ASSIGNMENT - 01

I2-5702
Section B

TOPIC

Indus Basin Irrigation System and it various Salient Features (Barrages, Headwork, Canals and Dams)

Irrigation and Drainage Engineering

LAB, Spring 2016

Contents

Irrigation means the artificial way of watering the crops. Pakistan is highly dependent on agriculture, which in turn is dependent on water. Of the79.6 million hectares of land that makeup Pakistan, 20 million are available for agricultural. Of those 20 million hectares, 16 million are dependent on irrigation. It is estimated that up to 90% of Pakistan's agriculture is dependent on irrigation. 67% of our land is irrigated due to little rainfall. The most important means of our irrigation is our system of canals. The progress of our country depends upon the means of irrigation and their progress. All parts except northern mountains depends upon irrigation. Our canals irrigate 70% of our lands while 14% is left for tube-wells, Persian wheels Karez and ponds.

Irrigation

Figure 1 Canals, The Major Source of Irrigation in Pakistan

Irrigation is the artificial application of water to the land or soil. It is used to assist in the growing of agricultural crops, maintenance of landscapes, and revegetation of disturbed soils in dry areas and during periods of inadequate rainfall. Additionally, irrigation also has a few other uses in crop production, which include protecting plants against frost, suppressing weed growth in grain field and preventing soil consolidation. Irrigation systems are also used for dust suppression, disposal of sewage, and in mining. Irrigation is often studied together with drainage, which is the natural or artificial removal of surface and sub-surface water from a given area.

Pakistan is Blessed with natural surface water and abundance of ground water as it is the part of one of world larges water resources, Indus basin.

History of Irrigation

Water is the most important input required for plant growth for agriculture production. Irrigation can be defined as replenishment of soil water storage in plant root zone through methods other than natural precipitation. Irrigations seen to have found its roots in the history of mankind since earliest beginning. It helps reduce the uncertainties, particularly the climatic uncertainties in agriculture practices. Archaeological investigation has identified evidence of irrigation where the natural rainfall was insufficient to support crops.

- Perennial irrigation was practiced in the Mesopotamian plain by coaxing water through a matrix of small channels formed in the field.
- Ancient Egyptians practiced Basin irrigation using the loading of the Nile to inundate land plots which had been surrounded by dykes.
- The Ancient Nubians developed a form of irrigation by using a waterwheel-like device called a sakia.

- In sub-Saharan Africa irrigation reached the Niger River region cultures and civilizations by the first or second millennium BCE and was based on wet season flooding and water harvesting.
- The Qantas, developed in ancient Persian about 800 BCE, are among the oldest known irrigation methods still in use today.
- The irrigation works of ancient Sri Lanka, the earliest dating from about 300 BCE, in the reign of King Pandukabhaya and under continuous development for the next thousand years, were one of the most complex irrigation systems of the ancient world.

Figure 2 Furrow Irrigation in Sahiwal District

- In the Szechwan region belonging to the State of Qin of ancient China, the Dujiangyan Irrigation System was built in 256 BCE to irrigate an enormous area of farmland that today still supplies water.
- The floodplain of the Santa Cruz River was extensively farmed during the Early Agricultural period, circa 1200 BC to AD 150.
- Terrace irrigations evidenced in pre-Columbian America, early Syria, India and China.

Indus Basin Irrigation System

Pakistan, a country of enchanting landscapes offers a combination of beaches, mountains, beautiful deserts and valleys. Its vast farm lands are sustained by the Indus Basin Irrigation System (IBIS), the largest contiguous irrigation system in the world. The IBIS irrigates 45 million acres of farm land which produces wheat, rice, fruits, vegetables, sugarcane, maize and cotton in abundance for local use as well as for export. This report provides the historical context in which the IBIS was developed. It discusses the economic impact of the IBIS on Pakistan, and provides recommendations for some current problems related to insufficient drainage and inefficient farming practices.

Figure 3 Drip Irrigation in Faisalabad Region

Historical Background

The Indus Valley Civilization was a Bronze Age civilization (3300-1300 BC) that was located in the northwestern region of the Indian subcontinent, consisting of what is now mainly

modern-day Pakistan and northwest India. Flourishing around the Indus River basin, the civilization primarily centered along the Indus and the Punjab region, extending into the Ghaggar-Hakra River valley and the Ganges-Yamuna Doab. Geographically, the civilization was spread over an area of some 1,260,000 km², making it the largest ancient civilization in the world

The Indus Valley has been the host to one of the most ancient civilization of human history, the Indus Valley Civilization. After the extinction of the Indus Civilization, new settlements especially in doabs grew slowly. New irrigation systems started to evolve. Inundation canals and small dams were constructed and population grew all around this area. In order to reduce the occurrence of low irrigation water supply the British authorities, towards the middle of the last century, started modernizing and expanding the irrigation system of the Indus Basin.

Treaty Between Pakistan and India

In 1947, the Indian sub-continent was partitioned by the British into two independent states – Pakistan and India. After the partition a commission was set up to resolve any issue that may emerge as a consequence of the partition. The matter of utilization of water resources of Indus Basin was raised by Pakistan. The boundary commission, chaired by Sir Cyril Radcliff, awarded control barrages (situated very close to the border) to India, while 90 percent of irrigated land lay in Pakistan. After a protracted negotiation of ten years through facilitation of the World Bank, the Indus Basin Treaty was signed by India and Pakistan in 1960 for distribution of water resources in the Indus Basin. According to the terms of the treaty India was given the exclusive use of the waters of the eastern rivers namely Ravi, Sutlej and Beas. Pakistan was not given its full historic share and was allocated only 75 percent of its legitimate share of the waters in Indus Basin. Consequently, Pakistan agreed to embark upon a gigantic project nicknamed as “Indus Basin Replacement Works”. The extensive undertaking involved the construction of two major dams, five barrages and eight link canals.

Figure 4 Flooded Irrigation for Cotton Crop

Pakistan and Indus Basin Water Treaty

Pakistan’s economy is largely based on its agricultural produce. Water is therefore a critical resource for its sustained economic development. In order to fully utilize the river water resources, the IBIS has emerged as the largest contiguous irrigation system in the world. The IBIS comprises of three large dams, eighty-five small dams, nineteen barrages, twelve inter-river link canals, forty-five canal commands and 0.7 million tube wells in monetary terms, this network is the biggest infrastructure enterprise of Pakistan accounting for approximately US$ 300 billion of investment.

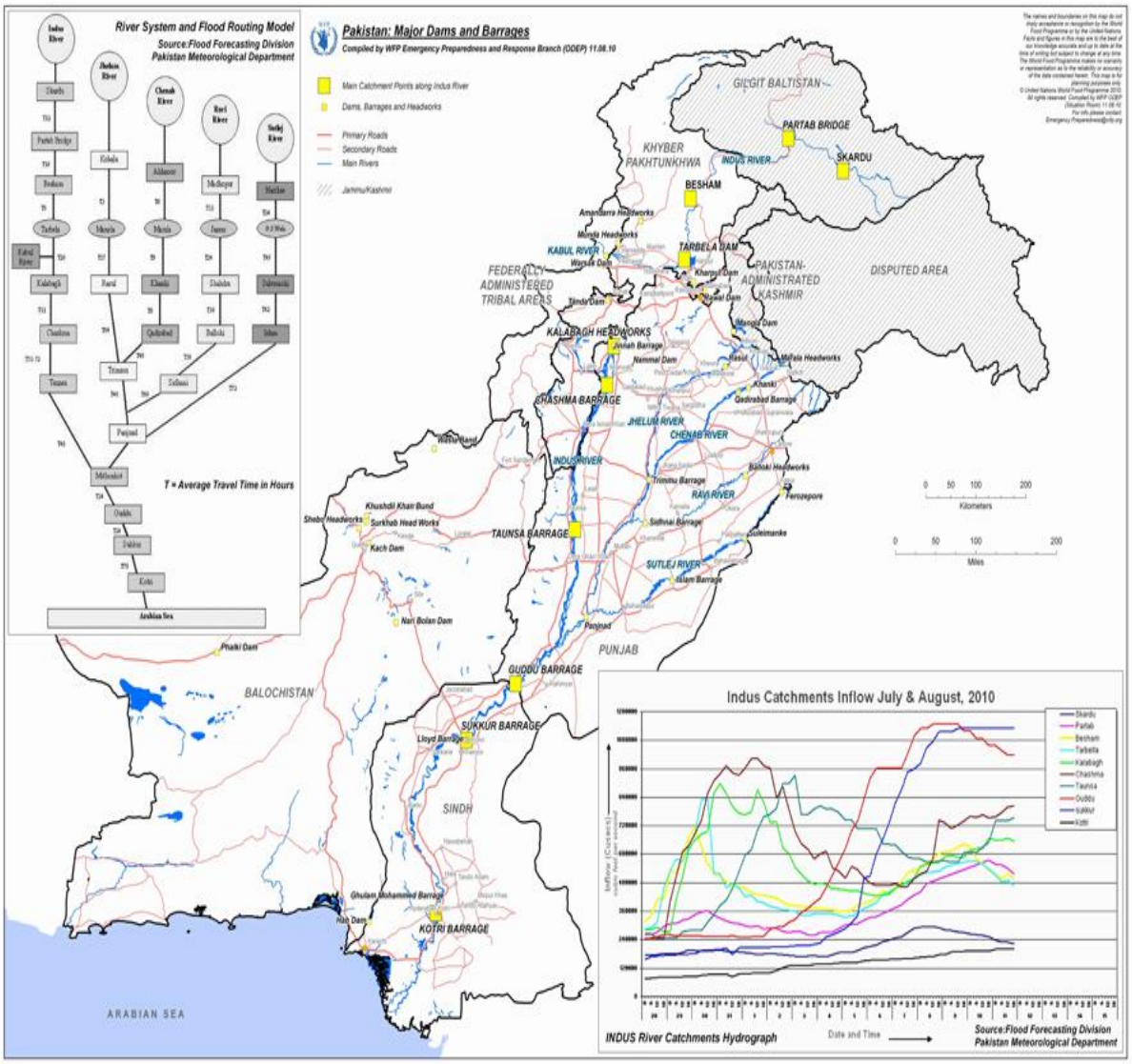

Figure 5 Extensive Irrigation System of Pakistan

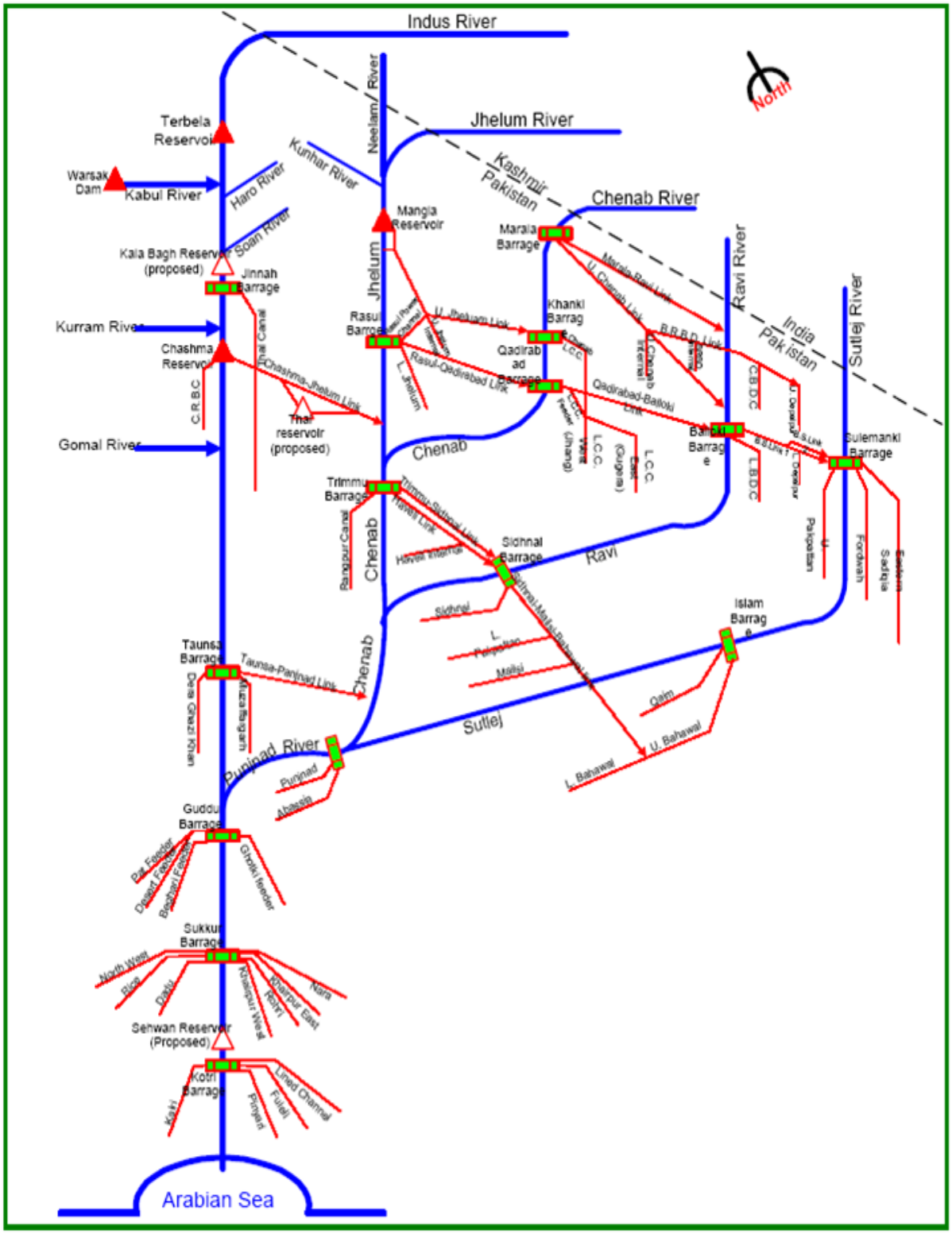

Figure 6 Irrigation Network IBIS

Pakistan Irrigation System

Historical Background

→ Controlled year round irrigation began in 1859 with the completion of the Upper Bari Doab Canal (UBDC) from Madhopur Headworks on Ravi River (now in India) .

→ UBDC was followed by Sirhind Canal from Rupar Headworks on Sutlej in 1872 (also in India).

→ Sidhnai Canal from Sidhnai Barrage on Ravi in 1886.

→ The Lower Chenab from Khanki on Chenab in 1892, and Lower Jhelum from Rasul on Jhelum in 1901 was constructed

→ Lower and Upper Swat, Kabul River and Paharpur Canals in KPK (NWFP) were completed between 1885 to 1914.

→ Ravi River, serving a large area of Bari Doab, was deficient in supply while Jhelum had a surplus.

→ An innovative solution was developed in the form of the Triple Canal Project, constructed during 1907 -1915.

→ The project linked the Jhelum, Chenab, and Ravi rivers, allowing a transfer of surplus Jhelum and Chenab water to the Ravi.

→ The Triple Canal Project as a land-mark in integrated inter basin water resources management and also provided the key concept for the resolution of the Indus Waters Dispute between India and Pakistan in 1960.

→ The Sutlej Valley Project, comprising of 4 barrages and 2 canals, was completed in 1933, resulting in the development of the unregulated flow resources of the Sutlej River and motivated planning for the Bhakra reservoir (now in India).

→ During the same period, the Sukkur Barrage and its system of 7 canals serving 2.95 million hectares of land in Lower Indus were completed.

→ Haveli and Rangpur from Trimmu Headwork on Chenab in 1939 and Thal Canal from Kalabagh Headwork on Indus were completed in 1947.

→ This comprised the system inherited by Pakistan at the time of its creation in 1947.

→ At independence (1947) the irrigation system, conceived originally as a whole, was divided between India and Pakistan without regard to irrigated boundaries

→ This resulted in the creation of an international water dispute in 1948, which was finally resolved by the enforcement of Indus Waters Treaty in 1960 with the help of the World Bank

→ The treaty assigned three eastern rivers (Ravi, Beas, Sutlej) to India, and the three western rivers (Indus, Jhelum, Chenab) to Pakistan

→ An agreement to share waters of the Indus River was reached among the four provinces of Pakistan in the form of the Water Apportionment Accord (WAA).

→ This accord is based on both, the existing and future water needs of the four provinces.

→ It has the following Purposes:

- It protected the existing uses of canal water in each province.
- It apportions the balance of river supplies, including flood surpluses and future storages among the provinces

→ The KPK (NWFP)/ Baluchistan projects, under execution, were provided their authorized quota of water as existing uses.

→ Balance river supplies (including flood supplies and future storages) was to be distributed as below:

→ The need for storages, wherever feasible on the Indus and other rivers was admitted and recognized by the participants for planned future agricultural development.

Punjab	Sindh	Baluchistan	NWFP	Total
37	37	12	14	100 %

Major issues and Recommendations

Farmers in Pakistan receive their share of irrigation waters on a rotational basis. To protect the right of share of their water, the farmers are using more than the optimum quantity of water required for healthy crops. Lack of modern irrigation techniques and agricultural practices further add to the wastage of irrigation water. Some solutions outlined below can potentially serve to address this issue:

1. Increase plantation of fruit trees.
2. Expand forested areas.
3. All existing dams small and large should be used for fish breeding and harvesting.
4. Develop agricultural based industries and timber factories in the rural areas to provide employment to small farmers and increase the percentage of value added goods for export.
5. Group small farms into larger units for cooperative farming using the latest irrigation and farming techniques and modern agricultural practices.
6. Increase the production of beans, lentils and edible oil seeds to reduce their imports.
7. Develop pastures for cattle farming and increase milk and meat production.

8. Big land holdings more than five thousand acres of area should be made available for cooperative farming.
9. The level and standard of research should be enhanced in the existing agricultural universities of Pakistan.

Salient Features of Indus Basin Irrigation system

It is world's largest and unified irrigation system that consists of three major reservoirs (Chashma, Mangla, and Tarbela); **18 barrages** (Ferozepur, Sulemanki, Islam, Balloki, Marala,Trimmu, Panjnad, Kalabagh, Sukkur, Kotri, Taunsa, Guddu, Chashma, Mailsi, Sidhnai, Rasul, Qadirabad, and Marala); **12 link canals**; **45 irrigation canals**; and over **107,000 water courses** and millions of farm channels and field ditches. The total length of main canal system is estimated about 585000 Kilometer (36932 miles) and that of watercourses &field channels exceeds 1.62million Kilometers (over 1.02 million miles). Catchment area of Indus is most unique in the sense that it contains seven (7) of the world's highest peaks after Mount Everest. Among these include the K2 (28,253 ft), Nanga Parbat (26,600 ft), Rakaposhi (25,552 ft) etc. Further to above, seven (7) glaciers situated in the Indus catchment are among the largest in the world, namely, Siachin, Hispar, Biafo, Baltura, Baltoro, Barpu and Hopper.

Barrage

A barrage is a type of low-head, diversion dam which consists of a number of large gates that can be opened or closed to control the amount of water passing through the structure, and thus regulate and stabilize river water elevation upstream for use in irrigation and other systems. The gates are set between flanking piers which are responsible for supporting the water load of the pool created.

Barrages and Headwork of Pakistan

There are following barrages that are built across the rivers of Pakistan: -

1. Chashma Barrage
2. Islam Barrage
3. Jinnah Barrage
4. Ghazi Barrage
5. Taunsa Barrage
6. Guddu Barrage
7. Sukkhar Barrage
8. Kotri Barrage (Ghulam Muhammad Barrage)
9. Marrala Barrage
10. Qadriabad Barrage
11. Trimmu Barrage
12. Punjnand Barrage
13. Rasul Barrage
14. Sulaimanki Barrage
15. Balloki Barrage

Figure 7 Flowing Canal During Rabi Crop Season

16. Sidhnai Barrage
17. Mailsi Barrage
18. Khanki Headwork

Chashma Barrage

Chashma Barrage is built across the Indus River in Mianwali district of Punjab province of Pakistan it is 304 KM NW of Lahore and 56 KM Downstream of the Jinnah Barrage. It is used for irrigation, flood control and power generation (The installed capacity of power Station is 184 MW, from eight Kaplan-type bulb turbine units each with a 23 MW capacity).

Salient Features of Chashma Barrage:

Year Of Completion	1971
Location	River Indus, South-west of Punjab
Design Discharge	1,176,000 Cusecs
Length	3,356 ft.
No Of Bays	52
No Of Under Sluices	11
Crest Level	37 ft.
No Off Taking Canals	2

Figure 8 Chashma barrage

Islam Barrage

Salient Features:

Year Of Completion	1927
Location	River Sutlej
Design Discharge	300,000 Cusecs
Length	1,650 ft.
No Of Bays	29
No Of Under Sluices	4
Crest Level	435.5 S.P.D
No Off Taking Canals	2

Figure 9 Islam barrage

Jinnah Barrage

Salient Features:

Year Of Completion	1946
Location	River Indus, North west District of Punjab
Design Discharge	950,000 Cusecs
Length	3,360 ft.
No Of Bays	42
Crest Level	28 ft.
No Off Taking Canals	1

Figure 10 Jinnah Barrage

Ghazi Barotha Barrage

Salient Features:

Year Of Completion	2004
Location	River Indus
Design Discharge	500,000 Cusecs
Length	170,560 ft.
No Of Under Sluices	
Crest Level	226 ft.
No Off Taking Canals	1

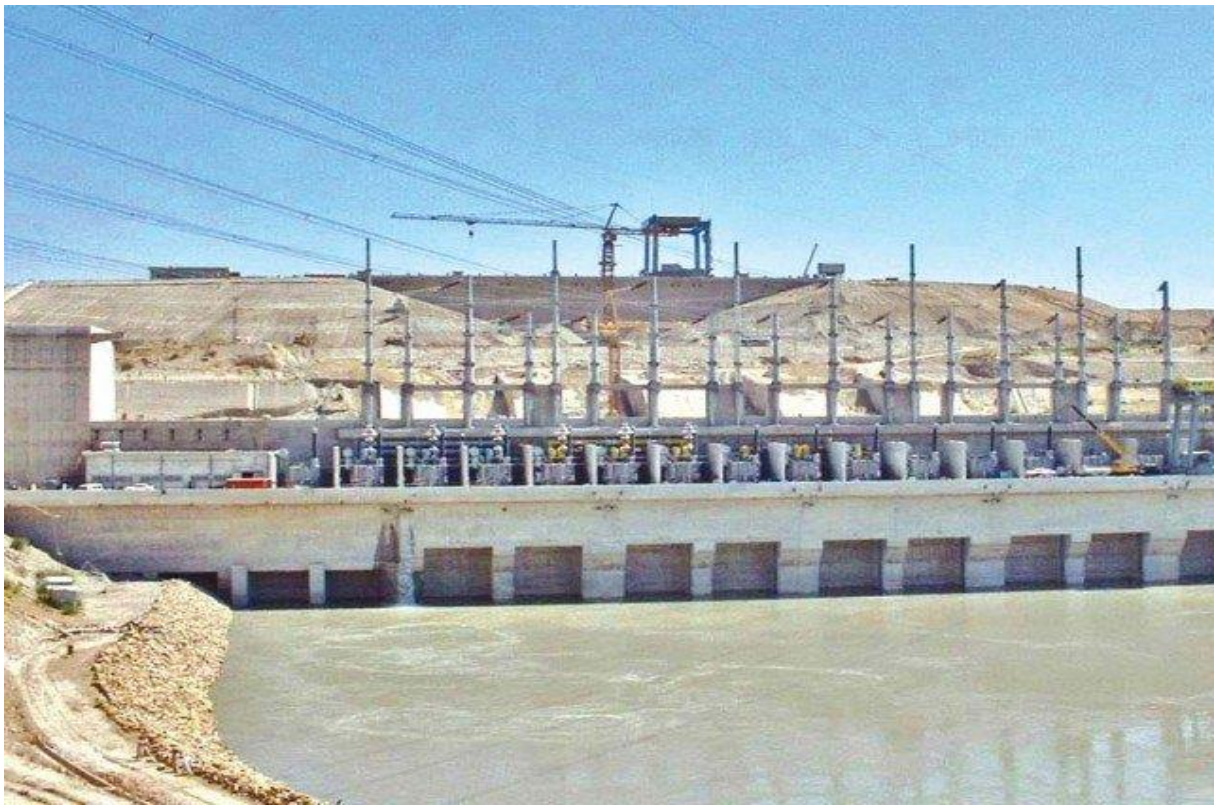

Figure 11 Ghazi Bharotha barrage

Taunsa Barrage:

Salient Features:

Year Of Completion	1958
Location	River Indus 20 Km of South –East of Taunsa City
Design Discharge	750,000-1,000,000 Cusecs
Length	4436 ft.
No Of Bays	53
No Of Under Sluices	12
Crest Level	-
No Off Taking Canals	4

Figure 12 Taunsa barrage

Guddu Barrage

Salient Features:

Year Of Completion	1962
Location	River Indus, Near Kashmore
Design Discharge	12,00,000 Cusecs
Length	3,840 ft.
No Of Bays	64
No Of Under Sluices	
Crest Level	26 ft.
No Off Taking Canals	5

Figure 13 Guddu barrage

Sukkhar Barrage:

Salient Features:

Year Of Completion	1932
Location	River Indus, Near Sukkur City
Design Discharge	1,500,000 Cusecs
Length	4,490 ft.
No Of Bays	54
No Of Under Sluices	12
Crest Level	177 ft.
No Off Taking Canals	7

Figure 14 Sukkhur Barrage

Kotri Barrage (Ghulam Muhammad Barrage)

Salient Features:

Year Of Completion	1955
Location	South-west of Karachi near Hyderabad
Design Discharge	750,000 Cusecs
Length	3,000 ft.
No Of Bays	44
No Of Under Sluices	
Crest Level	48 S.P.D
No Off Taking Canals	4

Figure 15 Kotri Barrage

Marrala Headwork

Salient Features:

Year Of Completion	1968
Location	River Chenab, Near Sialkot City
Design Discharge	1,100,000 Cusecs
Length	4,472 ft.
No Of Bays	66
No Of Under Sluices	13
Crest Level	800 S.P.D
No Off Taking Canals	2

Qadriabad Barrage

Salient Features:

Year Of Completion	1967
Location	River Chenab, Phalia Tehsil of Mandi Bahaudin
Design Discharge	900,000 Cusecs
Length	3,373 ft.
No Of Bays	50
No Of Under Sluices	5
Crest Level	684.5 S.P.D
No Off Taking Canals	1

Figure 16 Qadirabad Barrage

Trimmu Barrage

Salient Features:

Year Of Completion	1939
Location	River Chenab
Design Discharge	645,000 Cusecs
Length	3,025 ft.
No Of Bays	47
No Of Under Sluices	11
Crest Level	477.5-472 S.P.D
No Off Taking Canals	3

Figure 17 Trimmu Barrage

Punjnand Barrage

Salient Features:

Year Of Completion	1929
Location	River Chenab
Design Discharge	700,000 Cusecs
Length	2,856 ft.
No Of Bays	47
No Of Under Sluices	-
Crest Level	325 S.P.D
No Off Taking Canals	2

Figure 18 Panjnand Barrage

Rasul Barrage

Salient Features:

Year Of Completion	1968
Location	River Jhelum,72 km from Mangla Dam
Design Discharge	876,000 Cusecs
Length	3,209 ft.
No Of Bays	42
No Of Under Sluices	6
Crest Level	703 S.P.D
No Off Taking Canals	2

Figure 19 Rasul Barrage

Sulaimanki Barrage

Salient Features:

Year Of Completion	1927
Location	River Sutlej
Design Discharge	309,000 Cusecs
Length	2,220 ft.
No Of Bays	24
No Of Under Sluices	16
Crest Level	560 S.P.D
No Off Taking Canals	3

Figure 20 Sulaimanki Barrage

Balloki Barrage

Salient Features:

Year Of Completion	1914
Location	River Ravi
Design Discharge	140,000 Cusecs
Length	1,644 ft.
No Of Bays	35
No Of Under Sluices	-
Crest Level	625 S.P.D
No Off Taking Canals	2

Figure 21 Balloki Barrage

Sidhnai Barrage

Salient Features:

Year Of Completion	1965
Location	River Ravi
Design Discharge	167,000 Cusecs
Length	712 ft.
No Of Bays	15
No Of Under Sluices	4
Crest Level	454 S.P.D
No Off Taking Canals	2

Figure 22 Sindhnai barrage

Mailsi Barrage

Salient Features:

Year Of Completion	1965
Location	River Sutlej
Design Discharge	429,000 Cusecs
Length	1,601 ft.
No Of Bays	24
No Of Under Sluices	-
Crest Level	415.5 S.P.D
No Off Taking Canals	-

Figure 23 Mailsi Barrage

Khanki Headwork

Salient Features:

Year Of Completion	1889
Location	River Chenab, Gujrat Districts
Design Discharge	750,000 Cusecs
Length	4,000 ft.
No Of Bays	48
No Of Under Sluices	56
Crest Level	727 S.P.D
No Off Taking Canals	1

Figure 24 Khanki barrage

Canals

Balloki Barrage:

Balloki-Sulaimanki Link Canal

Location	**Bhai phero, Near Lahore**
Design Discharge	**6,500 Cusecs**
Length of canal	**39 miles**
Area Irrigated	**-**
Culturable Command Area	**-**

Lower Bari Doab Canal

Location	**Multan**
Design Discharge	**1000-9292 Cusecs**
Length of canal	**132.14 miles**
Area Irrigated	**2130937 acres**
Culturable Command Area	**1845974 acres**

Upper Chenab Canal

Location	**Lahore**
Design Discharge	**16850-11373 Cusecs**
Length of canal	**26.659 miles**
Area Irrigated	**19600 acres**
Culturable Command Area	**12449 acres**

Marrala Ravi Link Canal

Location	**Lahore**
Design Discharge	**22000-20000 Cusecs**
Length of canal	**63.463 miles**
Area Irrigated	**165598 acres**
Culturable Command Area	**154987 acres**

BRBD Link Canal (Bambawala-Ravi-Bedian-Dipalpur Canal)

Location	**Lahore**
Design Discharge	**7260-2380 Cusecs**
Length of canal	**107.40 miles**
Area Irrigated	**-**
Culturable Command Area	**-**

Khanki Headwork:

Lower Chenab Canal

Location	**Faisalabad**
Design Discharge	**8143 Cusecs**
Length of canal	**40.058 miles**
Area Irrigated	**3700000 acres**
Culture Able Command Area	**3400000 acres**

Qadriabad Barrage:

Qadriabad-Balloki Link Canal

Location	**Hafizabad**
Design Discharge	**18,600 Cusecs**
Length of canal	**79.483 miles**
Area Irrigated	**-**
Culturable Command Area	**-**

Trimmu Barrage:

Trimmu Sidhnai Link Canal:

Location	**Sidhnai, Multan**
Design Discharge	**12500-10000 Cusecs**
Length of canal	**44 miles**
Area Irrigated	**-**
Cultivable Command Area	**-**

Punjnand Barrage:

Punjnand Canal:

Location	**Bahawalpur**
Design Discharge	**10484-4274 Cusecs**
Length of canal	**38 miles**
Area Irrigated	**1293941 acres**
Culturable Command Area	**1186537 acres**

Abbasia Canal:

Location	**Bahawalpur**
Design Discharge	**1394-587 Cusecs**
Length of canal	**44.915 miles**
Area Irrigated	**117663 acres**
Culturable Command Area	**111333 acres**

Sulaimanki Barrage:

Pakpatan Canal

Location	**Multan**
Design Discharge	**5508-24 Cusecs**
Length of canal	**113.47 miles**
Area Irrigated	**1046326 acres**
Culturable Command Area	**961158 acres**

Eastern Sadqiya Canal:

Location	**Multan**
Design Discharge	**6820-5106 Cusecs**
Length of canal	**49 miles**
Area Irrigated	**616035 acres**
Culturable Command Area	**547472 acres**

Fordwah Canal:

Location	**Multan**
Design Discharge	**3447-2993 Cusecs**
Length of canal	**8.97 miles**
Area Irrigated	**465024 acres**
Culturable Command Area	**430112 acres**

Islam Barrage:

Qasim Canal:

Location	**Multan**
Design Discharge	**483-61 Cusecs**
Length of canal	**7.43 miles**
Area Irrigated	**55804 acres**
Culturable Command Area	**52797 acres**

Bahawal Canal:

Location	**Multan**
Design Discharge	**500-386 Cusecs**
Length of canal	**2.4 miles**
Area Irrigated	**57469 acres**
Culturable Command Area	**52023 acres**

Mailsi Siphon:

Sidhnai-Mailsi Bahawal Link Canal:

Location	**Bahawalpur**
Design Discharge	**5338-5123 Cusecs**
Length of canal	**30.40 miles**
Area Irrigated	**1229174 acres**
Culturable Command Area	**1048805 acres**

Rasool Qadirabad Link Canal:

Location	**Rasool**
Design Discharge	**19,000 Cusecs**
Length of canal	**30 miles**
Area Irrigated	**-**
Culturable Command Area	**-**

Lower Jhelum Canal:

Location	**Rasool**
Design Discharge	**5500-3705 Cusecs**
Length of canal	**39.366 miles**
Area Irrigated	**1728349 acres**
Culturable Command Area	**1485776 acres**

Jinnah Barrage:

Thal Canal Main Line Lower:

Location	**Bhakkar**
Design Discharge	**4100 Cusecs**
Length of canal	**100.50 miles**
Area Irrigated	**3534 acres**
Culturable Command Area	**2966 acres**

Thal Canal Main Line Upper:

Location	**Kalabagh**
Design Discharge	**9000 Cusecs**
Length of canal	**100.50 miles**
Area Irrigated	**2460861 acres**
Culturable Command Area	**2115931 acres**

Chashma Barrage:

Chashma Right Bank Canal (CRBC):

Location	**Damaan**
Design Discharge	**2500 Cusecs**
Length of canal	**71 miles**
Area Irrigated	**261000 acres**
Culturable Command Area	**240000 acres**

Chashma Jhelum Link Canal:

Location	**Punjab**
Design Discharge	**21,700 Cusecs**
Length of canal	**63 miles**
Area Irrigated	**-**
Culturable Command Area	**-**

Taunsa Barrage:

Dera Ghazi Khan Link Canal:

Location	**D.G Khan**
Design Discharge	**8900-5514 Cusecs**
Length of canal	**69.046 miles**
Area Irrigated	**947874 acres**
Culturable Command Area	**901984 acres**

Taunsa Punjnad Canal:

Location	**D.G Khan (Lashari)**
Design Discharge	**1200 Cusecs**
Length of canal	**38.20 miles**
Area Irrigated	**2150000 acres**
Culturable Command Area	**2000000 acres**

Muzaffargarh Link Canal:

Location	**Muzaffargarh Zone**
Design Discharge	**8901-2776 Cusecs**
Length of canal	**74.14 miles**
Area Irrigated	**906490 acres**
Culturable Command Area	**838380 acres**

Guddu Barrage:

Desert Feeder:

Location	**Sindh**
Design Discharge	**419 Cumecs**
Length of canal	**-**
Area Irrigated	**185000 acres**
Culturable Command Area	**-**

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