



# THE DEVELOPMENT AND SOCIAL IMPACTS OF PAKISTAN'S NEW KHANKI BARRAGE

## A PROJECT BENEFIT CASE STUDY

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NOVEMBER 2021

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About the cover: **Bird’s eye view**. The completed New Khanki Barrage and Headworks of the Lower Chenab Canal (photo by the Project Management Office Barrages, Punjab Irrigation Department).

Cover design by Joe Mark Ganaban.

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# ABBREVIATIONS

ADB	Asian Development Bank
BHU	basic health unit
GDP	gross domestic product
IBIS	Indus Basin Irrigation System
LCC	Lower Chenab Canal
O&M	operation and maintenance
PID	Punjab Irrigation Department
PIPD	Punjab Irrigation and Power Department
PMO	project management office
SCADA	supervisory control and data acquisition
TEVTA	Technical Education and Vocational Training Authority

## WEIGHTS AND MEASURES

ha	hectare
km	kilometer
m <sup>3</sup>	cubic meter
m <sup>3</sup> /s	cubic meter(s) per second

## CURRENCY EQUIVALENTS

(as of 22 September 2021)

Currency unit	–	Pakistan rupee/s (PRe/PRs)
PRe1.00	=	\$0.00594
\$1.00	=	PRs 168.46

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# EXECUTIVE SUMMARY

The impressive New Khanki Barrage in Punjab Province, Pakistan, was completed in 2017. The barrage, which was financed by the Government of Punjab and the Asian Development Bank (ADB), is more than a kilometer (km) wide with an innovative design. The new barrage has brought widespread benefits to the community, including increased agricultural output and income of over half a million farming families and far-reaching social and economic benefits, particularly for women and girls, through new health, education, recreation, and other community infrastructure.

**Background.** Pakistan is one of the world's most arid countries and yet it has a largely agricultural economy. The vast Indus River system contributes 80% of Pakistan's agricultural production and 66% of its agricultural gross domestic product. Punjab's irrigation system is controlled by 13 barrages and a vast network of canals that serve a cultivable area of 8.4 million hectares (ha). Much of the irrigation infrastructure is old, overutilized, and poorly maintained. The New Khanki Barrage replaced the Khanki Headworks, one of the oldest barrages in Pakistan. The old barrage was no longer able to safely regulate the river during strong floods, thus risking serious loss of life and property in the event of a major flood. The replacement is among the latest government efforts to implement its long-term investment plan of rehabilitating and improving Punjab's irrigation infrastructure. To date, international partners have financed 12 major irrigation infrastructure projects in the province. ADB, a major partner in supporting the province's agriculture sector, has financed nine of the projects.

**Innovative design.** The design of the new barrage was guided by climate projections for Pakistan. These include the likelihood of frequent recurrences of extreme weather events, increasingly erratic monsoon rains, glacial melting, and consequent periodic and intense floods and droughts. The design considered the assessment of disaster risks should the barrage fail. The new barrage has multiple operating mechanisms, including electronically controlled gates and a hoisting arrangement controlled by a centralized operation room equipped with a supervisory control and data acquisition (SCADA) system.

**Socioeconomic benefits.** The New Khanki Barrage achieved its objectives of providing (i) increased and sustained agricultural production and income, and (ii) increased resilience against damage from future natural disasters. The impact of improved agriculture production and farm income in the Lower Chenab Canal command area was measured by two target indicators. The first was a 10% increase in cropping intensity over the 2011 baseline by 2020. The overall irrigated area under crops growing in the project districts increased from 3.32 million ha in 2011 to 3.56 million ha by 2016, a gain of more than 7%, which was likely to reach the target of 10% by 2020. The second target was a 10% increase in average farm income of 25,000 farming families in the same period. The income of an average holding had already increased well beyond this target with a 15.4% gain by 2016. About 568,000 farming families benefited directly from the reliable irrigation water supply generated by the project.



**Extensive social uplift activities.** The large population in the vicinity of the new barrage, particularly women and girls, gained widespread social and economic benefits in education, health care, transport, recreation, and income generation. The project built a public road bridge, a girls' high school, a health-care facility, and a large recreation park in Khanki Village. The new 1.34 km bridge over the barrage greatly increased connectivity between residents and businesses by decreasing travel across the river from the previous distance of 30 km, to just 1.34 km. Consequently, the profitability of existing enterprises increased and many new business opportunities opened up.

Women have benefited from the improved business environment through extra household income and reduced expenses. Students have saved time and fare when traveling to schools, colleges, and post-secondary educational institutions. Furthermore, surveillance cameras and lighting on the bridge and the rehabilitated 30 km of access roads allowed students, especially the girls, to travel more safely.

The school existing prior to the project provided education only up to matriculation (year 10). The majority of girls in the area come from marginalized poor families with little prospect of being able to continue education after middle school, especially without a nearby high school for girls. The project built a new girls' high school, which was handed over to the Department of Education. The girls' high school education boosted the confidence and self-esteem of those now able to attend, and made a difference in their lives and future.

The project also built a much-needed basic health unit. The unit is currently headed by a female community health worker and especially benefits pregnant women and mothers, who can now avail of regular prenatal checkups and receive supplements without having to travel to health-care facilities elsewhere.










Families from villages and towns in the district and beyond now enjoy a 6 ha landscaped park near the barrage. The park has many attractions, such as a play area, fountains, food stalls, jogging area, and gym facilities with a separate area for women. It also has a new mosque with a separate prayer area for women. The park has become a local tourist attraction and a venue for festivals.

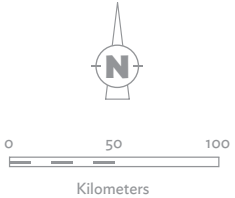
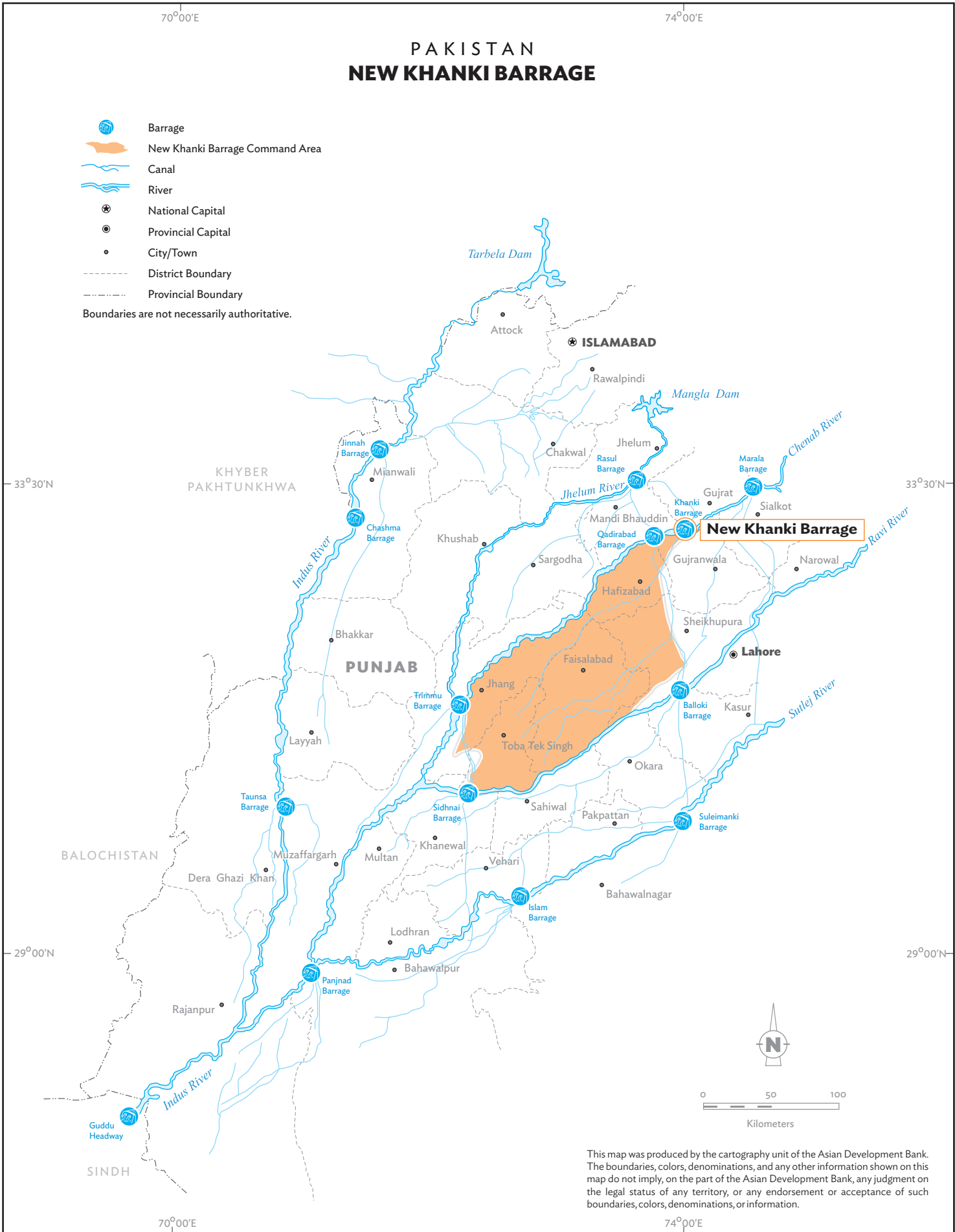
**Capacity building.** The New Khanki Barrage is an example of good design, planning, execution, and coordination between stakeholders—comprising ADB, the government, executing and implementing agencies, consultants, and contractors. The implementing teams on the ground worked closely together, enabling rapid decision making by the executing agencies and approval from the government and ADB. Projects such as the New Khanki Barrage that have proven to be successful can serve as models to guide development partners in designing future irrigation projects. The executing agency for the construction was the Punjab Irrigation Department, working through its experienced Project Management Office Barrages, whose staff capacity ADB further improved to fulfill ADB's development project requirements. After competitive international bidding, a single contract for the construction was awarded to a national engineering firm, thereby enhancing the pool of engineering skills in the country. The expertise of many local subcontractors was also upgraded through their participation in the work.

**Challenges.** Remaining challenges include (i) ensuring adequate financing and the continued operation and maintenance of the system; and (ii) addressing possible climate change impacts, particularly the worsening floods and droughts. Increasing competition among water users, pollution, and land degradation will require a holistic approach to water governance, encompassing technological, institutional, and policy options, including flood and land-use policies. Future irrigation projects will also need to be informed by solutions to water-related problems in several sectors, particularly agriculture. To make infrastructure investments more inclusive, complementary investments in areas such as education, finance, and health will need to be promoted, and are in line with ADB's multisector approach to ensure that interventions systematically address the key multidimensional features of food security.

# PROJECT MAP

## PAKISTAN NEW KHANKI BARRAGE

-  Barrage
  -  New Khanki Barrage Command Area
  -  Canal
  -  River
  -  National Capital
  -  Provincial Capital
  -  City/Town
  -  District Boundary
  -  Provincial Boundary
- Boundaries are not necessarily authoritative.



This map was produced by the cartography unit of the Asian Development Bank. The boundaries, colors, denominations, and any other information shown on this map do not imply, on the part of the Asian Development Bank, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries, colors, denominations, or information.

# BACKGROUND

## IRRIGATED AGRICULTURE IN PUNJAB, PAKISTAN

Pakistan is one of the world's most arid countries. It relies heavily on an average annual inflow of about 180 billion cubic meters (m<sup>3</sup>) of water to the Indus River System. The system includes the Indus River, a major transboundary river in Asia, and its five tributaries in Punjab—the Beas, Chenab, Jhelum, Ravi, and Sutlej rivers, which are also transboundary rivers. The river flows are largely fed by melting glaciers and snow from the Hindukush–Karakoram–Himalaya mountains coupled with summer monsoon rainfalls.

Pakistan's irrigation system is the largest contiguous such system in the world and the fourth largest in area. The system supplies water to more than three-fourths of the country's total cultivable land, transforming largely arid and semiarid ecological zones into fertile areas of production.

The Indus Basin Irrigation System (IBIS) is the foundation of Pakistan's agricultural economy. IBIS is a feat of civil engineering which began before Pakistan's independence in 1947. It continues to be operated and maintained by the Water and Power Development Authority and provincial irrigation departments since Pakistan's independence.

The original design of this extensive gravity-based irrigation system, which is supported by hydraulic infrastructure, was based on the need to develop new lands in the sparsely populated Punjab during the second half of the 19th century. The aim was to raise revenue from the sale of crown lands, settle nomadic tribes, and decrease the occurrence of chronic famines. During the British colonial period, nine barrages—of which eight are still operational—and the main canals were built on various parts of the Indus and the other five major rivers in Punjab.

Following independence, new dams, barrages, headworks, and canals were added to IBIS, which is now among the world's largest and most complex irrigation systems. International financial institutions provided technical and financial support for the development of IBIS after the Indus Waters Treaty between India and Pakistan was signed in 1960, giving Pakistan rights to the waters of the Chenab, Indus, and Jhelum rivers.

IBIS serves about 14 million hectares (ha) of Pakistan's total irrigated cropland of 17 million ha. At present, the Indus Basin in Pakistan has 2 main dams (Mangla and Tarbela), 19 barrages, 12 inter-river link canals, approximately 56,000 kilometers (km) of canals, and about 110,000 km of water courses. The inter-river link canals transfer water from the Indus and Jhelum rivers to the Chenab, Ravi, and Sutlej rivers. The Indus Basin system can be described as a funnel, with numerous sources of water at the top converging into a single river that flows out to the Arabian Sea, east of Karachi.

Nearly 58% of IBIS lies in Punjab Province, where more than half of Pakistan's irrigated lands are located. Punjab accounts for 58% of the country's gross domestic product (GDP). The province contributes 80% of Pakistan's agricultural production and 66% of its agriculture GDP. The irrigated agriculture sector is critical and pivotal for generating employment, income, and economic growth for both Pakistan and Punjab.

Punjab's extensive irrigation infrastructure, managed and operated by the provincial irrigation department, covers a gross command area of 9.45 million ha and cultivable command area of 8.41 million ha. Table 1 presents key data on the system.

**Table 1: Key Infrastructure of the Punjab Irrigation System**

Item	Quantity
Headworks/barrages	13
Main canal systems	24 (6,429 km)
Distributary and minor canals	2,794 (31,214 km)
Total offtake capacity and field outlets	3,399 m <sup>3</sup> /s (58,000 units)
Gross command area	9.45 million ha
Cultivable command area	8.41 million ha
Offtake capacity and length of link canals	3,115 m <sup>3</sup> /s (850 km)
Tubewells (public)	3,544
Length of surface drains	9,856 km
Length of flood embankments	3,228 km
Small dams	57
Number of watercourses	58,500

ha = hectare, km = kilometer, m<sup>3</sup>/s = cubic meter per second.

Source: Government of Punjab, Punjab Irrigation Department. 2007 *Asset Management Plan*. Lahore.

After 1960, the Indus Basin Program provided a significant thrust to the province's irrigation infrastructure.<sup>1</sup> Punjab's irrigation network now consists of 24 main canals fed by 13 barrages/headworks and 9 major inter-river link canals. The total length of the canals is nearly 38,000 km. Table 2 gives the details of the 13 barrages.

**Table 2: Barrages in Punjab, by River**

	River	Name of Barrage	Year of Project Commencement <sup>a</sup>	Barrage Length (meters)	Offtake Canals
1	Indus	Jinnah	1946	1,152	Thal
2		Taunsa	1958	1,325	Muzaffargarh, Dera Ghazi Khan, Taunsa–Panjnad Link, Kachi Canal
3		Chashma	1971	1,084	Chashma–Jhelum Link, Chashma Right Bank
4	Jhelum	Rasul	1901, 1967	978	Lower Jhelum, Rasul–Qadirabad Link
5	Chenab	Marala	1910, 1971	1,364	Marala–Ravi Link, Upper Chenab
6		Khanki Headworks New Khanki	1889, 2011	1,337	Lower Chenab
7		Qadirabad	1967	1,028	Qadirabad–Balloki Link
8		Trimmu	1939, 2020	1,205	Rangpur, Haveli Main Line, Trimmu–Sidhnai Link
9		Panjnad	1932, 2020	1,036	Panjnad, Abbassia, Abbassia Link
10	Ravi	Balloki	1913, 2017	502	Lower Bari Doab, Balloki Suleimanki Link Canal
11		Sidhnai	1913, 1965	217	Sidhnai, Sidhnai–Mailsi–Bahawal Link
12	Sutlej	Suleimanki	1926, 2017	678	Upper Pakpattan, Fordwah, Eastern Sadiqia
13		Islam	1927, 1954	494	Bahawal, Qaim

<sup>a</sup> Also shows the year that remodeling or replacement of the barrages commenced.  
Source: Government of Punjab, Punjab Irrigation Department.

Although the irrigation infrastructure has vastly expanded in the last 70 years, much of it is very old and operating well beyond its designed life. Key problems are low delivery performance and huge system losses due to aging, overuse, and poor infrastructure maintenance (Hussain et al. 2011).<sup>2</sup> The expenditure allocated for repair and maintenance is only about 10% of what is needed.

<sup>1</sup> The program built two major reservoirs: Mangla Dam on the Jhelum River and Tarbela Dam on Indus River, which largely contributed to improved food security and livelihood. Although these large dams are just outside the boundary of Punjab, their downstream impact greatly benefited the province's irrigation system and agriculture.

<sup>2</sup> The average delivery efficiency of IBIS is only 35% from the canal head to the root zone; a large portion of losses occurs in the watercourses.

The 2021 Global Climate Risk Index ranked Pakistan eighth among the countries most affected by climate-related extreme weather events in the period 2000 to 2019.<sup>3</sup> Extreme weather events cause loss of life and livelihood, and damage settlements and water resources infrastructure. The severity of floods and drought in Pakistan is expected to increase by the 2030s due to climate change. The frequency of droughts may already be observed as increasing. However, there is uncertainty on the impact of climate change on future water resources. Climate change is expected to shift seasonal rainfall patterns from summer to spring peaks. Glacial melt in the Himalayas, and associated river runoff in the Indus Basin, may accelerate in the medium term and decline in the long term.<sup>4</sup> Groundwater resources are consequently expected face additional pressure from growing demand.<sup>5</sup>

## INTERNATIONAL ASSISTANCE FOR IRRIGATION INFRASTRUCTURE

Safety evaluation studies of hydraulic structures and feasibility studies for upgrading six barrages were carried out in 1998–2007 (Government of Punjab, Punjab Irrigation and Power Department [PIPD] 2007). Based on these studies, the Government of Punjab and the PIPD sought assistance from international development partners. The government and the PIPD prepared a long-term investment plan to improve the irrigation infrastructure and initiated investment projects to rehabilitate and modernize critical components such as barrages and main canals.

International development partners responded positively to the government's requests and since 2004 have funded 14 major projects to rehabilitate and upgrade or construct canals and barrages in the province (Table 3). The assistance included related activities such as strengthening the institutional capacity to manage the irrigation system.

The Asian Development Bank (ADB) has long been providing assistance to Punjab's agriculture sector. Since 2006, ADB has financed 10 of the province's 14 large irrigation infrastructure works while signifying continued support for the sector. The first of these projects was the improvement of three barrages (Balloki, Khanki, and Suleimanki) and two main canals (Lower Bari Doab Canal and Pakpattan Canal) under the Punjab Irrigated Agriculture Investment Program. Improvement work is ongoing on three ADB-financed barrages (Trimmu, Panjnad, and Islam). ADB is also providing assistance for constructing a new main canal (Jalalpur Canal).

This document describes as a case study the construction and benefits of, and insights from, the New Khanki Barrage construction project, which was financed by ADB to replace the 1892 Khanki Headworks. Photographs of the old headworks and the new project's infrastructure are provided in the Appendix, Figures A1–A17.

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<sup>3</sup> D. Eckstein, et al. 2021. *Global Climate Risk Index 2021*. Bonn.

<sup>4</sup> ADB. 2017. *Climate Change Profile of Pakistan*. Manila.

<sup>5</sup> ADB and the World Bank. 2021. *Climate Risk Country Profile: Pakistan*. Manila and Washington, DC.

**Table 3: Punjab's Key Irrigation Infrastructure Assisted by International Development Partners**

Infrastructure Name	Type of Work	Year of Project Commencement	Financier
Lower Chenab Canal	Rehabilitation and upgrading	2004	JICA
Lower Bari Doab Canal	Rehabilitation and upgrading	2006	ADB
Balloki Barrage	Rehabilitation and upgrading	2006	ADB
Taunsa Barrage	Rehabilitation and upgrading	2005	World Bank
Jinnah Barrage	Rehabilitation and upgrading	2011	World Bank
New Khanki Barrage	New construction	2011	ADB
Suleimanki Barrage	Rehabilitation and upgrading	2012	ADB
Pakpattan Canal	Rehabilitation and upgrading	2012	ADB
Trimmu Barrage	Rehabilitation and upgrading	2014	ADB
Panjnad Barrage	Rehabilitation and upgrading	2014	ADB
Rivers Jehlum, Chanab and Indus (FERR Project)	Flood embankment rehabilitation	2015	ADB
Rivers Jehlum, Chanab and Indus (DCRI Project)	Flood embankment rehabilitation	2015	World Bank
Jalalpur Canal	New construction	2017	ADB
Islam Barrage	Rehabilitation and upgrading	2019	ADB

ADB = Asian Development Bank, DCRI = Disaster and Climate Resilience Improvement, FERR = Flood Emergency Reconstruction and Resilience, JICA = Japan International Cooperation Agency.  
Source: Government of Punjab, Punjab Irrigation Department.



# THE NEW KHANKI BARRAGE

## KHANKI HEADWORKS – ONE OF THE OLDEST BARRAGES IN THE SUBCONTINENT

The Khanki Headworks, constructed in 1889–1892 on the Chenab River in Gujranwala District, was designed to divert river flow to the Lower Chenab Canal (LCC), which was originally an inundation canal (Figure A1). The Khanki Headworks converted the LCC into a perennial canal. Since completion, the headworks has supplied irrigation water to 1.2 million ha of agricultural land through the LCC and its 241 minor distributaries throughout eight districts of central Punjab, benefiting about 568,000 farming families, producing a vast range of crops, boosting food security and exports, and contributing to the provincial and national economy.

The Chenab River is one of the largest rivers in the Indus Basin. It originates in the Himalayas and drains an area of 3,437 square kilometers. The Khanki Headworks was designed to have a flood discharge capacity of 17,000 cubic meters per second ( $\text{m}^3/\text{s}$ ). An exceptional flood in 1929 resulted in peak discharge of 21,000  $\text{m}^3/\text{s}$  at Khanki, beyond the original design capacity. In response, the structure was remodeled during 1933–1935 to increase its flood discharge capacity to 22,500  $\text{m}^3/\text{s}$  in order to raise its safety. However, from 1935 to 2004, 10 flood events resulted in discharges at Khanki that exceeded this discharge capacity (Table 4).<sup>6</sup> These events damaged the headworks structure, embankments, and other river training works, and inundated large areas of land.

During 1998–2007, the PIPD conducted various studies on flood management and headworks safety. The studies concluded that the old Khanki Headworks was no longer suitable for regulating the river during heavy floods. Its redesigned 22,600  $\text{m}^3/\text{s}$  capacity had been reduced to 18,400  $\text{m}^3/\text{s}$  due to increased sedimentation, while the 100-year-return flood estimates had increased to more than 31,000  $\text{m}^3/\text{s}$ . There was a very high chance that a major flood could damage the structure and breach its embankments, causing significant loss of life and property.

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<sup>6</sup> A super flood in 2010 devastated much of the country but did not reach the old Khanki Barrage or its command area.

**Table 4: Discharge at the Old Khanki Barrage Exceeding 22,500 m<sup>3</sup>/s in 1935–2004**

Date	Discharge (m <sup>3</sup> /s)
20 September 1950	28,600
26 September 1954	23,000
27 August 1957	31,000
6 July 1959	29,000
10 August 1973	24,000
26 September 1988	24,500
10 September 1992	25,700
24 August 1996	24,000
28 August 1997	24,000
7 September 2014	26,600

m<sup>3</sup>/s = cubic meter per second.

Source: Government of Punjab, Punjab Irrigation Department.

No road bridge connected the two banks of the headworks, and the shutters had to be operated manually. This was time-consuming, cumbersome, and dangerous. It also delayed the supply of irrigation water and endangered the lives of barrage workers (Box 1). The old technology used to operate the undersluice gates did not function smoothly and hindered the safety and timeliness of operations.<sup>7</sup> The shutters used in place of gates could not be properly operated and needed to be replaced with remotely operable, electronically controlled gates. The aged structure also caused leakages in water flow. The original headworks was designed and constructed under conditions of extreme economy. Subsequent modifications over the years used a mixture of several design and construction techniques, and none were suitable for the 21st century. All these issues indicated that a new barrage was needed.

In 2010, the most devastating flood in the country's history caused an economic loss totaling about \$10.00 billion (PRs1.53 trillion as of 7 May 2021), killing nearly 1,600 people and affecting 20 million people in 46 districts. Although the flood did not reach the Khanki Barrage or the command area it served, it provided a clear warning of the possible extent of damage if a major flood occurred in the Khanki area. Based on the findings from the earlier studies and the 2010 flood, the Government of Punjab decided to replace the Khanki Headworks with a new barrage, adopting modern civil engineering technologies to ensure sustainable delivery for irrigated agriculture in the command area and safe passage of a 100-year-return flood.

Climate change considerations also influenced the need for and design of the new barrage. The variability of monsoons and increased frequency of floods and droughts have led to more frequently fluctuating crop production across a wider portion of the IBIS area.

<sup>7</sup> Undersluices are short flank sections of a barrage, with low crest and sometimes a silt excluder, and are separated from the main weir by a dividing wall.

### Box 1: Irshaad Ahmad

Irshaad Ahmad is a third-generation employee at the Khanki Headworks/Barrage. He is fully aware of how barrages, headworks, and canals have brought prosperity to the region, and of the dangers the staff have encountered as part of their job to keep the system operational over the years. His grandfather had been associated with the headworks since its inception, and was followed by Ahmad's father. Both of them worked as a "sounding mistry," a mundane job measuring silt accumulated at the barrage. The old headworks, a complex web of 962 shutters, could only be opened by using a manually operated trolley over the bridge or by boat. Ahmad still remembers a story his grandfather told him when he was young, of an accident when two trolleys collided over the midsection.

By the time Ahmad was employed, there were quite a few sounding mistries. He was recruited as "regulation supervisor (*jamadar*)" and was trained to keep an eye on the shutters' operations. Ahmad recounts the danger associated with one of the most hazardous jobs on the Chenab. His duty, along with 12 colleagues, was to operate the shutters to regulate water supply in the river and the Lower Chenab Canal. It was a challenging task under normal conditions and very hazardous during the flood season as debris jammed the shutters, requiring brute force to clear blockages. Transported by a trolley, the mistries would jump out of it and onto an often wet, shuddering pillar, braving the thundering onrushing water just a meter below. Throwing iron bars and huge rocks at the shutter usually worked to unjam it but on occasion, shutters would open only when colleagues threw several rocks at the gate simultaneously. Returning to the trolley after the hazardous task without a safety harness was another daredevil adventure. Like other employees, Ahmad has benefited tremendously from the New Khanki Barrage, which has resulted in most of his job functions being electronically operated.



➤ **Old Practices.** Workers used the trolley for operations and maintenance in dangerous conditions at the old Khanki Headworks (photo by the Project Management Office Barrages, Punjab Irrigation Department).

"I have a lot to thank the project for as I have been retrained and promoted to head regulation *jamadar*, with an office and new responsibilities: keeping an eye on the new radial gates. Manual intervention is down to a bare minimum, with the operating room responsible for opening and shutting the gates on the barrage and the Lower Chenab Canal. Tasks that previously took 2–3 days now take only minutes."

Source: Irshaad Ahmed, head regulation *jamadar*, New Khanki Barrage. Interview by Wasif Rashid (28 April 2019).

Economic analysis of the proposed new barrage was based on the counterfactual scenario that without the project, the barrage would fail catastrophically sometime in the future and incur agricultural and income losses. Risk analysis results, including estimated project capital costs, produced a cumulative probability distribution of expected barrage failure during the years specified in the risk modeling framework. This approach improved the rigor of economic analysis required for the large investment in a new barrage and became the basis for upgrading similar structures in Punjab.

## NEW KHANKI BARRAGE

The design process of the New Khanki Barrage was a sustainable approach that incorporated modern construction techniques and systems and applied lessons learned from the recent rehabilitation of the Jinnah and Taunsa barrages and the experience of the 2010 flood. Finding sufficient resources to finance such large and technically complex infrastructure projects was the most difficult challenge for the Government of Punjab. Consequently, the Government of Pakistan and the Government of Punjab requested ADB for financial assistance. After ADB approved the assistance in 2011, two sites were considered: one 275 meters and the other 6.83 km downstream of the existing Khanki Headworks. The second option was rejected as it would have required acquiring 6,879 ha and resettling 1,500 households.

Civil works began in June 2013, and the project was completed in August 2017. Constructing the new barrage consisted mainly of building and/or installing (i) a new main weir and undersluices;<sup>8</sup> (ii) remotely operable, electronically controlled gates and hoisting arrangements; (iii) an operating deck; (iv) a canal head regulator and lead channel from the new barrage to connect with the lead channel of the LCC; and (v) a centralized operation room with a supervisory control and data acquisition (SCADA) system (Figure A8 and Chapter 3). The completed barrage increased flood discharge capacity by 37.5%, from 22,600 m<sup>3</sup>/s to 31,000 m<sup>3</sup>/s, and annual diversion to the LCC by 3.6% (ADB 2018). Overall, 568,000 farming families benefited from the reliable irrigation water supply generated by the project. The old headworks and barrage were dismantled in 2018 when the new barrage was completed.

The new barrage increased the main agriculture and water management benefits, sustained production and income, and lowered the risk of barrage failure. Two target indicators were used to measure the impact of improved agricultural production and farm income in the LCC command area. The first was a 10% increase in cropping intensity over the 2011 baseline by 2020. The overall irrigated area with crops growing in the project districts increased from 3.32 million ha in 2011 to 3.56 million ha by 2016, a gain of more than 7%, which was likely to reach the target by 2020. The second target was a 10% increase in the average farm income of 25,000 farming families in the same period. The income of an average holding had already increased well beyond this target with a 15.4% gain by 2016, to be validated after the 2020 harvest.

<sup>8</sup> A weir is a low barrier across a river that raises water level and may change the flow. It may also serve as the base for barrage gates.

The expected outcomes of sustainable improved delivery of services for irrigated agriculture and better water management in LCC command areas were measured against two targets: (i) water supplies of up to 326 m<sup>3</sup>/s diverted to the canal for at least 90% of the year with no risk of failure; and (ii) climate-resiliency of the infrastructure enhanced by strengthening the flood design capacity from 1-in-50-year return period events to 1-in-100 year events. Both targets were achieved through the completion of the barrage and improvement of the executing agency's project management capacity, as discussed in Chapter 3.

The project's other tangible benefits included constructing a bridge along with the barrage's operating deck, and constructing and rehabilitating 30 km of approach roads to the barrage (Figures A7, A9, and A10). As a result, connectivity between towns and cities on each side of the river improved. At Khanki, the LCC head regulator and the Punjab Irrigation Department (PID) housing compound for the barrage operation and maintenance (O&M) staff are on the left bank. Previously, even O&M activities could not be performed properly and in a timely manner because there was no road across the river. Rather, staff had to use a dangerous and inefficient, manually operated aerial ropeway and cradle to cross the barrage (Box 1). The bridge significantly improved physical inspection, regulation, and O&M works by PID staff, particularly in times of flood.

A key challenge was to keep the old structures functioning while the new barrage was being constructed (Figures A2–A6). This required building a coffer dam each year, along with a segment of the barrage.<sup>9</sup> Every year, the coffer dams were demolished before rainy season started and water levels usually began to rise. This cycle continued until the new barrage became operational. At the same time, work continued on other components, such as installing the electrical systems needed to power the new gates, strengthening the protective river embankments, widening the roads to and from Khanki, and creating community uplift programs. The new electronically operated radial gates use a technology that is generations ahead of the manual control systems of the old structure.<sup>10</sup>

The modern design of the new 1.34 km barrage improved water management. Pile foundations ensured smoother water flow. The independent undersluices and 71 radial gates (65 on the barrage, and 6 on the LCC) eliminated an annual water leakage of 370 million m<sup>3</sup>. The construction includes a canal head regulator and lead channel from the new barrage to the LCC, and a high-level channel pump room, which ensures that areas near Khanki that are higher than the right bank of the LCC are supplied with water. Table 5 compares the old and new structures at Khanki.

ADB and the PID conducted a project completion evaluation in April–May 2018. The project was rated *successful* overall. The development impact and performance of the PID and ADB were

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<sup>9</sup> A coffer dam is a temporary cordon to shut off a segment of the river and to drain water from the riverbed to facilitate construction of the new works.

<sup>10</sup> Radial gates, also known as Tainter gates (after the structural engineer who popularized them), are the most common type of spillway/barrage gate in use today and consist of a curved skin plate supported by a structural steel frame. They are classified as undershot gates because water flows under them.

**Table 5: Technical Comparison of the Old and New Khanki Barrages**

Component	Old Khanki Barrage	New Khanki Barrage
Main weir control	Shutters operated using cumbersome procedures; leakage about 370 million m <sup>3</sup> /s annually; high maintenance cost	Electronically operated hydraulic gates with centralized control; no leakage; lower maintenance cost
Upstream guide banks	Old banks not very effective in guiding the flow	New banks guide the flow more efficiently
Gates and hoisting	Shutters and manually operated gates	Radial gates with hydraulic hoist, operated electronically on site and remotely through a SCADA system
Operating deck	None. Gates operated from an unsafe cable trolley and by using a tugboat	Operating deck allows gate operations through electrical control panels as well as manually
SCADA	None	Integrated SCADA control and monitoring system
Canal head regulator	340 m <sup>3</sup> /s diversion capacity	425 m <sup>3</sup> /s diversion capacity
Access roads	Degraded, eroded	30 km of access roads rehabilitated
Bridge over barrage	None, requiring about 30 km travel from one bank to the opposite bank	Road bridge constructed over the barrage, eliminating the long journey between banks

km = kilometer, m<sup>3</sup>/s = cubic meter per second, SCADA = supervisory control and data acquisition.  
Source: Government of Punjab, Punjab Irrigation Department, Project Management Office Barrages.

also rated *satisfactory*. The assessment rated the project *highly relevant, efficient, effective, and sustainable* (ADB 2018).<sup>11</sup>

Post-completion economic analysis of the project showed that the new construction sustainably improved the delivery of water to the canal network of 2,925 channels (4,680 km) across more than 1.2 million ha of irrigated land in eight districts. Without the project and in the event of barrage failure, annual losses were estimated at 2.5% of Pakistan's GDP, which could take 7–10 years to recoup. The losses would affect the livelihoods of about 568,000 farm families.

Infrastructure projects that replace old structures can cause feelings of loss in the local population. This was observed among some people, especially senior citizens who witnessed the dismantling of the old barrage. However, as the new barrage took shape, they appreciated its simple, modern design. The bridge connecting the two riverbanks and the project's community uplift program brought immense benefit, as discussed in Chapter 4.

<sup>11</sup> ADB rates a project *successful* if no major shortfall has taken place and the expected outcome and impact will, on the whole, be achieved sustainably over the project's life. The project remains relevant, and its implementation and operations are efficient. Any negative effects are small in relation to the gains under the project. *Relevance* is the consistency of a project's impact and outcome with the government's development strategy, ADB's lending strategy for the country, and ADB's strategic objectives; *efficiency* describes, ex post, how economically resources have been converted to results and the resilience to risk of the net benefit flows over time; *effectiveness* describes the extent to which the outcome is achieved, as specified in the design and monitoring framework; and *sustainability* considers the likelihood that human, institutional, financial, and other resources are sufficient to maintain the outcome over its economic life.

# CAPACITY AND TECHNOLOGY CHALLENGES

## BUILDING NATIONAL CAPACITY AND PRIDE

The New Khanki Barrage serves a command area of about 3 million ha, which is the largest area served by one barrage in Punjab. It is the province's first barrage to use an electronically operated hydraulic system and has become a source of pride, not least because it was built using expertise almost entirely from within Pakistan. The PID was the executing agency for the construction, through the PMO Barrages. The PIPD had created the PMO Barrages in 2004 for managing feasibility studies and detailed design, and for implementing the rehabilitation and modernization works of some other barrages. The PIPD had earmarked, in its Asset Management Plan, several other barrages for urgent rehabilitation or replacement (Government of Punjab, Punjab Irrigation and Power Department 2007).<sup>12</sup>

The PMO Barrages was headed from the outset by a project director. It had separate subunits for finance, engineering, procurement, and social and environment matters. Within these subunits, dedicated staff deal with individual barrage projects. Through this staffing arrangement, the PMO Barrages has specialized staff equipped with relevant skillsets and training as a foundation to enhance its in-house capacity in all facets of large-scale irrigation infrastructure projects. The PID was therefore confident of its ability to manage the construction of the New Khanki Barrage, and had a strong sense of ownership in its implementation from the project's onset. A dedicated full-time team for the new barrage comprised a deputy project director and directors for the engineering, safeguards, procurement, and finance units. Additional staff members were hired in engineering, contract management, and financial management. Another 11 new PMO staff members were added during the project.<sup>13</sup> A team of consultants supervised the PMO's project activities.

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<sup>12</sup> In July 2013, the PIPD was restructured and divided into two newly created departments: the PID and the Punjab Energy Department.

<sup>13</sup> Additional staff positions included one director, three assistant executive engineers, four sub engineers for power, and three sub engineers for SCADA.

### Box 2: Project Management Office Barrages

The New Khanki Barrage is a success story of the Project Management Office (PMO) Barrages. The project has contributed to the institutional development of the PMO Barrages by enhancing its capacity and confidence for undertaking such mega projects in the future. Amjad Saeed, head/project director of the PMO Barrages, noted that the new barrage is the largest hydraulic structure in the province. It serves 1.2 million hectares (ha) of the total cultivable command area of 8.4 million ha—the largest command area served by one barrage in Pakistan. The project was completed on time despite the “super flood” of 2014, which affected the old barrage structure while construction of the new one was in progress. Not a single day of canal operation was disrupted while the new structure was being built, thus ensuring the command area’s inhabitants had reliable water delivery, food security, and livelihood protection.

Saeed particularly credits his team at the PMO Barrages for the smooth and successful project implementation. The team had low staff turnover and included specialists for the project. Teamwork at the PMO Barrages and good coordination between three entities—the PMO Barrages, consultants, and contractor—ensured that the project did not suffer any delays. Saeed emphasized that selection of a resourceful and experienced contractor was a key success factor for the project.

Saeed, who has been associated with the PMO Barrages since 2007 and served as the executive engineer at the old Khanki Headworks in 2004–2006, said that implementation of the supervisory control and data acquisition (SCADA) system for the electronic gate operation was the game changer that completely transformed the working of the barrage from the slow, manual shutter operations of the old Khanki Headworks. Other novel features of the project include applying the latest hydraulic engineering research for civil works design, incorporating seismic impact in the design, extensively using concrete, building coffer dams at three stages during construction, and avoiding disruption of any activity during the flood season. Coffers dams were also built during the three stages of demolishing the old barrage.

The project’s resettlement impact was negligible, and the overall social impact in terms of education, health, recreation facilities, and road construction was highly positive and inclusive. The project has boosted connectivity, enhanced quality of life by providing health and education facilities, spurred economic activity, generated jobs, mitigated flood risk, ensured food security, and contributed to economic growth in the area, making it a crowning achievement of the PMO Barrages and a flagship project for both the Asian Development Bank (ADB) and the Government of Punjab. This holistic and inclusive experience of project benefits coupled with strong leadership has strengthened the PMO Barrages as an institution with great prospects for the future. The PMO Barrages also benefited from good support from ADB’s project team. With continuing guidance and support from the Government of Punjab and the Punjab Irrigation Department, the PMO Barrages will continue to benefit from the sound institutional foundation built during the New Khanki Barrage project.

Source: Project Management Office Barrages.



ADB helped to enhance the capacity of the PMO Barrages' staff by organizing training sessions and workshops on project implementation and administration, ADB loan disbursement and financial management, best practices in land acquisition and settlement, and environmental safeguards management. Later training sessions improved management capacity for procurement, contract management, monitoring, implementation, and construction supervision. Staff turnover was low during the project, contributing to smooth project implementation and the development of institutional capacity for other similar projects.

The scale of the New Khanki Barrage provided local engineers with excellent exposure to various aspects of construction and contract management of large projects. The use of new diagnostic and control technology for the barrage gates required diversified skills within the PID, providing increased opportunities for electrical engineers to manage electronically operated systems and complement current expertise in civil and mechanical engineering. Coupled with low staff turnover, these engineers provide continuity of in-house knowledge to the PID and the PMO Barrages.

Ultimately, the project's successful and timely completion within budget can be attributed to close coordination between the PMO Barrages, the design and implementing consultants, and the contractor.<sup>14</sup> The project implementation consultant team reviewed the design and supervised construction activities and was instrumental in allowing timely decision making, quality control, and coordination. For example, the team was able to obtain the agreement of the PMO Barrages, the contractor, and ADB to a major change in foundation design to improve the resilience and structural integrity of the barrage, which clearly demonstrated the team's capacity to work under pressure.

A lesson learned from the early development of the project design phase was that, to reduce implementation complexities and the administrative burden, construction works should be packaged into a few large contracts rather than numerous small ones (ADB 2011a). For the construction works, the plan was to appoint two contractors: one international and one local. Subsequently, a single contract for constructing the barrage was prepared for international bidding, accompanied by a project "roadshow" in several countries. The merger of civil works into one contract proved to be a key procurement planning decision. The work was awarded to a Pakistan company, which was an acknowledgment of the availability of the requisite skills in country.

Although the new barrage was the first mega hydraulic structure the contractor had built, it overcame many challenges, including an early design change, the demanding project completion schedule set by the PMO Barrages due to the complex nature of the project, high flood discharges in the river, reduced construction time due to annual floods during July–September, effects of an extremely high flood in 2014 while construction was underway, a tight schedule for completing the barrage staff housing and office works, and congested logistic routes around the construction site. For example, the contractor responded effectively to the danger posed by the 2014 flood, when water surged over the top of the old barrage and imperiled the partly constructed new barrage. The contractor's timely action and deployment of machinery prevented serious damage

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<sup>14</sup> The consultants for the feasibility study and design were NESPAK–BURQAAB, the implementation consultants were SMEC–EGC, and the contractor was Descon.

to the new construction. By using cutting-edge technology and deploying more than 50 engineers on the ground at the peak of construction activity, the contractor achieved a record-breaking level for Pakistan of 50,000 m<sup>3</sup> of concrete poured in 1 month. Such steps greatly contributed to timely project completion.

The awarding of the contract to a national engineering firm enhanced the pool of engineering skills in the country. A spokesperson for the contractor expressed pride in the achievement and considered the new barrage a “role model project for future endeavors,” noting that attention to “diligent and detailed scheduling proved to be a key factor in the successful delivery of the project.”<sup>15</sup> The expertise of many local subcontractors was also upgraded through participation in the work.

The capacity developed during the construction of the new barrage was not limited to on-site and management personnel. The project was monitored by a project steering committee headed by the chair of the Punjab Planning and Development Board, and the committee’s members included the provincial secretaries for the departments of irrigation, finance, agriculture, and environment. The committee met at least once every 6 months to provide policy guidance and review progress. Exposure to successful projects such as the New Khanki Barrage can provide real examples and templates for relevant decision-makers, which should improve their capacity to plan for future investments.

## NEW BARRAGE – NEW TECHNOLOGY

Central to the design of the new barrage was the use of up-to-date technology to automate the control of overall water management, replacing the century-old manual operation of the old headworks. The SCADA system that was installed was an integral part of the New Khanki Barrage’s design. The system has remotely operable, electronically controlled gates for regulating the flow of water to the LCC and includes data collection, data transmission, and sophisticated camera-based surveillance. Some other barrages in Punjab have had partly or fully automated SCADA systems installed during rehabilitation.

The SCADA operating deck is the nerve center of operations. Information received from remote sensors on the gates is converted to digital data, which are linked to the offices of the chief engineer and superintendent engineer (LCC) in Faisalabad and the PMO offices in Lahore. It is now also easier to control the water flow upstream on the Chenab River in real time. A series of piezometers measure unusual changes in potentially damaging water pressure along the riverbed.

The LCC command area has benefited from the electronically controlled canal supply, which is monitored and maintained in real time. Dedicated silt excluders minimize the entry of silt into the canals. To ensure smooth operations, electricity is provided to the barrage through an exclusive,

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<sup>15</sup> Muhammad Imran Khan Cheema, Head Business Development Infrastructure Division, Descon, personal communication. 28 January 2021.

20 km, 11 kilovolt feeder line. Hydraulic pumps and backup generators are available in case of a major system failure. A system of 12 closed-circuit television cameras and lights was installed for added security, with panel boxes attached to each gate.

Uninterrupted water supply to the canal command area during construction was critical to the project, hence the work plan had to be designed to ensure that the normal irrigation requirements would continue to be met. Project planning achieved this satisfactorily by taking advantage of the seasonal demand patterns for water for winter and summer crops. Project financing also included a large contingency for any flood-related event during the construction period. Although the flood-related event in 2014 caused some damage, recovery was managed efficiently.

A residential compound was built for the barrage operations staff. The compound's bright, new, airy, and spacious houses, including a large, common, green area, transformed their living and social environment (Figure A17). The old area was declared unfit for human habitation and demolished to make way for a new LCC water channel.

A project completion review (p. 9) by ADB and the PID through the PMO Barrages rated the PMO's performance as *satisfactory*.<sup>16</sup> Successful completion of this state-of-the-art project—despite some initial delays in procuring a contractor and limited damage to work in progress during the monsoon rain season—is a testament to the capacity of the PMO Barrages to manage such projects and shows that local engineering design and execution expertise is available to undertake complex civil, mechanical, electrical, and telecommunication works, coupled with supervision by international consultants.<sup>17</sup>

## PREPARING FOR THE FUTURE

The New Khanki Barrage project has become a model for future modernization, rehabilitation, and construction of irrigation infrastructure in the province and a showcase for other provinces in Pakistan.<sup>18</sup> The technical expertise now available in the PMO will be even more important in the future as the effects of climate change continue to gain momentum.

Future climate scenarios for Pakistan point to a considerable increase in the occurrence and intensity of extreme weather events, erratic monsoon rains, and melting and recession of glaciers. When combined, such effects are likely to cause more frequent and intense floods and droughts, and greater siltation of major dams (ADB 2017a).

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<sup>16</sup> ADB rates borrower performance according to a number of criteria, such as success in meeting loan effectiveness requirements, degree of high-level support, staff quality and continuity, effectiveness of the project steering committee, and timeliness in meeting other loan requirements.

<sup>17</sup> As a result of its success, the PID created a new directorate in the PMO to deal with SCADA operations, currently staffed by 9 professional and 38 support staff.

<sup>18</sup> Applying technologies similar to those used in the New Khanki Barrage, two barrages in Sindh Province have been rehabilitated and upgraded, financed by the World Bank.

The Government of Punjab identified five new priority projects in the province's irrigation system, aiming to improve canal infrastructure and develop unproductive land using various types of new irrigation infrastructure to meet both climate change and food security challenges (ADB 2019). With the technical confidence built by the experience of the PID and the PMO Barrages, the PMO Barrages is now well placed to oversee their implementation and ensure that their construction provides the adaptations needed to minimize the impact of climate change.

The PMO Barrages' forward-looking approach was groundbreaking in the province. In addition to enhanced engineering and technology skills and now-proven ability to undertake massive modern construction, the PMO Barrages has strengthened its social safeguards team to make project benefits more inclusive for the expected beneficiaries, as required by international development partners such as ADB. The benefits of this approach, particularly for women, are described in the next chapter.

# INCLUSIVE SOCIAL BENEFITS OF THE NEW KHANKI BARRAGE

**A**DB and the Government of Punjab considered the construction of the New Khanki Barrage to be a flagship project. The project showcased the government's effective use of pioneering technology, and the construction validated the availability of homegrown expertise. ADB was equally concerned with the overall development impact, which was considerably more than stabilizing and improving agricultural production and farm income in the barrage's command area. The project was intended to benefit the large population in the vicinity, particularly women and girls, by providing better access to education, health care, transport, recreation, and places of worship, in addition to generating income. Community representatives were consulted in the design of the social facilities to ensure that the community would support the project and not be offended by it. Realization of the social benefits has substantially improved the lives of people within a wide radius of the new barrage.

## NEW ROAD – NEW OPPORTUNITIES

Khanki is a small, remote village in Wazirabad, Punjab Province.<sup>19</sup> Before the new barrage was built, people on opposite sides of the barrage had to travel 30 km to cross the river. The villagers' only benefit from the river or irrigation system was jobs for the men who maintained the barrage. Constructing a bridge on the new barrage was essential for its operations, and to provide access to the public (Figure A7). About 30 km of approach roads, including from the main highway (the Grand Trunk Road), were constructed or rehabilitated, reducing travel time between towns and cities on opposite sides of the river (Figure A9). The new bridge has shortened travel time across the barrage area, and the distance to major industrial hubs in Wazirabad and Gujrat has dropped from 40–48 km to only 6–7 km.

Travel before the new bridge was built was also unsafe, especially for women. People avoided traveling at night due to robberies and other insecurity, and they had to plan to complete their trips during daylight. The new bridge and the upgraded access roads are well lit, making travel safe at night, with traffic flowing at all hours. Travel options to larger cities have increased, from air-conditioned buses to motorbikes. Residents of Khanki are able to visit relatives and friends

<sup>19</sup> Wazirabad is a *tehsil*—a township or subdistrict.

in villages and towns across the river more frequently, strengthening social capital in these communities. Due to reduced time and travel expense, people can participate in family weddings and other special occasions more easily.

The new bridge vastly improved access and connectivity for local businesses. The shorter travel time has helped existing enterprises and opened up new business opportunities—the new roads led to better and cheaper trade linkages with, for example, the towns of Mangowal and Kharian, which are well known for their local cattle and fish markets. With the new bridge, the cost of transporting cattle has decreased by nearly 60%. For the wives of business owners, household expenses have eased considerably, and the amount reinvested in the livestock business has increased, with average monthly income per household increasing by \$90.00 (PRs13,748.60 as of 7 May 2021) due to the improved connectivity. The increased business activity in the area has led to financial inclusion and the new roads have helped empower women and boost social inclusion through enhanced connectivity and increased social activity.

Students have saved considerable travel time going to schools, colleges, and post-secondary educational institutions, and the public and private transport fares are now lower. Female students have benefited in particular, as they face more problems than males in terms of access, time, and safety. The project also invested in the construction of a police check post to improve safety in the area. Better access has led to more traffic on the new roads, and a toll booth on the bridge generates revenue (Figure A10).

## A NEW ERA IN GIRLS' EDUCATION

Wazirabad has 24 girls' high schools and middle-level schools, but only a few colleges in its major towns offer education beyond grade 8. Enrollment rates in secondary grades decline, largely for economic reasons, affecting girls in particular. For the great majority of the country's low-income families, educating daughters beyond grade 8 has been impossible. Khanki had only a middle school (i.e., up to grade 8), and the few parents who could continue their daughters' education sent them to a private school in the village, which had only a few students studying for the matriculation (year 10). The other higher secondary private or public schooling is in Saroke Cheema, about 20 km away. Sending girls to another town meant paying the high cost of tuition at the private school and arranging for safe and reliable private transport in the absence of any public transport. Thus, the project's construction of a new girls' high school to matriculation level in Khanki Village is a major social benefit and a significant step for women's education in the province.

The PID built the school on government-owned land (Figure A12). School operations and administration were handed over to the Punjab Education Department, which employed 15 female teachers on a permanent basis.

The first batch of 16 girls had a 100% pass rate in the 2017 matriculation examination. By school year 2019, 386 students were enrolled in grades 6–10, and 78 girls were in grades 9 and 10—68 of whom passed the examination. All matriculates are continuing through year 12, and those in the first batch have gone on to the bachelor/graduate level. Two girls (sisters) are studying for a nursing diploma in the teaching hospital in the divisional capital city, Gujranwala. Another has found employment in the PID.

As noted, most families in and around Khanki have little income, and at least 50 of the 78 girls in grades 9 and 10 could not have continued schooling beyond grade 8 previously (Box 3). Many would have been sent to work as domestic helpers. The girls' parents are now eager to support them in pursuing professional careers, which would mean better jobs for the girls and remittances for their parents. Their high school education has boosted their confidence and self-esteem and made a difference in their lives and futures.

### Box 3: Khanki Girls' High School

The New Khanki Barrage's most profound social impact has been advancing girls' education. The girls' public school that the project built on Punjab Irrigation Department land greatly improved opportunities for girls in the area. Opened in 2016, the school offers science and arts subjects through grade 10, with very impressive facilities that include science and computer laboratories and a sports ground. Girls are now better motivated to pursue higher education and seek better job opportunities. Girls from six other villages on both sides of the river are also enrolled in the school.

Almost 65% of the girls are from poor marginalized families that cannot afford to send their daughters to high school or buy warm clothes for them in winter. The teachers have a fund to which they all contribute for purchasing sweaters for the poorest of the students.

Graduating students have performed well; some have continued to colleges in various cities, and they aspire to pursue careers in education, teaching, law, nursing, medicine, or police work.

Source: Riffat Shaheen, school head. Interview by Samia Raouf Ali (19 June 2019).



➤ **Girl students using computers.** Schoolgirls learning computer skills at the high school's computer laboratory (photo by Wasif Rashid).

Pakistan's female education indicators are not impressive, and any initiative that addresses the imbalance in gender education is important.<sup>20</sup> The new upgraded school provides an opportunity for girls and empowers them to make decisions on further education and careers. These factors are important in the context of Pakistan's social milieu in which any steps that promote gender equality, enhance female education, and boost social inclusion for women—who are mostly housebound due to social norms—are very significant and have a salutary social impact.

## BRINGING HEALTH CARE TO KHANKI VILLAGE WOMEN

Khanki Village had no health-care facilities before the new barrage was constructed. Villagers had to travel several kilometers to a nearby town, which was challenging for women because of access, cost, and safety concerns. In 2017, the project provided a fully equipped and furnished building for a basic health unit (BHU) in Khanki to supply basic health care to the community (Figure A13). After completion, the project officially handed the BHU over to the provincial health department. A female health visitor (community health worker) is in the unit daily until 2:00 p.m. A resident doctor may be appointed in the future. The BHU has X-ray and ultrasound machines, two incubators, a fully equipped labor room, and a nursery for newborns. In 2019, the BHU employed 10 support staff and built new residential accommodation for medical staff.

The female health visitor has treated male and female villagers for minor and serious ailments. Common health complaints include fever, cough, cold, flu, throat-related problems, stomach ailments, and diarrhea. General medicines are free for most ailments, and more specific medicines are available for a minimum fee. About 60,000 patients received medical assistance at the Khanki BHU during March 2017–June 2019. Patients from Khanki and other villages on both sides of the river have benefited immensely from this new facility.

The BHU is especially valuable for pregnant women and mothers because it caters to maternal, newborn, and child health patients. The unit can provide regular prenatal checkups and refers women with gynecological problems to hospitals for further treatment and childbirth. The bridge has facilitated access to hospitals. The BHU also provides mothers and pregnant women with iron supplements, calcium, and vitamins, saving the time and expense of a 4–5 km travel to the nearest health-care facilities elsewhere. The unit also provides free polio vaccines (polio drops) for children on some days and free regular blood pressure checks for women with hypertension, saving travel time and cost to other BHUs.

<sup>20</sup> Government of Pakistan, Ministry of Planning and Special Initiatives, Bureau of Statistics. 2019. *Pakistan Social and Living Standard Measurement (PSLM) Survey 2018–19*. Islamabad. pp. 11–16; and Government of Pakistan, Ministry of Planning and Special Initiatives, Bureau of Statistics. 2018. Table 3. *Percentage distribution of population by age, sex, literacy and level of education: Pakistan & Provinces, Rural and Urban*.



## NEW SOCIAL AND RECREATION AMENITIES

The New Khanki Barrage built a conveniently located, landscaped park as part of the project's community uplift program (Figures A11 and A14). The park is on 6 ha near the new barrage and offers recreational facilities for adults and children, play areas for children, stalls selling a variety of food and drinks, a gazebo, a tiled solarium, benches under brightly colored canopies, and toilets. Entrance to the park is free. Other facilities include a jogging track, a badminton court, a waterfall and fountains, bird cages, and an outdoor barbecue area. A new mosque of modern design was built inside the park (Figure A15). In addition to becoming a venue for festivals, the park is now a major tourist attraction for families from about 50 villages.

For women from many villages and towns in the district and beyond, the park provides a welcome change from the household environment. Elderly women with their grandchildren, younger women with their elders and parents, mothers watching their children, and families with their guests stroll around the park freely and enjoy its many attractions. The park has promoted social inclusion, encouraged social activity, and contributed to community health through the exercise facilities.

Women have a separate prayer area in the new mosque and separate facilities in the gymnasium area. Men have taken the opportunity to set up food and toy stalls in and around the park. Their families benefit from the increased income, which women appreciate because the snacks are mostly bought from a market or made at the stall, leaving the women with only light extra work at home. An exception is a vendor outside the new school who set up a stall selling snacks made by his wife and other women at home.

Fishing and boating activities are always popular in the area and have flourished as visiting families enjoy boat trips and fishing upstream of the barrage. The improved road network and the bridge have boosted shopping for fresh fish in the nearby market towns of Qadirabad and Gujrat.

## DEVELOPING NEW SKILLS

The project team liaised with the Punjab Government Technical Education and Vocational Training Authority (TEVTA) to conduct a 1-month voluntary training and skills development program for men and women. The electrician course for men focused on both basic and complex circuitry, providing them with an alternative career choice. Diplomas were awarded to successful candidates, who began using their new skills to earn income. Some graduates opened small shops. The program also conducted a 1-week course on flood risk and disaster management for men (Figure A16).

The program for women taught the basics of drafting and pattern making and encouraged them to think of new designs and marketing concepts. Working in groups, the 40 participants were asked to defend their projects by setting up stalls and marketing their designs to TEVTA teams. After completing the training, the women began saving money by stitching their own clothes and those of their family; a few earned small sums by sewing for neighboring households in their villages. The course enhanced the women's confidence and sense of well-being. The training provided income-generating opportunities and gave women a chance to socialize and spend time with other women—an important benefit given the few opportunities women had to go outside of their houses.

# Chapter 5

## INSIGHTS AND WAY FORWARD

The construction of the New Khanki Barrage offers valuable lessons for infrastructure projects. Its design, which incorporates social uplift programs to benefit the wider population; the rigorous economic analysis; and the use of modern technologies serve as a model for future infrastructure projects. The implementing teams on the ground worked closely together, enabling the executing agencies to make decisions rapidly and obtain approval from the government and ADB as construction progressed. This harmonious coordination among stakeholders enabled quick resolution of matters that could have caused conflict and delayed construction.

The project has shown how a high-tech solution that incorporates adaptations to climate change projections can enhance the sustainability of agriculture on more than 1 million ha of cultivable land. The project has attracted the attention of irrigation managers wanting to improve water use management and agricultural production. However, the sustainability of the new barrage infrastructure will depend on continuing to meet O&M requirements, as noted in the independent evaluation of the project (ADB 2019). To meet this challenge will require adequate financing and O&M of downstream irrigation canals and the associated distribution system. Given the huge Asia-wide gap between infrastructure financing needs and funding available from the public sector (ADB 2017b), private sector assistance may be necessary, such as by raising irrigation service fees. That farmers elsewhere in Punjab Province are willing to pay more for reliable water supply than is paid in the New Khanki Barrage command area indicates the potential for increasing the current water charges (Bell et al. 2014).

The impact of climate change is the other major challenge. Climate change will not only affect availability of water, but also the water requirements of crops and the cropping seasons. New irrigation projects in the province are being designed to capture climate adaptation benefits by improving existing canal infrastructure and utilizing new, more efficient irrigation technology (ADB 2011).

Conflicting demands for water are coming from other sectors (including urban development, industry, and energy) and the potential impact of climate change on those sectors is growing as well. The PID is taking steps to broaden its traditional role to encompass integrated water resources management and water-related disaster risk management approaches (ADB 2016b). Transforming the PID's scope from its traditional focus on irrigation to encompass the entire water sector will help to increase the sector's efficiency and sustainability.

Holistic governance across sectors is required to address the growing competition for water and to manage the effects of pollution, wastewater, floods, droughts, and land degradation. To feed the growing population, ways are needed to sustainably increase the agricultural production area and land productivity for a future when less water is available. The design of future irrigation infrastructure projects must incorporate (i) new developments such as pressurized (drip and sprinkler) irrigation systems and automated, or smart technologies such as IRRInet for monitoring and controlling water delivery; and (ii) the application of recent agriculture research findings, including water-saving technologies such as dry seeding, transplanting, and alternate wetting and drying in rice farming, as well as precision land leveling and preparation to maximize water-use efficiency.

Appropriate policies must be put in place to promote such integrated management and development. For Punjab Province and for the Indus Basin nationwide, technological, institutional, and policy options need to be assessed; a flood policy developed; and a land-use policy enforced (Ali 2013). Further, making infrastructure investments more inclusive through complementary investments—for example, in education, finance, and health—is in line with ADB’s multisector approach to ensure that interventions systematically address the key multidimensional features of food security.

At present, the Asia and Pacific region has a huge infrastructure investment gap and a high demand for knowledge on infrastructure. Governments in the region are very interested in modern infrastructure design, but face a significant knowledge gap regarding the long-term benefits (ADB 2017c).

The insights and knowledge disseminated from projects such as the New Khanki Barrage will assist ADB efforts to increase knowledge sharing and improve policy dialogue in inclusive infrastructure development in the region. As part of that effort, members of the study team prepared a short video on the project and presented it to more than 5,000 global participants of the 50th Annual Meeting of the ADB Board of Governors in Yokohama (ADB 2016b). The team hopes that this document will also contribute to the dissemination effort by presenting insights and lessons learned from the project to a broader audience.

# INTERVIEWS

## **People Interviewed by Study Team Members**

Raza ur Rahman Abbasi (deputy project director, Project Management Office [PMO]).  
29 January 2020.

Irshad Ahmed (head regulation jamadar, New Khanki Barrage). 28 April 2019.

Khuda Bakhsh (site manager, Infrastructure Projects, Descon). 29 January 2020.

Muhammad Imran Khan Cheema (head of business development, Descon). 29 January 2020.

Sumrana Irshad (senior teacher at the school). 30 January 2020.

Muhammad Aamir Khan (chief, Strategic Planning Reform Unit, Punjab Irrigation Department).  
30 January 2020.

Sohaib Raziq Khan Khitran (director SCADA, PMO). 30 January 2020.

Javed Munir (general manager, NESPAK). 30 January 2020.

Sajjad Naseem (design team leader, SMEC). 29 January 2020.

Ghulam Rasool (executive engineer, New Khanki Barrage). 31 January 2020.

Amjad Saeed (project director, PMO). 28 January 2020.

Riffat Shaheen (school head). 30 April 2019.

Shaikh Anees (ex-site manager, Infrastructure Projects, Descon). 12 March 2020.

Mohammad Ibrahim (medical technician at the Basic Health Unit). 30 January 2020.

# APPENDIX: PHOTO GALLERY



➤ **Figure A1: The Old Khanki Headworks.** One of the oldest headworks in Pakistan, completed in 1892 and dismantled in 2016.



➤ **Figure A2: New Khanki Barrage project site.** Work continued while the old headwork, as seen on the right, was still operating.



➤ **Figure A3: Barrage bays under construction.** The New Khanki Barrage has 65 bays.



➤ **Figure A4: Gate installation.** Gate being installed in one of the bays.



➤ **Figure A5: Silt excluder under construction.** Removing the silt from the river to divert clearer water to the canal.



➤ **Figure A6: The new Lower Chenab Canal headwork.** The new headworks replaced the 120-year-old structure.



> **Figure A7: New road connectivity.** The 1.34-kilometer bridge across the New Khanki Barrage connects the opposite riverbanks.



> **Figure A8: Supervisory control and data acquisition system.** The view from the control room, with the barrage in the background.



> **Figure A9: New and improved access.** New access roads in the areas surrounding the New Khanki Barrage.



> **Figure A10: Road user fee.** The toll plaza on the New Khanki Barrage.



> **Figure A11: Bird's eye view of the recreation park.** Located on the left bank with the barrage visible in the background.



> **Figure A12: Khanki girls' high school.** Entrance to the new building located in Khanki Village.



➤ **Figure A13: Basic health unit.** Located next to the recreation park.



➤ **Figure A14: Recreational park.** Children in play areas reserved for families.



➤ **Figure A15: Masjid (mosque).** Located at the corner of the recreation park.



➤ **Figure A16: Empowering the community.** Flood mitigation and first-aid training for the community.



➤ **Figure A17: New housing colony for Punjab Irrigation Department employees.** Modern residential buildings for barrage operations staff and their families.

All photos are courtesy of Project Management Office Barrage.



# BIBLIOGRAPHY

- Asian Development Bank (ADB). 2011a. *Periodic Financing Request Report for Punjab Irrigated Agriculture Investment Program: Tranche 2*. Manila.
- . 2011b. *Water Operational Plan 2011–2020*. Manila. Asia-Wide, Irrigation Efficiency Remains Low at an Average of 37%.
- . 2013. *Indus Basin Floods. Mechanisms, Impacts, and Management*. Manila.
- . 2016a. *New Weir in Pakistan’s Punjab Provides Extensive Irrigation*. Manila.
- . 2016b. *Technical Assistance to the Islamic Republic of Pakistan for Institutional Transformation of the Punjab Irrigation Department to a Water Resources Department*. Manila.
- . 2017a. *Climate Change Profile of Pakistan*. Manila.
- . 2017b. *Meeting Asia’s Infrastructure Needs*. Manila.
- . 2017c. *Technical Assistance for Asia Infrastructure Insights*. Manila.
- . 2018. *Completion Report: Punjab Irrigated Agriculture Investment Program–Project 2*. Manila.
- . 2019. *Pakistan: Punjab Irrigated Agriculture Investment Program—Tranche 2*. Independent Evaluation. Manila.
- . 2020. *Project Readiness Financing for Punjab Water Resources Management*. Manila.
- A. R. Bell, M. A. A. Shah, and P. S. Ward. 2014. Reimagining Cost Recovery in Pakistan’s Irrigation System through Willingness-to-Pay Estimates for Irrigation Water from a Discrete Choice Experiment. *Water Resources Research*.
- Government of Pakistan. 2018. Table 3. *Percentage Distribution of Population by Age, Sex, Literacy and Level of Education: Pakistan & Provinces, Rural & Urban*.
- . Ministry of Planning and Special Initiatives, Bureau of Statistics. 2019. *Pakistan Social and Living Standard Measurement (PSLM) Survey 2018–19*. Islamabad. pp. 11–16.
- Government of the Punjab. Bureau of Statistics Punjab. *Punjab Development Statistics*.

- . 2018. *Report on Annual School Census 2017–18 Programme*. Lahore: Monitoring & Implementation Unit, Punjab Education Sector Reform Programme.
- Government of Punjab, Punjab Irrigation and Power Department. 2007. *Asset Management Plan*. Lahore.
- . 2008. *Feasibility Study for Construction of New Khanki Barrage. Volume 1 – Main Report*. Lahore.
- I. Husain. 2018. *Governing the Ungovernable*. Karachi: Oxford University Press.
- J. Hussain, et al. 2011. Water Balance, Supply and Demand and Irrigation Efficiency of Indus Basin. *Pakistan Economic and Social Review*. 49 (1). pp. 13–38.
- A. Latif. 2019. Climate Change Triggers Widespread Pakistan Migration. Anadolu Agency. *Punjab Primary and Secondary Healthcare Department*.
- M. Rizwan, A. Bakhsh, X. Li, L. Anjum, K. Jamal, and S. Hamid. 2018. “Evaluation of the Impact of Water Management Technologies on Water Savings in the Lower Chenab Canal Command Area, Indus River Basin” *Water* 10, no. 6: 681. <https://doi.org/10.3390/w10060681>.
- United Nations Development Programme (UNDP). 2017. *Inclusive and Sustainable Development—Analytical Basis and Policy Framework*. Lahore.
- United Nations Educational, Scientific and Cultural Organization (UNESCO) Pakistan. 2019. *Country Strategic Document 2018–2022*. Islamabad.
- United Nations Children’s Fund (UNICEF) Pakistan. 2020. *Investing in Pakistan’s Young People: Our Time, Our Turn, Our Future*. Islamabad.

## **The Development and Social Impacts of Pakistan’s New Khanki Barrage**

### *A Project Benefit Case Study*

This study examines the development and describes the advanced technology used for the construction and operation of the New Khanki Barrage in Punjab, Pakistan. It highlights the socioeconomic benefits of the project, including an increase in agricultural outputs and income of over half a million farming families and the empowerment of communities, particularly women and girls, through new health, education, recreation, and other infrastructure. The study also presents challenges identified in the process, which offers valuable lessons in the design and implementation of other infrastructure projects. The New Khanki Barrage was financed by the Asian Development Bank through the Punjab Irrigated Agriculture Investment Program, Project 2.

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