty atleast for those who are interested or care to know for possible repercussion on Paki-

stan's economy as a whole and Sindh in particular. The intention is to provide food for thought and invite the debate to remove the web of ambiguity before this costly adventure is undertaken by debt-ridden Pakistan. It is hoped that this effort of mine will be seen in the spirit with which this is written. A copy of Sindh Punjab Agreement is also attached as Annexture.

"سيني سڃان جي ڪر حوالي ڪَرَ
ٽي تحقيق تسليم ٿيو، لاهي غمَ وَهَرَ
قادر سائ ڪرم، حاصل ڪري حاج تر"

August, 1992
Jamshoro

A.R.Memon
Irrigation and Power
Department - Sindh

1.INTRODUCTION

Of late there have been lot of speculations, rumours and controversies going on about the construction of Kalabagh Dam, notwithstanding the demonstrations, meetings, seminars and resolutions passed by political parties, District Councils, Municipal Committees, Union Councils, Government of N.W.F.P. and Government of Sindh. It has hit the headlines of all national dailies. It is proposed to enlighten the intelligentsia in layman's language, the "Anatomy" of the whole issue. It is not possible to give all the details, but an effort is made to give an overall review of its salient features and its implications in which public at large is interested and it is left to the intelligentsia to draw their own conclusions.

To start with, brief back-ground information regarding its genesis and subsequent conceptual thinking is necessary to understand the nature of the problem.

2. LOCATION

Kalabagh Dam Project envisages the construction of a Dam across River Indus at a point just below its confluence with River Soan. The reservoir created by the Dam will extend up to Nowshera Town on the right bank of River Indus in the Province of N.W.F.P. The reservoir area and the Dam site are located in the administrative districts of Mianwali and Campbellpur in the Punjab and Kohat and Nowshera in N.W.F.P.

The waters released from Kalabagh reservoir can be utilized anywhere in the country through the canal system of any of the barrages located downstream i.e. Jinnah, Chashma, Chashma-Jhelum link canal, Taunsa, Taunsa-Panjnad link canal, Guddu, Sukkur and Kotri Barrages. Thus the location of Project area can be described as the total Indus Plain. (Map attached).

3. INDUS RIVER BASIN

The Indus River originates in Tibet Plateau north of Mansrowar Lakes from the glaciated northern slopes of Kailas range of mountains at an elevation of 18,000 feet above mean sea level. It is joined on the right bank by Zaskar, Shyok and Shigar rivers which drain the Korakoram in the north and join the Indus in the vicinity of Skardu Town. Further downstream, it is joined by Gilgit river near Gilgit Town. These tributaries of Indus drain giant glaciers and the most extensive ice fields of the world. On the left, it is joined by Siran River and then on the right bank by Kabul River at Attock. The river Kabul which rises from Hindu Kush mountains in Afghanistan is a major western tributary of River Indus. At Attock, Indus enters the hilly gorge about 100 miles long extending from Attock to Kalabagh. In this reach the river is joined by its tributaries namely Haro and Soan from the left and Kohat Toi from the right bank. The Indus finally enters the plains at Kalabagh. Below Kalabagh it traverses some 770 miles of alluvial plains before its out- fall into the Arabian Sea. In its journey in the plain, the Indus is joined at Panjnad by the Panjnad river which drains the five eastern rivers namely Jhelum, Chenab, Sutlej, Ravi and Beas.

4. CLIMATE

The climate of the project basin with a wide areal extent and distinct physiographic regions, varies considerably in different parts of the catchment. Howevér, the relief of the upper basin produces a dominating influence on the climate of the whole basin because the mountains of the Karakoram, Himalaya and Hindu Kush ranges rise above the level of the usual planetary winds and form an effective movement barrier between the basin and central Asia. The southwards movement of cold winds into the basin is thus checked by the northern ranges of Karakoram and Hindu Kush. While the Himalayan range excludes the

influence of moisture-laden south-eastern/south western winds from a major part of the project basin.

5. PRECIPITATION

The project basin is subject to the precipitation both in summer and winter. Rainfall in winter is, however, very limited in duration and extent. The mountainous valleys of Kashmir and adjoining areas, protected as they are, from the influx of monsoon current by the barriers of the Himalayan Range, receive very meagre precipitation in winter in the form of snow. The summer rainfall in the basin is due to monsoon activity originating from the Bay of Bengal and the Arabian sea, subjecting the project basin to south-eastern/south-western winds.

The average annual rainfall is highest in the extremity of the Indus River catchment on the east and north-east of Tarbela Dam (over 45 inches) and gradually falls in the north western and southern directions to about 10 inches in the vicinities of Jalkot, Nowshera and Kalabagh Dam site. The Kabul basin receives very little precipitation. A small part in the south-eastern extremity has a rainfall of about 30 inches, progressively decreasing as one goes west, and the catchment beyond Pakistan is almost totally arid.

6. INFLOWS

The river Indus passes a mean annual run-off of 89.22 MAF at the Kalabagh Dam site. The maximum and minimum annual flows recorded since 1922 to 1985-86 were 120.09 MAF and 65.76 MAF respectively. The Kharif maximum is 102.17 (1942) and Kharif minimum has been 53.49 (1947). The Rabi maximum has been 20.25 (1959-60) and Rabi minimum 9.36 MAF (1971-72). The major part of the run-off consists of glacier-melt and snow-melt which also provide river base flow. The river flows with a steady discharge in the range of 20,000 cusecs in winter before ris-

ing gradually from March due to snow-melt and occasional rainfall activity. The summer flows are characterised by high discharges due to increased snow-melt and monsoon activity.

7. FOUNDATIONS

Following passages are quoted from the Project Report of 1988 submitted by Kalabagh Consultants:

GEOLOGY

2.4 "The sequence of the geological formations through which the river indus passes from Attock to Kalabagh town is:

the Hazara formation,
the Upper Siwalik formation,
the Kalachitta Limestone formation,
the Rawalpindi formation,
the Middle and Lower Siwalik formations, and
the Salt Range formation.

2.5 . The dam site lies on the southern fringes of the Soan Basin which is an area relatively undisturbed by tectonic forces. At the northern end of the reservoir area the Bannu-Hazara fault systems give rise to unconformable contacts between the different geological formations and considerable folding. Further north are the major fault systems of the Himalayas. To the south of the damsite, the tectonic disturbance increases and the Salt Range is thrust up above the Punjab Plain and terminates at the Kalabagh fault. This tectonic activity is the result of the convergence of two tectonic plates.

2.7 Salt deposits are ductile when subjected to high stresses and this can lead to salt "diapirism" with the formation of domes and other intrusive features. The outcrops near the Kalabagh fault have been caused by such processes, related to folding of the rocks during the pleistocene

period.

2.9 At the damsite, the Indus flows in a relatively narrow valley, some 1300 feet wide. The river bed is at an elevation of approximately 680 feet above sea level and is composed of sand and gravel alluvium up-to 90 ft. thick generally except in one pocket under the upstream shoulder where it is about 150 ft. thick. The rocks on both sides of the river comprise interbedded sandstones, siltstones and claystones with occasional gravel lenses, of the Middle Siwalik Dhok pathan formation.

2.14 The Dhingot fault, which is 13 miles long and probably connected to the Kalabagh fault, is at its closest point about 2 1/2 miles from the right abutment of the dam. The amount of faulting increases downstream of the damsite as the Kalabagh fault is approched. No major faulting has been found at the damsite. However a high angle normal fault (the Kharjwan fault), which has a throw of 70 to 100 ft, has been mapped over a length of about 4 miles. This fault crosses the axis of the dam between the proposed locations of the two spillways but in that area the zone disturbed by the fault is only 5 to 10 ft. wide, and it is generally tight. All available evidence suggests that this fault is inactive.

2.27 The Kharjwan fault, although generally tight, does contain zones with a higher permeability than the surrounding rock. The highest "Lugeon value" obtained was 32. The fault zone will be treated to prevent the development of preferred seepage paths and internal erosion.

2.30 Loading and unloading will cause elastic settlement and rebound of the ground respectively. Where the change in load is large, such as under the main dam where there will be a large increase in load or under the approach channel to the power and convertible conduit intakes where excavation will cause a large reduction in load, the amount of vertical movement could be of the order of one or two feet. Some differential movement will occur between areas which are loaded or unloaded differently and filling and drawing the reservoir down each year will also cause

slight differential movements.

2.31 Small ground movements will also occur due to change in the effective stress in the ground causing long term swelling and consolidation. These movements will occur over a period of years"

COMMENTS

According to para 2.30, loading and unloading will cause elastic settlement and rebound of the ground respectively. Where the change in loading is large viz main dam, approach channel to power house/convertible low level conduit intakes, the amount of vertical movement could be of the order of one or two feet. This vertical movement at these points appears too large to be safe if it is not noticed and adequate measures taken in time to stop these cracks from developing below reservoir level.

It is also understood that some differential settlement is also likely to occur between the areas which are loaded differently and yearly loading and unloading due to filling and drawing down of the reservoir may cause induced seismicity resulting in liquefactions of bars formed on upstream and down-stream of gorge - thus choking the power house turbines. All this evidence goes against good foundations for such a massive dam like Kalabagh. Risk involved is too great for a country like Pakistan. Due to these suspect foundations, the World Bank Experts preferred Tarbela over Kalabagh Dam while executing works connected with Indus Basin Treaty 1960 although Kalabagh Dam was in the advanced stage of investigations at that time. Even M/S Tipton and Hill stated in 1956 report that since foundations were based on "Swaliks", both the sandstones and shales may change over short distances and thinner layers may sometimes pinch out and disappear.

8. SEDIMENT

The Indus and its tributaries transport heavy loads

of suspended sediment which in the course of time will affect the usable capacity of Kalabagh reservoir. Kalabagh, being constructed on Indus, the question of sediment action assumes great importance. The Kalabagh reservoir - if designed for 100 percent trap efficiency - will get silted up in 30 years and as such silt exclusion becomes a Must.

The sediment inflows at Kalabagh are transported from 1,10,800 sq. miles of drainage area having diverse sediment producing characteristics. It drains an area of 65,500 square miles upto Tarbela Dam, out of which 61,500 square miles are snowfed. The heavy sand content of about 60 percent in the sediment recorded at Darband 21 miles upstream of Tarbela is due to glacial erosion in upper catchment. The average concentration of sediment at Durband is 0.40 percent by weight, the distribution being 59 percent sand, 34 percent silt and 7 percent clay.

Between Tarbela and Attock the river flows mostly in plains forming meander channels into the sediment during low flows. The Kabul River which brings in about one third of annual run-off at Attock, contributes only about 10% of the total sediment load recorded at this station. At Mandori which is located just below Attock and 36 miles downstream of Tarbela, the average concentration is 0.276 percent consisting of 44 percent sand, 41 percent silt and 15 percent clay. The fall in the sediment load between Darband and Mandori is mainly due to lower sediment concentration of Kabul river.

Haro and Soan together drain 5400 square miles of rainfed area, with loose erodible soil cover and contribute about 10 percent of the annual sediment inflow at Kalabagh, though their share of water run-off, is only 2.5%; Kohat Toi carry higher concentration of sediment in monsoons, the average being 0.972% and 1.18% respectively. The bulk of annual water run-off is in the months of June to August and so does the suspended sediment load. Taking silt-data of Mandori, an annual silt load of 469 MST at Kalabagh Dam site was obtained. Thus the long range mean annual sediment yield of Indus at Kalabagh in natural condi-

tions amounted to a volume of 0.287 million acre ft. If the above load gets settled, the life of the reservoir as stated earlier would be of the order of 30 years only. It was therefore thought to resort to sluicing so that the life of the Dam is prolonged and made economical.

9. PROJECT AREA

The project area in PC-I (1975) has been assumed as designated in the LIEFTINICK report.

a) Area I:- It is the most extensive and substantial part of the project area. It includes 897,000 acres of Haveli/Sidhnal, 318,000 acres of Pakpattan, 677,000 acres of Mailsi, 596,000 acres of Bahawal, 1345,000 acres of Panjnad and 110,000 acres of Abbasia Canal.

b) Area II:- It includes 14,55,000 acres of Ghotki Feeder and Khairpur East and Khairpur West Feeder.

c) Area III:---It consists of 104,000 acres of Paharpur Canal. It includes some area of the proposed Chashma Right Canal.

The Project elements include 260 feet high dam and 5000 feet long earth rock-fill dam and auxiliary embankment to create a reservoir of 6.1 MAF of usable storage capacity with free reservoir level at 915.0 elevation.

10. OBJECTIVES OF THE DAM

"According to UNDP documents, "The nature of the Project has been defined as multipurpose and its functions are as follows:

a) To generate a large amount of low-cost Hydro Electric Power near Major Load centers and supply the existing grid for meeting the growing power demand of domestic, Agricultural and Industrial consumers

b) To replace the lost live storage capacities of Mangla and Tarbela Reservoirs gradually being depleted due to sedimentation.

c) To provide additional storages on the Indus, the biggest source of surface potential in Pakistan and thus provide better system management and control for assured, adequate and timely supplies for crops.

d) To regulate and control the extreme flood peaks on the Indus to alleviate flood damage downstream.

e) To extend Irrigation facilities to new areas.

f) This second large storage on the River Indus would substantially increase Pakistan's capacity to manage its distribution and power generation through conjunctive use of Tarbela."

Para **(f)** in fact is repetition of Para (a) and **(c)**. As for as flood alleviation (d) is concerned, it is practically insignificant. When translated in simple words, the objectives will be as under:-

A) To utilize surplus water wastefully flowing to sea.

B) To remove shortfall in the Irrigation supplies due to siltation of Tarbela.

C) To generate the energy necessary to meet the demand and stop load-shedding.

It is proposed to discuss each of these points to remove the misunderstandings.

A) SURPLUS FLOWS

The Project elements include 260 ft. high dam and 5000 feet long earth rock-fill main dam and auxiliary embankment to create a reservoir of 6.1 MAF and usable storage capacity with free reservoir level at 915.0 elevation.

The construction of Kalabagh Dam is being actively discussed in the highest formus of the country on the premise that lot of water is wastefully flowing to the sea: and it could, instead, be well-utilized by construction of a dam at Kalabagh.

In considering the potentially available surface supply, it has to be kept in view that the flows are quite variable from year to year and until there is storage capacity large enough to absorb the above - average flows for

carry-over into the subsequent years, the development would have to be based on the level of flows which can be relied upon at least in 4 years out of 5. This would apply not only to the direct use of the flows but also to the creation of additional surface storages. The above principle is in consonance with international practice also. Let us therefore analyse the water availability on the above basis.

Water availability for the whole Indus system is as under:

Indus system (Indus,Jhelum and Chenab)

	Kharif	Rabi	Total
Mean flow 1923-86	115.24	22.03	137.27
Minimum flow	84.61	15.74	100.31
4 out of 5 years	101.28	18.76	123.59

In order to study the water availability according to International practice, we rely on 4 out of 5 years (80%) availability to ensure proper supply to Agriculture. Moreover high dams are very cost-intensive and have large variable seasonal availability. In case of power, such dams have approximately 25% firm load. On the basis of 80%, the availability works out as under:

		Remarks
Kharif	101.28 MAF	
Indian withdrawals (Kharif) out of yearly total of 2.0 MAF	1.5 MAF	Losses supplied by Ministry of Water & Power in reply to a question to Senator Abdul Majeed Kazi.
Net availability	84.34 MAF	
Water Accord allocation (Kharif)	77.34 MAF	
Minimum allocation to sea	10.00 MAF	
Net availability	(-) 3.00 MAF	

It is considered that with the construction of storage reservoir (more withdrawals) in the North, the pattern of losses will change and become higher than the historical losses. In this particular case, the experience for Indus system is quite pertinent. After construction of Tarbela, the losses have considerably increased as is evident from the data supplied by the water resources and management of WAPDA.

Losses from 1966-67 to 1976-77 6.92 MAF After construction of Mangla.

Losses from 1977-78 to 1988-89 15.44 MAF After construction of Tarbela.

Losses are of very complex nature depending upon number of variables and cannot be determined with mathematical exactitude. It is only the experience which gives the trend. In view of the above, the trend in the Indus shows that the construction of another storage in the upper reach will increase the overall losses more than that of the historical. This is also supported from the International experience as is clear from the following statement from Yellow Book.

"On the Colorado river below Hoover Dam, River losses increased beyond that they were prior to the construction of the dam., similarly on Pecos river, following an agreed division, losses increased boyond the historical losses to the point that during the last few years, no usable supplies whatever have been available to Texas, the lower riparian."

In view of the above, it is well nigh possible that at least 3 MAF more losses will occur after the construction of new dam due to evaporation alone from its 160 square miles of reservoir area. The net available supply will therefore

be -3+(-3)
=-6 MAF which indicates that the availability on the basis of International practice will be on negative side and it is not possible to embark on the construction of a new dam.

It would be worthwhile to examine the criteria as laid down by WAPDA for reservoir filling operations of Kalabagh in the light of last 10 years experience of Tarbela and Chashma filling and drawing down periods.

RESERVOIR FILLING

According to WAPDA "Technical Memorandum 50" Tarbela and Kalabagh reservoirs are planned to be operated conjunctively to maximise their Irrigation and Power benefits. In their study, the reservoir operation criteria include:

i) The estimated Irrigation Demands as per PPR (Project Planning Reports)

ii) Mandatory Sluicing of Kalabagh from June 1 to July 20 (50 days).

iii) No Sluicing in Tarbela during initial years, allowing surplus water retention in Tarbela during wet years above the minimum rule curve level elevation R.L. 1300.

iv) Mandatory slucing at R.L. 1400 after year 2012 when sediment builds upto this level.

v) Storage of surplus water, if any, in Tarbela instead of Kalabagh.

vi) Ensuring Tarbela filling before Kalabagh.

Following comments are offered on the reservoir filling:

Pakistan basically is an Agriculture country and the dams which are cost intensive are constructed to increase the availability of water. According to water resources Management Committee Report WAPDA September 1987, "In considering the potentially available surface supplies, it has to be kept in view that the flows in any River are quite variable from year to year and unless there is

storage capacity large enough to absorb above average flows for carry-over in subsequent years, the development would have to be based on the level of flows which can be relied upon at least in 4 out of 5 years. This would apply not only to the direct use of flows through diversion structures but also to the creation of additional surface storages". This is also in conformity with international practice. Incidentally WAPDA has worked out the availability on the basis of median inflows at Kalabagh. It has evolved simulation model "ROCKAT" (Reservoir Operation of Chashma, Kalabagh and Tarbela) which was used for reservoir filling study. This mode was previously used for the reservoir operation studies of the Kalabagh Project, for the evaluation of the Project Feasibility and optimising the conjunctive operation of Tarbela, Kalabagh and Chashma for maximum power and irrigation benefits.

Since median inflows have been fed into simulation model, the simulation results from reservoir operation obtained from "ROCKAT" for filling of Kalabagh Dam, Chashma and Tarbela will therefore be materially different if 80% availability is assumed to be fed into model and results obtained therefrom.

If we take long range data for Indus Arm, from 1922-86, the mean and 4 out of 5 years are as under:

Kalabagh Inflows(MAF)	Kharif	Rabi	Total
Mean	76.1	13.12	89.22MAF
4 out of 5 years	66.36	11.59	77.95MAF

If we take PPR estimated withdrawals according to Memorandum 50, they are as under vide Table 3.

Kharif	Rabi	Total
54.96	22.54	77.5 MAF

The dam has to be filled up in Kharif and after Tarbela's commissioning, the losses in Indus have considerably increased. System losses which were 9.3 MAF in 1974-75, have increased to maximum of 16.66 MAF in 1988-89.

Normally Indus is a loss reach where as Jhelum-Chenab is a gain reach. If some losses do occur sometimes in this latter reach, they are very small and could be neglected. Even if we take 15.0 MAF as an average loss in the Indus Arm and out flow to sea as 7.0 MAF from Indus Arm alone, we need 54.96 + 15 + 7.0 = 76.96 MAF as against 66.36 MAF in Kharif which is 80% availability excluding water (9.3MAF) required for filling Tarbela.

If we take on the basis of whole Indus system, the figures for mean and 80% are as under:

	Kharif	Rabi	Total
Mean	115.24	22.3	137.54MAF
4 out of 5 years	101.28	18.76	120.04 "

In accordance with "Water Accord" we need 77.34 for the Provinces and accounting for system losses (Kharif) as 15.44 based on 1977 to 1989 period and 10 MAF as out flow to sea down-stream Kotri plus 1.5 MAF as Indian withdrawals, out of yearly total of 2.0 MAF, we get 77.34 + 15.44 + 10 + 1.5 = 104.28 MAF as against 101.28 MAF availability. Even in this case, the balance availability is in the negative. This will increase to 118.28 MAF by transfer of 14.6 MAF to Tarbela and Mangla.

There is yet another aspect. According to the criteria laid down by WAPDA, Kalabagh has to be filled up after Tarbela. There is no mention of Chashma which normally gets filled up after Tarbela as is evident from last 10-12 years of water resources and management directorate record. For last 10 years, Chashma filling lags behind Tarbela. In other words, Kalabagh, it is presumed will be filled up after Chashma. Moreover as laid down by WAPDA, Kalabagh will be filled after 20th July, through September. The examination of the WAPDA's 10 years record i.e. 1980 onwards indicates that Chashma has never filled up earlier than 25th August and Tarbela not earlier than 20th August. Drawing-down starts in early September. It will be nothing short of miracle if the dam fills up in the reduced period after making adjustment for increased allocations to

N.W.F.P., Punjab and Baluchistan under the "Water Accord" and consequential increased losses due to construction of Kalabagh through evaporation and seepage from long reservoir comprising 160 sq. miles. The above analysis also indicates that Kalabagh will never get filled up if 80% availability is made the basis and median inflows should never be used as a base for filling the dam as done by WAPDA which is against international practice. Even on the basic of mean availability, the dam can not be filled up.

ESCAPAGES

An erroneous impression however exists that seems to have been created that there is plenty of water outflowing into sea even after construction of dams in India and Pakistan. Such impression is based on the escapage below Kotri from year 1975-76 to 1988-89 as the average due to flood years of 1976-77 and 1978-79 etc. works out to above 30 MAF. Table below gives (1)Escapages below Kotri (2)Escapages from eastern rivers handed over to India for its exclusive use (3) Net escapages from 3 western rivers.

Year	Total Escapages Kotri below (from all the 6 rivers (Kharif) MAF	Inflow/ Escapages from trhee eastern river into Pakistan (in Kharif) MAF	Escapages below Kotri from three western river (Kharif) MAF
1	2	3	4
1975-76	37.76	11.49	26.21
1976-77	64.05	16.81	27.24
1977-78	29.00	10.36	18.86
1978-79	75.02	16.50	58.52
1979-80	29.38	4.20	25.18
1980-81	18.74	6.77	11.97
1981-82	33.53	5.28	28.24
1982-83	9.43	4.16	5.27
1983-84	43.81	5.97	37.84
1984-85	25.11	3.75	21.36
1985-86	10.93	4.12	6.81
1986-87	26.70	4.55	22.15
1987-88	17.4	1.88	15.52
1988-89	44.2	10.2	34.00

"Indus Basin Irrigation System abstract of Operational data" published by Water Resource Management Directorate (WRMN) WAPDA Lahore.

Following comments are offered to explain the implications:

1) The escapages from three eastern rivers allocated to India shown in column 3 have been on the decrease. Infact under Indus Water Treaty 1960 these waters have been apportioned for exclusive use of India. India has already constructed three dams on Sutlej and Beas and is in the process of building Thein dam on Ravi River which will come into operation in 1993. Thereafter, there will be no significant flows into Pakistan from these three eastern rivers. It is therefore, obvious and logical that the contribution of eastern rivers in the total escapages into sea has to be excluded for the purpose of determining availability of surplus water for storage purpose.

Besides, under Indus Basin Treaty 1960, India is entitled to the withdrawal of 2 MAF from western rivers. India has already commissioned Salal Dam on river Chenab and is constructing Woolar Barrage on river Jhelum. India can conveniently utilize at least their allocation of 1.5 MAF (Kharif) resulting in reduction of escapages to that extent.

2) The live storage capacity in the modified Kalabagh Dam Project has been indicated as 6.1 MAF. Besides, the Kalabagh Dam Project in response to the demand from provinces of Punjab and NWFP contains a proposal for high level outlets. The capacity of proposed Kalabagh Right Bank Canal for NWFP is 15000 cusecs while that for proposed Kalabagh Left Bank Canal for Punjab is also 15000 cusecs. Moreover there is further proposal from Punjab for transfer of water from Chashma-Jhelum Link for Greater Thal to the extent of 10500 cusecs. These two proposed high level outlets coupled with Greater Thal Canal will require a quantity of 7.2 MAF in addition to 6.1 MAF to be stored at Kalabagh Dam as stated earlier.

3) The additional losses due to evaporation and seepage in the river system have to be taken into account while planning any major Dam for storage. With the construction of high dam anywhere in the world, the losses below the dam increased beyond historic pattern of losses prior to the

construction of the dam.

This is confirmed from our experience as well as international experience as explained earlier.

4) Minimum Compulsory Out Flow to Sea:

A minimum amount of river flow has to be maintained in the river Indus to keep the river section alive and also prevent sea water intrusion. According to the recommendation of Harza consultant's American Engineer Mr.Karpov, a minimum quantity of 11 MAF as compuslory out flow to sea was necessary. This is notwithstanding the other adverse effects on lower riparian like dwindling of mangroves and riverain forests and sailaba, reduction in catch of famous 'Palla' fish, Chiko and Bannana plantation. Reduced flows in the river will also result in accretion of river bed giving higher water levels for lower discharges. This will render the present river protective embankment inadequate from the onslaught of future high floods. Besides, drinking water in the area below Kotri will turn even more saline resulting in great hardship to the resident communities of the area.

5) To sum up, while considering the proposal for construction of any major dam on River Indus such as Kalabagh Dam, the net availability of water taking into consideration the provision and usages discussed above have to be kept in view. These are reproduced below:

i)	India's future withdrawal from western rivers (Kharif)	1.5 MAF
ii)	Withdrawals of proposed right bank and left bank Kalabagh Canals and Greater Thal canal.	7.92 MAF
iii)	Live storage of proposed Kalabagh Dam.	6.1 MAF
iv)	Additional losses below Kalabagh Dam due to its construction.	3.0 MAF
v)	Sutlej Valley Extension.	0.41 MAF
vi)	Dajal Extension.	1.12 MAF
vii)	Compulsory out flow to sea.	10.1 MAF
viii)	Rohri Remodelling and Schwan Barrage.	3.5 MAF
		33.55 MAF

The net availability is shown on Table II below:-

Table-II

Year	Escapages from all the three western rivers below Kotri MAF	Water Accord minus actual withdrawals. (77.34-)Actual Kharif withdrawals MAF	Usages and provisiona MAF	Net availability from all three western rivers. Kotri below MAF Col.2-(3+4)
1	2	3	4	5
1977-78	18.86	12.81	33.55	- 27.5
1978-79	58.52	17.24	"	+ 7.73
1979-80	25.18	9.12	"	- 17.49
1980-81	11.97	7.91	"	- 29.49
1981-82	28.24	10.32	"	- 15.63
1982-83	5.27	10.02	"	- 38.3
1983-84	37.84	14.98	"	- 10.69
1984-85	21.36	11.68	"	- 23.88
1985-86	6.81	17.01	"	- 43.75
1986-87	22.15	10.09	"	- 21.59
1987-88	15.52	6.25	"	- 24.28
1988-89	34.91	12.08	"	- 11.72

From the above Table, it is abundantly clear that considering the escapages below Kotri in Indus river including Jhelum and Chenab, no water whatsoever is available for storage except in very freak year like 1978-79 when we got super-flood in the country.

The concept of average annual escapages is therefore fallacious and illconceived because the surplus availability has to be computed on year to year basis. It is quite apparent that surplus water of freak super flood year cannot be utilized in subsequent year or thereafter as we have no sites for carry-over dams in Pakistan.

The above study establishes beyond any doubt that there is absolutely no justification for construction of storage dam anywhere in Indus Basin system because water is simply not available. Under such circumstances if any storage dam/Kalabagh Dam or even Basha Dam is constructed on River Indus it will seriously affect the existing water rights of lower riparians and will convert Sindh into illusory desert land.

B) SHORT FALL IN THE SUPPLIES DUE TO SILTATION OF TARBELA

The necessity of second storage on Indus was emphasized by the Bank consultants due to rapid siltation of Tarbela which was envisaged as 0.2 MAF per year. However there is a redeeming feature that this has not materialized. Present WAPDA estimates based on 10 years experience for Tarbela and 20 years experience of Mangla have indicated that the life of Tarbela will be 125 years and that of Mangla 175 years as against estimated life of 55 years and 75 years respectively. The element of dwinding capacity as projected by WAPDA and the World Bank is therefore just not there. Any hasty decision might do irrepairable harm to the nation.

C) LOAD SHEDDING

The WAPDA's present installed capacity ending 1987-88 according to 7th year draft plan is 5674 M/W and the demand is expected to increase to 9570 M/W at the end

of the plan period i.e. 1992-93. In other words during 7th plan period additional power requirements will be of the order of 4000 M/W at the rate of 11% annual increase.

WAPDA's perspective plan for power of Pakistan indicates that the power requirements will jump to 18000 M/W by the year 2004 A.D. Mr.Junejo, the then Prime Minister of Pakistan announced on 28th January, 1988 that Pakistan will need 20,000 M/W by the year 2000 A.D. and will have to go nuclear in order to be self-sufficient in "Power".

Hydel Power units generate varying amount of power in different months, reaching maximum in August, September and October and minimum which is naturally in February to May. In fact power generated in May is considered as primary power. It is therefore necessary to install thermal units to match the peaking requirements of hydel units, as it is not possible to firm up hydel with hydel.

For elimination of load-shedding the firm capacity of hydel units for the months of May and June when reservoirs on Indus are at their lowest is considered. Although the installed capacity of Kalabagh would be 2400 M/W and subsequently raised to 3600 M/W in 2nd phase but its contribution to load-shedding would be 1138 M/W in the months of May-June. If we consider the power projections by the end of 7th plan period, the contribution of Kalabagh would be 12% and if we consider perspective plan, its contribution would be 6%. It would therefore be travesty of truth to propagate that everything will turn dark if Kalabagh was not on line.

The present estimates (1985) of Kalabagh Dam are 5.5 billion dollars. In the cost estimates 64% has been charged to power, 32% to water and 4% to flood control. It is therefore obvious that for the production of 1138 M/W, the nation will have to spend Rs.64 billion which is a staggering sum by any estimates. The search has therefore to be made for alternatives in the form of medium hydel power units which are less costly and have less gestation period.

WAPDA has already identified Jinnah Barrage, Chashma Barrage and Taunsa Barrage as small medium type

hydel power stations. Preliminary estimates indicate that the Chashma could be commissioned by December, 1992, Taunsa by December, 1993 and Jinnah by December, 1994. The three stations would generate 500 M/W in May and June at a total cost of Rs.15.0 billions. Additionally, Gazi Ghariala would generate 700 M/W at approximately Rs.42.0 billions on 1987 cost. In other words, Pakistan would get as an alternative to Kalabagh, the same quantum of power at reduced cost. It will save Pakistan from flooding of one part, desertifications of the other and above all the political turmoil on which no premium or costing could be done. Subsequent to this, Gudu, Sukkur and Kotri and their off-taking channels could be investigated which might contribute another 1000 M/W. Besides we are already going in a big way for fossil and oil fired power stations. Today fossil fuel contributes 47% of the country's energy needs.

Incidentally Thermal Plants have another big advantage in their having the flexibility of being located near the load centres. This is of particular value in stabilizing voltage and balancing load flow in a far and wide spread- out system like that of WAPDA, where as the major sources of generation viz: hydel is up in the North with load centres being mostly located in the centre and South.

According to Prime Minister's (Mr.Junejo) statement we will have to go nuclear in order to be self-sufficient in power. Even according to WAPDA's projections, the gap is so wide in supply and demand of Power, that Pakistan will have to go nuclear/solar in any case with or without Kalabagh. It may be added that combined power cycle in case of fossil fuel will save 33% by generating 50% more Kilo-Watt-Hours.

It is time to think dispassionately. Where there is will, there is a way. It is high time nation should consider alternatives to Kalabagh in terms of water as well as power to avoid controversy, hatred and infighting by the provinces.

11) DESILTING OPERATION (SLUICING)

According to summary feasibility report 1975 by A.C.E., it has been stated "For any reservoir on Indus to have a reasonable protection against siltation, there has to be adequate provision for desilting arrangements. The case was put up to the "First Board Meeting" which was also attended by late Dr.Einsten who was a well known authority on silts and their movements. He agreed "Generally" with ACE's proposal of massive desilting operations in the early flood season and only storing waters at the tail end. The supplies in the river are enough to "Generally" assure the filling up of the reservoir even if storage is started after Ist August. After the demise of Dr.Einsten another hydrologist "Dr.B.D. Simons" of Fort Collines University, was included in the Panel. Dr.Simons expressed opinion as below:

"It is anticipated that with water level at low pool level (R.L. 825), the velocities through the reservoir may be sufficient that a large percentage of silts, clays and sands may be washed through the system. After raising to higher pool level (R.L. 925) near the end of flood, of course, the sediments would drop out further upstream where the tributa-ries and Indus river enter the reservoir particularly, the coarse particles. This deposition would result in the formation of deltaic deposits during the filling and high pool period-preceding any new flood season, the reservoir level would be dropped to low elevation (R.L.825), it is "Anticipated" that much of material deposition in the channels of Soan, the Kabul and the Indus during the development of floods in subsequent year would be washed downstream. The extent to which the material transported would be moved through the total system can be answered after making detailed studies utilizing both physical model and mathematical model"

WAPDA in their publication KC-108 have stated that the removal of sediment from Kalabagh will be through power units, the orifice spillway and most importantly through the low level outlets. The power house is at R.L.752

and is adjacent to low level sluices which have sill level at R.L. 680. The discharge capacity of power house tunnels at R.L. 825, the minimum operating level of the dam is as under:

4 Units 68000 cusecs
8 Units 136000 "
12 Units 204000 "

The theoretical pattern of releases for Irrigation (including losses) according to the same publication is given below:

Month	Discharge	Month	Discharge
April	75000 cusecs	October	43000 Cusecs
May	138000 "	Nov:	82000 "
June	188000 "	Dec:	73100 "
July	222000 "	Jan:	47000 "
August	178000 "	Feb:	75000 "
Sept:	99000 "	March	80000 "

It is apparent that except for July, the release will be made by power house tunnels. Infact from 21st of July, the dam will start impounding storage waters and as such except for the above normal years, the low level sluices whatever their worth, will remain closed for the whole year round.

This will put the sluicing arrangement which is the basic protection against siltation on which whole economics of the Dam is dependent in Jeopardy. This will reduce the life of the reservoir to a miserably short period. The dam instead of working as a replacemcnt for Tarbela, will be a domino.

Even if we consider above normal flows, the power tunnels will serve as a "Sluiceway" for more than 10 months in year as low level sluices will be opened only when the discharge exceeds 2,04,000 cusecs. Even if low level sluices are opened while the power house tunnels are

open, most of the Shingle and other bed material would be flowing, due to churning, through power house-thus creating sand blasting conditions for tunnel as well as turbines. The concentration of bed load sediments in the power house will erode turbine components, create difficulties of operation of the butterfly valves, following a unit shutdown, extensive and rapid wear of the turbine shaft Seals etc. It is also considered that the silt erosion may create imbalance in the moving machinery and contribute to higher than normal levels. A recent victim of this sort of tragedy is Warsak Dam.

The Warsak with 250' high concrete Dam was commissioned in the year 1960. After 5 years of commissioning of the Project, the reservoir silted up to spill-way crest level R.L. 1230 from natural bed level at R.L. 1108. The power house intake at R.L. 1206 was provided protection in the form of curved concrete sill baffle wall with its crest at R.L. 1240, situated 80 ft. upstream of the intake structure. The sediment has since overtopped the wall and have buried two lower trash sections. WAPDA has appointed consultants to divert the silt through spill way without much chance for success. However only the time will tell if consultants are able to get at any innovative methods. Presently the dam is working on the run off the river.

It may be pointed out the consultants Chase T.Main for Kalabagh recommended low level sluicing at R.L. 700 on the concept of low Aswan Dam to increase the life of reservoir. As against this advice, WAPDA has adopted "Middle sluicing" to save the power potential of the Dam. The basic question still remains whether "mid level sluicing" will succeed in the light of experience of Warsak Dam.

As indicated by WAPDA there are 3 comple-mentary methods to evaluate the matters regarding silting and scouring during subsequent years in long reservoirs like Kalabagh, through sluicing.

i) Case histories.
ii) Mathematical modelling.
iii) Physical model.

WAPDA considers case histories as an empirical approach in which predictions are based on experience somewhere else. The evidence of case histories can carry as much weight as calculations and unless directly comparable situation has been studied, it can be dangerous to apply the results.

Lately a paper has been published in 64th annual "Pakistan Engineering Congress Proceedings" regarding monitoring of Warsak Dam. The Warsak Dam has long reservoir and as stated earlier the dam silted up in 5 years after commissioning. WAPDA has introduced a reservoir flushing procedure for Warsak since 1976 during later stages of the annual high flow period when the flow through the units is interrupted or substantially reduced. This flushing is an annual feature and as reported in the paper. effect of flushing was limited and there was need to develop the scheme that would ensure silt free supplies to the two intakes all the year round. Same has been our experience with sluicing operations on Indus Barrages. The effect is very limited and not lasting.

Warsak is a dam with a long reservoir in Pakistan and directly comparable where sediment characteristics are similar as that of Kalabagh. It is not understood as to why this experience in Pakistan cannot be applied.

Apparently case history of Warsak negates the type of flushing envisaged by WAPDA consultants. It is time to think, rethink, have open debate, get second opinion, third opinion if such an experience is available any where in the world.

Qualitatively as well as quantitively, this will be much better experience than physical model. Let the consultants evolve a scheme to ensure silt free water to the Power House of Warsak before embarking on a big dam like Kalabagh. It will be futile to reject this experience. It is apprehended that the same fate as that of Warsak may not overtake Kalabagh in its early stages after its commissioning and the dam may start working on the run off the river like Warsak.

MATHEMATICAL MODELLING

WAPDA considers the analytical method based on the application of sediment transport theory, to be the most flexible approach, as detailed analysis is complex and involves extensive computational effort. The use of mathematical model to increase the speed of calculation was thus desirable. Whilst there were models available which simulate sediment transport and deposition, none of them would simulate satisfactorily the process of sluicing. Ultimately WAPDA selected U.S. Corps of Engineers HEC-6 and developed it into mathematical model HEC-6KC to simulate realistically, the operation of Kalabagh and Tarbela and for refined studies, was calibrated with Tarbela reservoir sedimentation observed in 1979 to 1985 for long term sedimentation of Kalabagh.

In this connection, it is stated that whatever analytical approach based on sediment transport theory is used, certain assumptions have to be made as it is not possible to represent every complex parameter of the field condition with mathematical exactitude. It will be pertitent to point out that "Cohesion" and the resultant tractive force to erode the deposition is one such basic and important parameter. The cohesion of the soil is the capacity to resist shearing/ tractive force. The soil gets consolidated under continuous water pressure, especially, in fine grained soils, cohesion increases considerably with pressure. As a result of this compaction under different depths of water the use of mathematical model based on law of averages for every basic parameter to determine the scour during subsequent year becomes irrelevant. Due to adoption of "mid level sluicing" and consequent great reduction of slope than in-natural conditions prior to construction of dam, falls victim to the "State of art". This view is reinforced by the fact that mathematical model is one dimensional and thus cannot fully represent all parameters. This will have limited utility in fully representing sluicing operations.

Physical model:- The third and last option is the

physical model as recommended by Dr.Simons. It is understood that the physical model has been set up at Nadipur and the operation of "State of art" for sedimentation proved both problematic and time consuming "as per Project Report June 1988".

It is therefore difficult to comprehend as to how the sluicing will work on the prototype. Should it not give the desired results, the damage in the form of considerable reduction in life, reservoir power potential and resultant higher levels in the upper reaches will be unbearable for the economy of Pakistan. Even Warsak experience and our own experience on Indus Barrages as stated earlier does not support the assumption that sluicing will have chance of success in increasing the life of the Dam.

The formation of a permanent bar at the junction of soan like Mangla is another apprehension. It is felt that with very small discharge of soan with loose cover on soil in its catchment, may not be able to wash away the bar formation during sluicing operations of the Dam.

It may be pertinent to point out that Pakistan does not have ideal dam sites with narrow gorge and large reservoir upstream. Even Tarbela and Mangla are some of the most expensive dams but had to be constructed under the emergencies of "Indus Waters Treaty 1960" in exchange for division of waters. In terms of volume of earth work and rock, high "Aswan Dam" in Egypt which is one of the highest dams in the world has only 0.428 million cubic yards against 10 million cubic yard per MAF of the storage in Kalabagh. Even the country like Canada cannot afford the costly adventure like Kalabagh. It will be nothing but the miracle and addition to my knowledge and experience of 40 years in the Department and WAPDA to learn that more than 100 miles long reach of the river with number of complex parameters viz. nature of sediment, cohesion, tractive force presence of Attock gorge, bar formation etc. can be adequately represented on any type of model and correct results of sluicing operations obtained to match the huge investment of billions of rupees. We should not de-

pend on the expert opinion and weave the web of ambiguity. In fact expert opinion has been responsible for all the hazards in the world. Pakistan is not alone and has already suffered under the garb of expert opinion in Tarbela. Let us shun the loud silence on the issue and save Pakistan from any further drag on its economy.

It is time to think before Pakistan embarks on a huge investment in Kalabagh Dam for which she will not get proper return.

ENVIRONMENTAL IMPACT ON MANGROVES, FISHERIES AND DRINKING WATER

The delta and the mangroves within it, form a fragile ecosystem that needs a mixture of fresh water from the river and saline water from the sea to survive. Due to the construction of Bhakhra (8 MAF) on Sutlej & a multipurpose Pong Dam (5.6 MAF) on Beas river and a link canal "Ravi Beas" carrying the water of Ravi from Modhopur Head works on Ravi to Beas in India and system of link Canals, Mangla (5.3 MAF), Tarbela (9.3 MAF) and Chashma Dams in Pakistan under Indus water 1960 Treaty, substantial portion of the flow of Indus water system has been diverted, resulting in appreciably reduced flows downstream Kotri than those existing before the Treaty 1960 as is evident from the following figures.

YEAR	OUT FLOW TO SEA BELOW KOTRI
1950-60	61.43 MAF
1961-70	55.83 MAF
1971-75	34.93 MAF
1976-80	49.82 MAF
1981-85	27.1 MAF
1986-90	23.22 MAF

By the time water reaches the beginning of the delta during late Kharif season, it has been further reduced by another 20%. This is the only fresh water entering the delta ecosystem for the whole year.

After the construction of link canals, Mangla and Terbela Dams against average of 23.22 MAF during 1986-90, the escapage downstream of Kotri during low years has been as under.

1972-73	21.02 MAF
1974-75	8.07 MAF
1980-81	18.74 MAF
1982-83	9.43 MAF
1985-86	10.93 MAF
1987-88	17.40 MAF

India has still to construct Thein Dam on Ravi (3.0 MAF) which will be commissioned in 1992-93.

According to National Commission on Agriculture 1988, the mangrove forest is given as 347,000 hectares (8,57,000 acres). A map by the forest department giving the extent of mangrove is attached. It may be pertinent to point out that the Government of West Pakistan vide Notification dated 28th August 1958 declared different species of mangroves to the extent of 8,57,000 acres as "Protected" forest in the Indus delta.

The delta region consisted of three distinct areas. In the upper reachs, there were thick "Lai" (tamarisk) forest, sustained by the annual flooding of the river. Below them were the mud flats which were covered within "Sohand" and "Pal" grass, and large quantities of "Lana" shrub. Still further, where the sea at the river delta channels met, "Timmar" or mangrove swamps where almost all marine life in coastal region is conceived. All the three forms of vegetation bound the soil together and made it possible for the delta to absorb the silt brought by the river and pushed the delta region into the sea.

The tamarisk forest were cut and used as timber. The "Sohand" and "Pal" grass in the mud flats was excellent feed for buffaloes and cows and the region produced a considerable amount of Ghee and butter. The "Lana" shrub & mangrove are both consumed by camels. Red rice was sown

without ploughing on the mud flats between the delta channels comprising heavy quantity of silt left over by the river. The yields of red rice were higher than any where else in the Indus valley.

After the commissioning of number of barrages in the North viz. Sutlej valley head works on Sutlej, Haveli and Punjnad on Chenab and Sukkur Barrage - practically simultaneously, fresh water disappeared from the Indus channels except for Hydri & Ochito branches for 4 months in the year. During these months, the sea would creep into the mud flats and the mangroves would no longer be flushed with fresh water of the river. This caused immense inconvenience to the delta communities. However they managed to survive alongwith land.

With the commissioning of links, Barrages and the dams in the North, the fresh water ceased to flow in the delta channels except for few weeks in the flood season and the sea moved into lower reachs of Indus creeks for good and the once fertile mud flats became saline marshs unfit for cultivation. During 1982-83 and 1985-86 when the out flow to sea downstream Kotri, reduced to near about 10 MAF, number of Dehs in Thatta and Badin Districts were affected by the sea intrusion. Drinking water for which Indus was the only source, was no longer available.

Historically the Indus Waters carried to the ocean enormous quantities of nutrients and sediments. They helped support the entire mangrove ecosystem in the delta. Since the disappearance of delta channels, there has been sharp decline in breeding and a number of important species of marine life, such as "Palla" have almost disappeared.

Lack of silt nutrient and enough fresh water are already showing signs of degradation on mangroves such as stunted growth and reduction in number of species of mangroves. Although mangroves are salt resistant, they do require enough fresh water to flourish. Short and irregular supplies will bring an end to the ecosystem of mangroves. Due to enormous erosion of the coastline by sea, loss of tens of thousand of acres of mangrove has already taken place.

This process is continuing, and as the sediment built by, Indus over the centuries is slowly eroded, it will increase sharply. It is time to rehabilitate the mangrove ecosystem and save the marine and human population of the region from extinction.

The Indus delta provides an ideal habitat for fisheries. The most important is the prized shrimp Industry on coastal and deltaic region. The shrimp Fishery is the backbone of Pakistan's Fisheries resources. The annual export of shrimp in different forms amounts to about 15000 Tons and the earning 980 Million rupees in foreign exchange and are exported to about 26 countries.

The almost flat and muddy bottom of the continental shelf off the Indus delta, provides a conducive habitat for demersal (Sea bottom) fish and suitable conditions for trawling. During monsoon demersal fishes viz flat fishes, pomfrets, grunters shrimp etc migrate towards to nearly broad and flat shelf area of estuary and back waters in the early post larval phase of their life history and then return to sea.

The high productivity of Indus delta is attributed to the discharge of substantial quantity of nutrients by the river Indus. These nutrients including floating microscopic organisms form the food chain of the fishes. The annual fish catch of the variety of fish and shrimp from the creeks of Indus delta alone is estimated at about 1000 tonnes (Metric).

Another important "Hilsa" fish popularly known as "Palla", is found in the delta, where mangroves form its breeding ground. It used to ascend upto Sukkur but is now checked due to faulty fish ladder at Kotri Barrage. However the fish has survived in the 182 Miles stretch from the sea to Kotri but its production has reduced drastically from about 6000 Tons to 1000 Tons annually.

The mangrove area of the Indus delta is facing deforestation due to the conditions of the estuary. It is understood that in order to conserve this resource, a forest management Plan was developed for the period 1966-82 and

second plan is being developed by the Sindh Forest Department for the conservation of the Indus delta mangroves and associated ecosystem. A National mangrove Committee has also been formed recently for the management of the mangroves. The important problem is the lack of understanding of the ecosystem regarding different species characteristics, water requirement and its availability, Industrial population, reduced Indus discharge, reduced quantum of silt etc.

Importance of mangroves for coastal development requires to be over emphasized due to following reasons.

They play a significant role in enhancing the productivity of delta and its adjacent coastal waters.

The mangrove ecosystem provides the spawning and nursery grounds for a variety of fish and shrimp including many commercial species.

The mangroves directly support much of near shore production along Sindh coast.

They provide firewood for local population and fodder.

They check soil erosion and help land stabilization along shore line.

It is necessary that a programme of multi- disciplinary scientific observations may be planned and implemented to monitor long term environmental changes in the deltaic region including the adjacent coastal area to detect abnormal changes and suggest appropriate measures to check soil erosion which is slowly taking its toll and for further preservation and revival of the old ecological balance.

It will be pertinent to mention the opinion expressed by UN expert Dr.Peter-John Reynell programme coordimator coastal ecosystem unit, IUCN Pakistan vide "Dawn" March 21, 1992, "If upstream demands persist, as they will, mangrove managers both foresters and fisheries officers cannot be expected to maintain the levels of productivity in trees and fish as their ecoystem is in decline. It is infact possible that the added value from natural re-

sources of the Indus delta is more valuable per unit of water allowed to flow to the delta than if it is used for irrgation and hydropower"

SINDH PUNJAB AGREEMENT
1945

AGREEMENT BETWEEN THE PUNJAB AND SINDH REGARDING THE SHARING OF THE WATERS OF THE INDUS AND FIVE PUNJAB RIVERS

1.SCOPE OF THE AGREEMENT

This agreement refers to the sharing of Indus water between the Punjab and Sindh. The Punjab share comprises the withdrawals controlled by the Punjab from the Indus and its tributaries for the use of the Province of the Punjab and certain Indian States. The share of the Punjab under Priority V detailed below shall also include the share of the North-West Frontier Province. Sindh's share under Priorities, I,III, as detailed below, comprises withdrawals for the use of the Province of Sindh and Khairpur, its share under Priority II (as detailed below) is, however, for British Sindh Canals only.

2.GRADING OF PRIORITIES.

(1) To give effect to this agreement, five grades of Priorities are recognized:-

I. Existing withdrawals on-

A) Panjnad (Punjab rivers). (First Priority on Punjab rivers).

B) Indus. (First Priority on Indus Main and the next priority on Punjab rivers).

II. Primary, i.e., prescriptive supplies, for projected canals, i.e., canals specified in Clause 11.

III. Secondary additional supplies for projected canals.

IV. Storage water and other subsequent allocations.

V. Balance supplies.

(2) Except as otherwise provided, allocations under a higher priority will have precedence over those under all lower priorities.

3.PRIORITY I. (EXISTING WITHDRAWALS)

(1) Period (Ist April to 30th September, except as otherwise provided).

(A) Panjnad. (Five Punjab rivers).

i) This priority comprises:-

a) The supplies taken by old canals, i.e.-

1) Northern Canals (i.e., Upper* and Lower Chenab, Upper* and Lower Jhelum and Bari Doab Canals).

(*For the Upper Chenab and Upper Jhelum Canals, the "supplies taken" shall be the supplies used plus absorption losses).

2) Upper Bari Doab Canal and Kashmir Canal.

3) Sirhind Canal.

b) The supplies taken in the past by the undeveloped canals, i.e.

1) Sutlej Valley Canals.

2) Haveli Canals including the Pakpattan Link

3) Panjnad Canals.

with additions providing for their future development.

ii) These withdrawals will have the first claim on the waters of the Punjab Rivers and no claims on the waters of the Indus, subject to the limitation that such withdrawals shall not on any day exceed those given in Table 1(a), unless, with due allowance for time lag, water is sufficient for the requirements of Priorities I-B, II and III specified below.

(B) Indus

i) This priority comprises the supplies allocated to-

1) Thal Canals.

2) Sukkur Barrage Canals including Khairpur State Canals.

ii) The Thal and the Sukkur Barrage Canals will have an equal claim on the waters of the Indus River and of the five Punjab rivers surplus to Priority I-A subject to the limitation that the Punjab withdrawals shall not on any day exceed those given in Tables I(a) and I(b), unless, with due allowance for time lag, water is sufficient to meet the requirements under Priorities II and III.

(2) Period (Ist October to 31st March except as otherwise provided).

A) Panjnad (Five Punjab rivers).

i) This priority comprises:-

a) the supplies taken by old canals i.e.-

1) Northern Canals (i.e. Upper and Lower Chenab, Upper and Lower Jhelum and Lower Bari Doab Canals).

2) Upper Bari Doab Canal and Kashmir Canal.

3) Sirhind Canal.

b) The supplies taken in the past by Sutlej valley Canals with additions providing for development upto perennial capacity.

c) The supplies authorized for the Panjnad and Haveli Canals.

d) Further allocations to Panjnad and Haveli upto their perennial capacities, as provided in B(v), below-

ii) The withdrawal under (a),(b) and (c) above will have the first claim on the waters of the Punjab rivers and no claims on the waters of the Indus.

iii) The withdrawal under (a) and (b) shall be limited only by the river supplies available or by the rabi capacity of the canals.

(B) Indus.

i) This priority comprises the rabi supplies allocated to

1) The inundation canals merged in new Sindh Barrage as prescriptive supplies, equal to the average withdrawals of the three lowest years in any decade.

2) The inundation canals to be merged in the Punjab Indus Barrages, on their conversion to weir control as prescriptive supplies, equal to the average of the three lowest years in any decade.

3) Sukkur Barrage Canals including Khairpur State Canals.

4) Thal Canal, upto its authorizations.

5) Thal Canal, in addition, upto its capacity (6,000 Cs).

ii) The mean monthly allocations for (1) to (4) above are given in Table I(c). If Indus supplies plus Panjnad supplies surplus to Priority I-A are below the allocations of these

canals; after meeting the allocations for (1) and (2) above [vide Table I(c)] the balance supplies will be shared in the proportion given in Table I(d), which is based on an assumed lag of 15 days. Provided that in the period 17/2 to 8/3 (Sukkur dates) the Sukkur canals will have priority on Indus water upto their capacity of 34,000 cusecs.

a) over Thal alone till the Punjab Indus Inundation canals are converted to weir control, and

b) over Thal and the Punjab Indus Inundation canals when the latter are converted to weir control,

while in periods 11/12 to 24/12 and 3/3 to 31/3 (Kalabagh dates).

a) Thal will have priority upto its capacity of 6,000 cusecs till the Indus Inundation canals are converted to weir control, and

b) Thal will have priority upto its capacity of 6,000 cusecs and the Punjab Inundation canals upto the authorizations laid down in Table I(e) when the Punjab Inundation canals have been brought under weir control.

iii) During periods of shortages the Punjab shall be at liberty to make good supplies to the Thal upto its capacity by using Indus water at Kalabagh, provided that equivalent supplies of the same duration are released below Panjnad from the Punjab share of the five Punjab rivers over the same period, with due allowance for time lag and losses or gains.

iv) When the Indus supplies plus Panjnad supplies surplus to Priority I-A are in excess of the allocations of Sukkur Barrage and Thal as specified in Table I(c), the canals, mentioned under (i) (1) and (i) (2) above, may draw supplies as laid down in Table I(e). Thereafter the Thal canal may draw on balance supplies upto its capacity of 6000 cusecs, after which the Sukkur Barrage Canals may draw upto their rabi capacity (34,000 cusecs) subject to the proviso under (v) below. The Punjab and Sindh Inundation Canals, when brought under weir control may then draw upto their authorized perennial capacities.

v) The Sukkur Barrage Canals have priority on Panjnad

water surplus to Priority I-A until their allocations in Table I(c) are met. Thereafter Haveli and Panjnad may take water upto their capacities as given in Table I(f) after which the Sukkur Barrage Canals may withdraw upto their rabi capacity (34,000 cusecs), as in (iv) above.

vi) The water accounts during the rabi shall be maintained and balanced in ten-day periods as well as in calendar months.

4. PRIORITY II.

[PROJECTED CANALS (PRIMARY, i.e. PRESCRIPTIVE SUPPLIES)]

1) The total withdrawals for the Punjab and Sindh under this priority are detailed in Table II(a).

They comprise:-

a) Ravi water set free by the Haveli project, less supplies utilized in Pakpattan Link.

b) Prescriptive rights for Grev Canals to be utilized on Bhakra Canals.

c) Prescriptive rights of Inundation canals merged in the new Sindh Barrages

d) Prescriptive rights of the Punjab Indus Inundation canals, when brought under weir control.

2) Withdrawals for projected canals by either party may be made only when water is surplus to the actual requirements of the Punjab and the allocations of Sindh under Priority I-A and I-B.

3) When water is short of the requirements of Priority II, the balance supply left after meeting the requirements of the Punjab and the allocations of Sindh for Priority in full, shall be divided between the Punjab and Sindh in the ratio of their prescriptive rights, with due allowance for time lag, i.e.-

a) till the Punjab Indus Inundation canals are converted to weir control in the proportions laid down for the relevant period in Table II(b) and

b) when the Punjab Indus Inundation canals are converted to weir control in the proportions laid down for the

relevant period in Table II(c).

In both these tables a time lag of ten days has been assumed.

Thus, where Pe and Se are the Kharif allocations for the Punjab and Sindh weir-controlled existing canals respectively [vide Table I(a), I(b) and II(d)], Pe is the Punjab requirements against the allocations for their existing canals, R is the total river supply to be distributed, and 1-n are the proportions of prescriptive rights for Punjab and Sindh respectively [vide Table II(b) or II(c), as the case may be], then-

Sindh's share-S plus 1-n (R-p -S)

Punjab's share-P plus n (R-p - S)

5.PRIORITY III.

[PROJECTED CANALS (ADDITIONAL OR SECONDARY SUPPLIES)].

1) The mean monthly withdrawals under this head are detailed in Table III(b) being the difference between the total allocations [vide Table III(a)] and the primary supplies of the Punjab and Sindh projected canals [vide Table II(a)]. They comprise:

Sindh:-(a) Additional or secondary allocations for the new Lower Sindh and Upper Sindh Barrages.

(b) Allocations for Sailab areas in Khairpur and Middle Sindh.

Punjab:-(a) Additional allocations for the Balloki Sulemanki Link or an accepted variant (e.g., Marhu Tunnel).

b) Flow water for Bhakra Canals (including Grey Canals), Bist Doab Canal and Sutlej Valley Sailab areas.

2) Withdrawals for Priority III shall be made only when water is in excess of the actual requirements of the Punjab and the allocations for Sindh under Priorities I(A and B) and the allocations of Punjab and Sindh under Priority II.

3) When water is short of the full requirements of Priority III, the balance supply left, after meeting the requirements of the Punjab and the allocations of Sindh under Priorities I(A and B) and II in full, shall be divided between the Punjab and Sindh in the proportions laid down for that period in Table III(c) which is based on an assumed time

lag of 10 days. Thus, where
PA= allocations for the Punjab existing canals [vide Tables I(a) and I(b)] plus prescriptive rights for the Punjab projected canals [vide Table II(a)]
P1= the prescriptive rights of the Punjab projected canals [vide Table II(a)] and the actual Punjab for the period against the allocations of their existing canals.
SA= allocations for the Sukkur Barrage Canals plus the prescriptive rights of the new Lower and Upper Sindh Barrages, [vide Table II(d) and II(a)].
R= total river supplies to be distributed between existing and projected canals.
n & 1-n=the share ratios of Punjab and Sindh respectively of the secondary or additional supplies [vide Table III(c)].

Sindh's share = SA plus 1-n(R-P1-SA).

Punjab's share=P1 plus n(R-P1-SA).

4) Whenever water is short of the total authorizations of the three Sindh Barrages, the withdrawals of the Balloki Suleimanki Link or its accepted variant (e.g., Marhu Tunnel) will be limited to Punjab's unused share for the projected canals under Priority III or to a daily maximum withdrawal as specified in Table III(d), Column 2, whichever is less.

5) The provision of this clause shall be subject to the conditions laid down in sub-clause (6) of clause 6.

6. PRIORITY IV.
(STORAGE WATER AND OTHER SUBSEQUENT ALLOCATIONS).

1) The provisions of sub-clauses 2 to 5 (inclusive) shall have effect subject to the conditions laid down in sub-clause 6.

2) After the indents of the two new Sindh Barrages and the Sukkur Barrage upto their allocations have been met the Punjab shall be entitled to withdraw the allocations detailed in Table IV(a) for use by flow comprising:-

a) 2nd allocations for the Thal canal.

b) 2nd additional allocations through the Balloki Sulci-

manki Link or its accepted variant (e.g., Marhu Tunnel) subject to the provision of sub-clause (3) below.

c) 2nd allocations to Punjab existing canals on the Panjnad.

3) After the indents of the three Sindh Barrages, upto their allocations have been met, the withdrawals under sub-clause (2)(b) above shall be restricted to the unused portion of Punjab's share for the projected canals under Priority III or to the mean monthly figures given in column 3 of table III(d), whichever is less.

4) In the months of July and August, however, the link or its accepted variant may transfer water under this Priority, subject to the provision of clause 5(4), upto a limit of 19,300 cusecs for supplementing the Punjab canals or for the separation of hydro-electric power, in which case water will flow down the Sutlej instead of the Chenab.

5) After the indents of the two new Sindh Barrages and the Sukkur Barrage Canals, upto their allocations have been met, the Punjab shall be at lib-erty to store at the storages specified in clause II up to the limits of their respective capacities shown therein. Such storage water may be subsequently released and used at will. Storage water so used will not count against allocations of flow water under any priority.

6) Withdrawals by the Punjab for their projects specified in Clauses II and 12(c), falling under Priorities III and IV, shall be subject to the following conditions:-

a) no withdrawals shall be made for any such project before 1954 or before the completion of both the new Sindh Barrages whichever is earlier, except as provided in sub-clause (d) below,

b) in the years 1954 to 1957, withdrawals may be made for:-

i) the Punjab projected canals as specified under Priority III;

ii) storage at Bhakra except in the period Ist to 30th September, and

iii) storage at Dhiangarh and the other small storages

in July and August only [Sukkur dates with respect to (i) and (ii)].

c) even after the year 1957, withdrawals for the Dhiangarh Dam and the small storages shall be made during the calendar months of July and August only (Sukkur dates), except as may be subsequently provided under clause 14 (2).

d) Punjab may construct at any time the Bist Doab canal scheme and its linked storage dams on the Soan and Sirsa torrents provided that the combined live storage capacity at these two dams does not exceed 5,00,000 acre-feet and provided that no water shall be stored in these reservoirs nor direct withdrawals made into the canal from the river, in the months other than July and August (Sukkur dates) if as a result of such withdrawals the supplies to the Sindh inundation canals or the new Sindh Barrage Canals are likely to fall below the prescriptive supplies as laid down in Table II(a).

7. PRIORITY V. (BALANCE SUPPLIES)

1) Until the expiry of the period specified in Clause 12, either party will have the right to use water surplus to Priorities I to IV in any canal or storage reservoir upto the limit of its capacity, but such use will not confer any prescriptive rights in respect of any additional withdrawal taken under this sub-clause. Such additional withdrawals may be made only with the previous consent of the other party. This consent will be given, as early as practicable, and may only be refused by the other party if in its opinion, the additional withdrawals is likely to injure its interests.

2) After the expiry of the period specified in Clause 12, the balance supplies including water used under subclause (1), will become the property of the parties in the proportions laid down in Table V(a) and either party may thereafter frame and carry out projects for the use of such waters with the consent of the other party. The second par-

ty will have the right to object to the construction of such projects only if it can show that the projects infringe its rights under this agreement.

3) For the purpose of sharing under this clause

i) The balance supply in Indus at Ghazighat shall be obtained by deducting from the measured discharge at Ghazighat, the equivalent at Ghazighat, after allowing for losses or gains, of:-

a) the existing rights between Ghazighat and Mithankot [vide Table V(b), Col.2];

b) the authorized withdrawals for Sukkur Barrage Canals and the new Sindh Barrages and the existing rights of the Middle Sindh Inundation canals and Middle Sindh and Khairpur Sailab areas [vide Table V(c)]; and

c) the authorized withdrawals of Thal [vide Table V (b)] minus the actual withdrawals.

75 percent of this balance supply shall be taken as Sindh's share of the Indus at Ghazighat and transferred to Gudu.

ii) The balance supply from the five Punjab rivers at Punjnad shall be obtained by deducting from the measured discharges at Pajnad (below):-

a) the existing rights of the Punjab canals [as specified in column 4, Table V(b)] minus the actual withdrawals at the time; and

b) the equivalents, at Panjnad of the authorized withdrawals of the Punjab projects [vide column 5 and 6 of Table V(b) and of withdrawals for storage (vide clause 6)] minus the actual withdrawals in these at the time.

The shares of this balance supply from the five Punjab rivers at Panjnad for the Punjab and Sindh shall be laid down in Table V(a). The shares from the Panjnad as so calculated shall be added to the shares of each party from the Indus Main, obtained under sub-clause (3) (1), to give the Party's total apportionment of the balance supplies under Priority V.

4) In the event of disagreement under sub-clause (2) supra, the matter in dispute shall be referred to arbitration

as provided under Clause 17.

8. RIGHTS OF INUNDATION CANALS

1) Inundation canals have the right to take whatever river levels permit. The existing authorized capacities of the inundation canals shall not be increased to take increased supplies until such time as they come under weir-control. No water will be specially released in order to ensure any water levels required for them.

2) Whenever any inundation canals are brought under weir control they will be given supplies as under:-

a) during Kharif under Priority II:-

i) for the months of April,May and June equal to the average withdrawals of these canals in any ten consecutive years prior to the date of this agreement;

ii) for the months of September and October supplies equal to average withdrawals of the canals in the same or any other ten-year period prior to the date of this agreement;

iii) for the months of July and August full authorized discharge of the canals; and

b) during rabi (November to March) under Priority I:-

i) in periods when river supplies are short of the authorizations of the Sukkur Barrage Canals and Thal, supplies equal to the average of the three lowest years in any ten consecutive years prior to the date of this agreement; and

ii) In other periods supplies equal to the average withdrawals in any ten consecutive years prior to the date of this agreement.

3) Additional supplies for such future projects shall be met from the party's apportionment of balance supplies and will rank under Priority V.

9. PROVISIONS RELATING TO SHARING OF SUPPLIES

1)(a) The share supplies specified under Priorities I to IV shall be given at the off-takes of the canals men-

tioned therein or their accepted variants.

b) The Punjab Government shall be responsible to see that Sindh is supplied its due share of water under Priorities I to IV. Should be Punjab at any time use, or store, any water to which Sindh has a right, an equivalent supply of water shall be returned to Sindh from the supplies to which the Punjab has at that time a right. This return shall be made at such rates of release and at such times within two months of the commencement of such use or storage, as shall be selected by Sindh, and at such site at which it is practicable to return the water.

c) Water permitted by Sindh to be wasted to the sea at-times when it might have been used to meet Sindh's rights i.e., up to indents under this Agreement shall be considered to have been so used and Sindh shall have no rights under this Agreement in respect of any shortage of supply which might have been avoided by the use of this water.

2)(a) For sharing balance supplies under Priority V, the share for the Punjab shall be as at Ghazighat in respect of Indus supplies and as at Panjnad in respect of supplies in the five Punjab rivers and the supplies for Sindh shall be as at Gudu.

b) If any supply in excess of the Punjab share is withdrawn by the Punjab, the Punjab shall return to Sindh an equivalent supply of water in any 15-day period within two months of the excess withdrawal, the period to be fixed at the discretion of Sindh.

10. TRANSFERENCE OF SHARE SUPPLIES

Either party may use the water to which it has a right in any of its canals at will subject to the limit of existing or agreed capacities and subject further to the following provisos:-

a) Allotments to the Punjab for its canals under Priorities I to IV on the Panjnad shall not be met from the Indus.

b) In periods when supplies under Priorities II and III are not sufficient for the Sindh projected canals, the Punjab shall not transfer supplies allotted for its existing

canals under Priority I to its projected canals or their ac-
quirements of the three Sindh Barrages, supplies allotted for the Punjab existing canals may be transferred to its projected canals provided that during the periods of years specified in clause 12 the previous consent of Sindh will be obtained.

c) Any transfer of supplies between projected canal inter se, in the Punjab, shall be restricted to periods of shortages on the Sutlej-cum-Beas and be limited:-

i) during periods of shortages for the three Sindh Barrages, to the un-used share of the projected canals or to a daily maximum withdrawal specified in col.2 of Table III (d), whichever is less;

ii) in other periods, to the unused share of projected canals or the mean monthly withdrawals given in col.3 of Table III (d) whichever is less.

11. PROJECTED CANALS AND STORAGES

1) The construction of the following works is agreed to

I. Sindh.

a) A Barrage across the Indus in Upper Sindh with canals of 40,000 cusecs capacity.

b) A Barrage across the Indus Lower Sindh with canals of 47,000 cusecs capicity.

c) Canals from Sukkur Barrage of capacity of 2,000 cusecs for Sailab areas.

II. Punjab.

a) A link or links totalling 19,300 cusecs capacity from the Chenab and the Ravi to the Sutlej.

b) The Bhakra Dam with a live storage capacity of 40,00,000 acre feet.

c) The Dhiangarh Dam with a live storage capacity of 25,00,000 acre feet.

d) Four small storages on the tributaries of the Punjab rivers as under:-

Three storages on Ravi (including Deg)	10,28,520
Woolar Lake on Jhelum.	3,34,000
	13,62,520
Less Deg storage.	4,34,520
	9,28,000
	acre feet.

e) The Bhakra Canals with a capacity of 13,000 cusecs.

f) An increase of Kharif capacity of Canal to 10,000 cusecs.

g) The Bist Doab Canal with a capacity of 1,200 cusecs and storages on the Sirsa and Soan Torrents of an aggregate capacity of 500,000 acre feet.

h) An increase of capacity of the Sutlej Valley Canals of 1,800 cusecs for Sailab areas of Bahawalpur and Punjab.

2) Either party may with the consent of the other party substitute a substantially equivalent variant or variants for any one or more of these works. The second party shall have the right to withhold such consent only if they can show that the variant or variants proposed will throw a greater burden on the river supplies than the replaced project or projects. Provided that the Punjab shall not construct more than two major storage dams (including the Bhakra), each having a capacity exceeding 500,000 acre feet.

3) In the event of disagreement under sub-clause (2), the matter in dispute shall be referred to arbitration as provided under clause 17.

12 .FUTURE PROJECTS

1) No new works other than those specified in clause II or modification of old works designed with the object of increasing river withdrawals will be constructed by either party without the consent of the other party, until after the expiry of 10 years from the date of completion of the two new Sindh Barrages, or 20 years from that of the first

Barrage, or twenty five years from the date of agreement, whichever is earlier provided that:-

a) minor projects involving a storage capacity of less than half a million acre feet or a canal capacity of less than 1,500 cusecs may be undertaken earlier by either party after obtaining the specific consent of the other party; and

b) until the new Sindh Barrages are built, no withdrawals for storage of direct supplies to new canals shall be made in September (Sukkur dates);

c) subject to the conditions of clause 3 and 4 and sub-clause (2) below the Punjab shall be permitted to construct a barrage across the Indus above Ghazighat with canals not exceeding 20,000 cusecs capacity.

2) Any additional supplies required for projects constructed under sub-clause (1) above shall be met from the party's share under Priority V.

13. SINDH NON-PERENNIAL CANALS

The non-perennial canals of the Sukkur Barrage and the two proposed new Sindh Barrages may be opened in the first fortnight of April and may remain open from 16th to 31st October if water is surplus to the requirements of the Panjnad and Haveli canals as specified in paras 25,26 and 34(b) of the Anderson Committee Report (1935), Vol.I provided that no prescriptive rights shall be established by Sindh in respect of these additional withdrawals. Nothing in the above shall adversely affect the existing rights of the Sutlej Valley Canals in this respect.

14. SHARING OF FLOW RIGHTS AND FRESHETS

1) Irrespective of whether allocations under Policy I are met or not, the Punjab shall be entitled to store water in the Bhakra Reservoir in the months of November, February, March and April whenever the combined discharges of the Sutlej and Beas rivers is less than 19000 cusecs and in the

months of December and January whenever the combined discharges of the rivers is less than 17000 cusecs. For the purpose of this clause the Sutlej discharge shall be the storage at Bhakra plus the discharge at Rupar (above) and that of the Beas shall be at Mandi Plain.

2) When other storage reservoirs are constructed by the Punjab, the question of giving similar storage rights will be considered and the Punjab will be given such rights as are compatible with no injury to Sindh.

3) The Punjab and Sindh shall have the right during the period 1st January to 31st March (Punjab dates) to store or use by flow in any of their canals half the freshet water as measured at the point of off-takes of these withdrawals. Freshet water is defined as all water in excess of Sindh and Punjab withdrawals under Priority I(A and B).

4) The Punjab shall have the right to diurnal storage at any time when this is necessitated by variations within the twenty-four hours in the electrical load; but the total volume of water discharged from a reservoir, within every period of twenty-four hours, shall be not less than that entering the reservoir except when this is inconsistent with the day to day storage permissible under this agreement.

5) In the event of disagreement under sub-clause (2) supra, the matter in dispute shall be referred to arbitration as provided under clause 17.

15. ALLOCATIONS NOT TO BE REVISED.

Allocations made under this agreement shall not be revised or prejudicially affected without the consent of both the parties.

16. RIVER DATA,ETC.

1) Accurate measurements of river discharges shall be made jointly by Sindh and Punjab at all discharge sites, in the Punjab and Sindh, with up-to-date equipment (including launches) and by the most modern method known at

the time for this purpose, one or more observers of Sindh shall be permitted by the Punjab to be stationed at each Punjab site, in the hills or in the plains, as selected by Sindh, and one or more observers of Punjab shall be permitted by Sindh to be stationed at Sindh discharge sites, as selected by the Punjab. Such observers shall take original and check measurements, either jointly or individually as may be considered nccessary; and when duly signed by the parties, shall be considered to be correct.

2) Gauges and discharges data of rivers, canals and storages should be made available to both the parties at agreed intervals in the quickest practicable manner.

3) Whenever time lags have been provided in this agreement on assumed figures, these figures will be liable to modification in the light of experience gained, subject to agreement of both the parties.

4) Wherever figures of percentage for losses and gains are required for the operation of the Agreement, such figures shall be determined in the light of experience gained, subject to agreement of both the parties.

5) In the event of a dispute as to the scope or operation of this clause the matter in dispute shall be referred to arbitration as provided under clause 17.

17. Any disputes for which arbitration has been provided under clauses 7(4), 11(2), 14(2) and 16 shall be referred to an officer to be appointed by the Government of India who shall be acceptable to both parties and whose decision shall be final, and binding on the parties.

18. Agreement on all these clauses is subject to a satisfactory settlement of the financial issues on the lines of clause(III), (IV) and (V) of the Grant-Khosla Memorandum of February 1945, or by any other method acceptable to both parties.

Chief Engineer in Sind
(Sd,) J.L.GRANT.
28th September,1945.

Chief Eigineer,Punjab
(Sd.) E.L.PROTHEROE.
(Sd.) F.F.HAIGH.
28th September, 1945.

SINDH PUNJAB AGREEMENT

Table I(a)

[Reference Clause 3(I)(A)]

Daily maximum withdrawals during Kharif to which the existing Punjab weir controlled canals on the five Punjab rivers shall be limited during periods in which water is insufficient for priorities II and III

Month	Period (Punjab dates)	In thousand cusecs	Remarks.
	KHARIF		
April	1-15	36.7	
	16.30	42.6	
May	1-10	54.9	
	11-20	60.0	
	21-31	68.2	
June		80.9	
July		88.3	
August		88.7	
September	1-10	98.5	
	11-20	94.0	
	21-30	88.3	

SINDH PUNJAB AGREEMENT

Table I(b)

[Reference Clause 3(I)(B)]

Daily maximum withdrawals on the Indus during Kharif to which the Thal Canal, under Priority I-B, shall be limited during periods in which water is insufficient for Priorities II and III.

Month	Period (Punjab dates)	Thal (in cusecs)	Remarks.
April	1-5	4000	
	16-30	4000	
May	1-10	4000	
	11-20	5000	
	21-31	6000	
June		6000	
July		6000	
August		6000	
September	1-10	6000	
	11-20	6000	
	21-30	6000	

SINDH PUNJAB AGREEMENT

Table I(c)

[Reference Clause 3(2)(B)(ii)]

Mean monthly allocations for Sindh and Punjab existing Canals under Priority I-B during the period November-March.

Month	Prescriptive supplies of Sindh inundation canals merged in projected Sindh Barrage.	Prescriptive supplies of Punjab inundation canals to be merged in the Punjab Barrage on the Indus above Dera Ghazi Khan.	Sukkur Barrage	Thal	Remarks.
November	1435	973	23482	6000	
December	607	795	25548	5600	
January	532	485	24923	2000	
February	578	483	24923	2000	
March	430	656	25721	3600	

SINDH PUNJAB AGREEMENT

Table i(d)

[Reference Clause 3(2)(B)(ii)]

Proportions for sharing supplies between Sukkur Barrage and Thal during periods of shortages in rabi, subject to the provisos of clause 3 (2) (B) (ii).

Month	Period date	Proportions for		Remarks
		Punjab	Sindh	
October	1-15	.157	.843	
	16-31	.204	.796	
November	1-15	.193	.807	
	16-30	.180	.820	
December	1-15	.073	.927	
	16-31	.074	.926	
January	1-15	.074	.926	
	16-31	.074	.926	
February	1-15	.126	.874	
	16-28	.123	.877	
March	1-15	.123	.877	
	16-31	.114	.886	

SINDH PUNJAB AGREEMENT

Table I(e)

[Reference Clause 3(2)(B)(ii)]

Supplies allocated to Punjab and Sindh inundation canals when converted to weir control, when river supplies are in excess of the authorizations of Thal and Sukkur Barrage, in the periods November-March.(IN CUSECS)

Month	Supplies of Sindh Inundation Canals in the Projected Sindh Barrage.	Supplies to the Punjab Indus Inundation Canals when brough under weir control.	Remarks
November	2025	1586	
December	1157	1282	
January	927	943	
February	941	888	
March	749	1195	

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Table I(f)

[Reference Clause (3)(2)(B)(v)]

Capacities of Haveli and Panjnad Canals during Rabi.(In cusecs)

Months	**Haveli** (In cuses)	**Panjnad** (In cuses)	**Remarks**
November to March	2,750	1,500	Source-Anderson Committee Report

SINDH PUNJAB AGREEMENT

Table II(a)

(Reference Clause 4)

Primary i.e., prescriptive supplies of projected canals in the Punjab and Sindh under Priority II.

Period		Primary supplies		Punjab Indus Inundation canal on conversion to wier-control	Remarks
		Sindh	Punjab weir controlled canals		
April	16-30	904 (April-30)	452	(April 1-30) 1500	
May		4991	1111	5800	
June		28984	3530	11200	
July		82843	3859]	Full supply capac-	
August				ities not exceeding	
September	1-10	80191	3586]	20000 cusecs.	
	11-20	52000	3470	10400	
	21-30	37000	2213	7400	
October	1-15	22000	866	4400	
		5466(Oct.1-31)	352	(Oct.1-31) 2700	

SINDH PUNJAB AGREEMENT

Table II(b)

(Reference Clause 4)

Proportions for sharing water available under Priority II [Primary, i.e., prescriptive supplies for the Sindh and Punjab projected] when water is insufficient for the total requirements of Priority I-A, I-B and II (Time lag 10 days), before the Indus Inundation Canals are brought under weir control.

Month	Period (Punjab dates)	Proportions for Punjab	Proportions for Sindh	Remarks
April	16-20	.333	.667	
	21-30	.083	.917	
May	1-10	.182	.818	
	11-20	.182	.818	
	21-31	.037	.963	
June	1-10	.109	.891	
	11-20	.109	.891	
	21-30	.041	.959	
July	1-10	.045	.955	
	11-20	.045	.955	
	21-31	.046	.954	
August	1-10	.043	.957	
	11-20	.043	.957	
	21-31	.064	.936	
September	1-10	.086	.914	
	11-20	.091	.909	
	21-30	.137	.863	
October	1-5	.061	.939	

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Table II(c)

(Reference Clause 4)

Proportions for showing water available under Priority II (Primary supplies, i.e., prescriptive supplies for the projected canals in the Punjab and Sindh) when water is insufficient for the total requirements of Priorities I-A, I-B and II (with time lag of 10 days), after the Punjab Indus Inundation Canals have come under weir control.

Month	Period (Punjab dates)	Proportions for Punjab	Proportions for Sindh	Remarks
April	16-20	683	317	
	21-30	281	719	
May	1-10	581	419	
	11-20	581	419	
	21-31	193	807	
June	1-10	337	663	
	11-20	337	663	
	21-30	151	849	
July	1-10	224	776	
	11-20	224	776	
	21-31	229	771	
August	1-10	227	773	
	11-20	227	773	
	21-31	312	688	
September	1-10	273	727	
	11-20	304	696	
	21-20	491	509	
October	1-5	358	642	

NOTE: The ratios for July and August are calculated with an assumed capacity of 20,000 cusecs for the Punjab Indus Inundation Canals and would change if the capacity is revised.

SINDH PUNJAB AGREEMENT
Table II(d)
(Reference Clause 4)

Kharif allocations of the existing weir controlled Sindh Canals.

Month	Allocations(Cusecs)
April	27896
May	38660
June	44763
July	45763
August	45763
September	45763
October	32339

SINDH PUNJAB AGREEMENT
Table III(a)
(Reference Clause 5)

Total allocations for the Sindh and Punjab projected canals and for Khairpur Sailab areas under Priority III.

Period		Mean Monthly Allocations				Remarks
		Projected Sindh Barrage	Khairpur State & Middle Sindh Sailab areas*	Total for Sindh	Punjab	
April	16-30	13563		13563	2600	
May		34504		34504	20455	
June		65122	2000	67122	20455	
July		82843	2000	84843	19210	
August		80191	2000	82191	20455	
Sept.	1-10	80200	2000	82200	20455	
	11-20	60000	2000	62000	17605	
	21-30	40000	2000	42000	16655	
Oct.	1-15	24012	2000	26012	1200	

* In col: (3) 600 cusecs are provided for Khairpur State Sailab areas and 1400 cusecs for British Sindh Sailab areas between Sukkur and Kotri in Middle Sindh.

SINDH PUNJAB AGREEMENT

Table III(d)

[Reference Clause 5(4),6(3) & 10(c)]

Limits of transference of unused share for the Punjab projected canals under Priority III and under Priority IV.

Period dates		Under Priority III Unused share of Punjab projected canals limited to daily maximum figs. as under (Cusecs).	Under Priority IV Unused share for Punjab projected canals limited to mean monthly figs. as under (Cusecs).
April		452	18055
May		5000	6800
June		5000	11800
July		5000	19300
August		5000	19300
September	1-10	5000	18300
	11-20	5000	11800
	21-30	5000	6800
October		347	16655

SINDH PUNJAB AGREEMENT

Table III(b)

(Reference Clause 5)

Additional (or Secondary) allocations for the projected Sindh and Punjab Canals and for Khairpur and Middle Sindh Sailab areas under Priority III. (Assumed time lag 10 days).

PUNJAB			SINDH	
Punjab months	Punjab dates	Additional allocations or secondary supplies	Corresponding Sindh dates	Addl.allocations or secondary supplies.
April	6-15	2148 April	16-25	12659
	16-20	2148	26-30	12659
	21-30	2148 May	1-10	29513
May	1-10	19344	11-20	29513
	11-20	19344	21-31	29513
	21-31	19344 June	1-10	38138
June	1-10	16925	11-20	38138
	11-20	16925	21-30	38138
	21-30	16925 July	1-10	2000
July	1-10	15351	11-20	2000
	11=20	15351	21-31	2000
	21-31	15351 Aug.	1-10	2000
August	1-10	16869	11-20	2000
	11-20	16869	21-31	2000
	21-31	16869 Sept.	1-10	30200
September	1-10	16985	11-20	25000
	11-20	15392	21-31	20000
	21-30	15789 Oct.	1-10	20546
October	1-5	848	11-15	20546

SINDH PUNJAB AGREEMENT

Table III(c)

(Reference Clause 5)

Proportions for sharing water available for Priority III (secondary supplies i.e., total allocations less primary supplies) for the Sindh and Punjab during the periods of shortages (assumed time lag ten days).

Month	(Punjab dates)	Proportion for		Remarks
		Punjab	Sindh	
April	6-15	.145	855	**Source:** Derived
	16-20	.145	855	from Table III(b)
	21-30	.068	932	excluding 2000
May	1-10	.396	604	Cs. for Sailab ar-
	11-20	.396	604	eas for Khairpur
	21-31	.349	651	and Middle Sindh
June	1-10	.319	681	in June, July,
	11-20	.319	681	August, Septem-
	21-30	1.000	Zero	ber and October
July	1-10	1.000	Zero	from the figs. for
	11-20	1.000	Zero	additional allo-
	21-31	1.000	Zero	cations for the
August	1-10	1.000	Zero	Sindh projected
	11-20	1.000	Zero	canals.
	21-31	.374	626	
September	1-10	.425	575	
	11-20	.461	539	
	21-30	.460	540	
October	1-5	.044	956	

SINDH PUNJAB AGREEMENT

Table IV(a)

(Reference Clause 6)

Mean monthly withdrawals of further allocations under Priority IV to the Punjab existing canals and other subsequent allocations to the Punjab projected canals or variants (in thousands cusecs).

Months in Punjab		Punjab further allocations			Remarks
		Further allocations to existing canals.		Ex-Marhu Tunnel.	
		On Punjab	For Thal on Indus		
April		10.3	6.0	15.5	
May		6.4	5.0	1.8	
June		Zero	4.0	6.8	
July		Zero	4.0	14.3	
August		Zero	4.0	14.3	
September	1-10	Zero	4.0	13.3	
	11-20	Zero	4.0	9.7	
	21-30	Zero	4.0	5.6	
October	1-5	Zero	4.0	15.5	

SINDH PUNJAB AGREEMENT

Table V(a)

(Reference Clause 7)

Proportions for sharing balance supplies available under Priority V for the Punjab and Sindh.

Month	INDUS		FIVE TRIBUTARIES	
	Punjab at Ghazighat	Sindh at Gudu	Punjab at Punjnad	Sindh at Gudu
April	25	75	62	38
May	25	75	62	34
June	25	75	62	6
July	25	75	62	6
August	25	75	62	6
September	25	75	62	34

SINDH PUNJAB AGREEMENT

Table V(b)

(Reference Clause 7)

Allocations made to the Punjab to be deducted from measured discharges at Ghazighat-Panjnad before distribution of balance supplies available under Priority V between Sindh and Punjab.

Period (Punjab dates)		Mean Months allocations in thousand Cusecs. Inundation canals between Ghazighat and Mithankot.	Thal	Canals on the Five Punjab rivers including inundation canals	Punjab projected canals	Additional through the link or its accepted variant.equal to Punjab's unused share for the projected canals limited to the following.
April	1-15	0.7	10.0	51.8		
	16-30	1.0	10.0	51.8	2.6	15.5
May		2.9	10.0	70.8	20.5	1.8
June		6.5	10.0	83.8	20.5	6.8
July		7.9	10.0	90.5	19.2	14.3
August		7.5	10.0	91.8	20.5	14.3
Sept.	1-10	4.0	10.0	93.8	20.5	13.3
	11-20	4.0	10.0	93.8	17.6	9.7
	21-30	4.0	10.0	93.8	17.1	5.6

SINDH PUNJAB AGREEMENT

Table V(c)

(Reference Clause 7)

Allocations made to Sindh to be deducted from measured discharge at Ghazighat before distribution of balance supplies available for Priority V between Sindh and Punjab.

Period (Sindh dates).	Mean monthly allocations in cusecs.			
	Sukkur Barrage	Middle Sindh Inundation Canals	Sailab areas in Middle Sindh and Khairpur.	Upper and Lower Sindh Barrage.
April 16-30	27896	324		13563
May	38658	354		34504
June	44763	354	2000	56122
July	45763	4755	2000	82843
August	45763	4755	2000	80191
Sept. 1-10	45763	354	2000	80200
11-20	45763	354	2000	60000
21-30	45763	354	2000	40000
October 1-5	32339	350	2000	24012

From

E.L.Protheroe,Esquire, I.S.E.,
Secretary to Government, Punjab,
Public Works Department,Irrigation Branch.

To,

The Secretary to the Government of Sindh,
Finance Department,Karachi.

No.013 Cn. Dated Lahore, the 13th October,1945.

SINDH PUNJAB INDUS DISPUTE

Sir,

I am directed to acknowledge receipt of your letter No.1442-W. and S., dated 2nd October 1945, regarding the above and to say that the contents thereof have received the careful attention of the Punjab Government.

2. I AM TO CONFIRM THAT THE TENTATIVE AGREEMENT REACHED BY THE ENGINEER REPRESENTATIVES OF THE TWO GOVERNMENTS IN THEIR RECENT DISCUSSIONS AT KARACHI ARE ACCEPTABLE TO THE PUNJAB GOVERNMENT, PROVIDED IT IS ACCOMPANIED BY A SATISFACTORY SOLUTION OF THE FINANCIAL ISSUE.

3. Regarding the latter, it is noted that Sindh considers it would be a concession on their part to accept a limitation of the suggested Punjab contribution to the cost of the new Sindh Barrage to a minimum of three and a maximum of five crores. The Punjab also, after carefully considering this proposal, are of the opinion that such limitation is not desirable, and consequently this suggestion may be discarded.

4. The Punjab Government notes that the Sindh Government were prepared to accept the proposal of the Grant-

ment were prepared to accept the proposal of the Grant-Khosla Memorandum of February last for assessment of the Punjab contribution by an independent Committee and also to agree to the repayment clause. The Punjab Government is also prepared to entrust the assessment of this contribution, if it cannot be decided by agreement, to an independent committee. They consider, however, that the terms of reference sggested for the committee in the Grant-Khosla Memorandum are not quite suitable in that they impose on the committee the artificial standard that productivity shall be attained in a period of ten years. The Punjab Government consider that all components of the standard of productivity to be applied to the projects should be a matter for the committee itself to decide, and consequently the terms of reference should be framed in more general terms.

5. They also consider that the repayment clause of the Grant-Khosla Memorandum is not suitable in that it defines the profits of the projects as the difference between the return and an artificial productivity standard. A productivity standard usually contains provision for possible errors in estimating which is reasonable when applied to estimated figures. When however the profits are being calculated from actual revenue, working expenses and interest charges, there is no necessity for such a margin or for any artificial productivity standard. The actual profits should be taken i.e., the difference between net revenue and the interest charges.

6. The Punjab Government have not yet received the statement of data regarding the new projects which the Sindh Government have so kindly promised to supply. They doubt, however, whether the data at present available would be sufficient for the framing of an accurate estimate of the proposed contribution. In any case, they are assured that it is quite impossible for an adequate examination of the financial prospects of these large projects to be made within a period of less than six months. They consider,

therefore, that no useful purpose would be served by the suggested meeting of Ministers.

7. I am to say, however, that without prejudice to any claims that may be urged by the parties should the matter ultimately be referred to His Majesty's Government for decision, the Punjab Government is prepared to agree to a settlement of the financial issue of the dispute on the terms detailed in the enclosed memorandum. These terms provided time for consideration of the projects when ready, with a view to fixation of the contribution by Agreement, and failing this, arbitration by an independent committee on the lines of the Grant-Khosla Memorandum modified in accordance with the above. I am also to draw attention, in this connection, to the fact that, as a final concession to Sindh in the interests of a quick settlement of the case, the repayment clause in these terms has been modified to reduce the rate of repayment to half the profits in any year instead of the whole.

8. The Punjab Government trusts that the Government of Sindh will find these terms acceptable and thus enable both Governments to report a satisfactory settlement of this long outstanding dispute to the Governor-General.

I beg the honour to be,
Sir,

Your most obedient servant,

(Sd) E.L.PROTHEROE.
Secretary to Government, Punjab,
Public Works Department,Irrigation Branch.

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