ECONOMIC AND FINANCIAL ANALYSIS

A. Introduction

1. The economic analysis of the project was undertaken according to Asian Development Bank (ADB) guidelines and describes the economic rationale for public intervention. The analysis quantifies the benefits and costs of the investment for rehabilitation of the Trimmu and Panjnad barrages in economic terms and measures the net worth of the project to the country. Financial values are converted to economic values by removing the effects of government intervention and market distortions. An economic surplus analysis framework is used to estimate the project impacts upon consumers and producers of agricultural commodities. A benefit–cost analysis is undertaken to measure the key investment criteria of economic internal rate of return (EIRR) and economic net present value (ENPV).

2. Two scenarios are compared to determine the economic net benefits of the project: without project, and with project. The without-project scenario assumes the barrages will fail at some point in the future, thereby incurring agricultural losses in following years and additional capital costs for emergency repair works to restore water supplies. The with-project scenario assumes a continuation of current crop areas and yields. The project will not result in increased agricultural production or productivity, and the primary benefit is elimination of the income foregone associated with a barrage failure. The value of the benefits is dependent upon the year of failure (due to discounting), which is unknown. Consequently, a risk modeling framework is used to account for variability in the barrage benefits along with uncertainty in other key variables.

B. Macroeconomic Assessment

3. Pakistan has shown progress on both gross domestic product (GDP) and poverty head count ratios during 2003 and 2013. Annual real GDP increased from $110 billion in 2005 to $138 billion in 2012.[1] The ratio of value added in the agriculture sector to GDP slightly increased from 22.2% in 2004 to 24.4% in 2012.[2] Employment in the agriculture sector was 44.7% of the total employment in 2008 (footnote 1). The poverty headcount ratio of national poverty line in 2006 was 22.3%, and 13.1% in urban areas and 27.0% in rural areas. The agriculture sector is important for the Pakistan economy in terms of both outputs and employment. To reduce poverty in Pakistan, it is important to sustain agricultural productivity and secure employment in the agriculture sector.

C. Demand Analysis

4. Annual water requirements at the farm gate are estimated to be 8.9 million acre-feet (MAF) (10,978 million cubic meters [MCM]) in the Trimmu barrage area and 7.2 MAF (8,881 MCM) in the Panjnad barrage area. However, actual water supply at canal heads have been computed at 8.1 MAF (9,991 MCM) in Trimmu and 5.0 MAF (6,168 MCM) in Panjnad. Moreover, water supply from canal heads is reduced when it reaches the farm gate because of inefficient water conveyance. Water supply at the farm gate is estimated at 5.5 MAF (6,784 MCM) in Trimmu and 3.3 MAF (4,071 MCM) in Panjnad. Shortfalls between actual demand and

[1] World Bank. *World Development Indicators*. http://data.worldbank.org/country/pakistan.
[2] Calculation by ADB staff based on data available on World Development Indicators.

estimated supply are 3.5 MAF (4,317 MCM) (39%) in the Trimmu barrage area and 3.9 MAF (4,811 MCM) (54%) in the Panjnad barrage area.

D. Rationale

5. To meet future water requirements and maintain agricultural productivity, it is important to rehabilitate and improve the deteriorating infrastructure. At present, the annual supply of water represents 61% of annual water requirements in the Trimmu barrage area and 46% in the Panjnad barrage area. Furthermore, there are concerns regarding barrage failures without the project. Hence, it is predicted that the project areas will face severe water shortage and reduced agricultural productivity because of insufficient conveyed water to crop lands.

6. The project is further justified on the basis of addressing a market failure through provision of a public good through flood control provided by barrages. These benefits are nonexcludable and nonrival in nature. Flood control in the area is important to agricultural productivity but it is unlikely to be provided by the private sector. Hence, government intervention is required to rehabilitate and upgrade barrages.

E. Project Alternatives

7. There are two alternatives for management of the barrages: (i) immediate rehabilitation and (ii) rehabilitation deferred to some future year. With the first alternative, there are high initial investment costs but these are offset by the expected benefits from the protection of agricultural production following possible barrage failure and elimination of potential flood losses. The second alternative will involve reduced investment costs with emergency repair costs required in the years following a possible barrage failure, and associated agricultural losses due to reduced water supply in the canals while a barrage is under repair.

F. Methodology

1. Economic Surplus

8. An economic surplus model is used to measure the project benefits. As a result of a project intervention, changes in the quantity of a commodity (e.g., rice, wheat) can result in product price changes, which leads to changes in economic welfare. Economic surplus consists of two elements—consumer surplus and producer surplus. Consumer surplus is defined as the extra amount a consumer would have been prepared to pay and is measured as the area below the demand curve and above the price line. The basic premise of consumer surplus is that, at a certain market price, there are some consumers who would be willing to pay a higher price to obtain the same quantity, and their welfare is increased by obtaining the product at a lower price. The traditional measure of producer surplus is the area above the product supply curve and below the price line. This area represents the difference between what a producer actually receives for a sale and the minimum amount he or she would have been prepared to accept.

9. The standard economic surplus model is used to measure the impact of a leftward shift in commodity supply functions resulting from lost agricultural production from barrage failure. This will have consumer and producer effects both within the project area (region A) and the rest of Pakistan (region B). Within region A there will be a direct effect on producers through the reduction in supply of a commodity following barrage failure. Assuming competitive conditions prevail, this will also have broader implications for the rest of the country through the increased

market price as a result of reduced supply. This will impact upon consumers (who lose) and producers (who gain) from the increased market price.

2. Benefit Estimation

10. The main project benefit is elimination of the opportunity cost of agricultural production lost following failure of the Panjnad and Trimmu barrages. In the years following a potential barrage failure, reductions in canal supplies are estimated to be approximately 100% in year 1, 40% in years 2 and 3, and 10% in year 4. In the year of failure, winter crops (*rabi)* will not be sown because of lack of water in the canals. Summer crops (*Kharif*) are assumed to be unaffected in the initial year as they are sown and harvested prior to the months when a barrage failure is expected to occur. Emergency repairs to the barrages are expected following failure to restore supplies. Despite the repairs, substantial reductions in canal supplies will result in direct reductions in both *rabi* and *kharif* season crops in years 2–4 following failure. It is expected supplies are fully restored in the fifth year after failure. Hence, the project benefit will be the elimination of the combined impacts of lost agricultural production and emergency barrage repair costs.

11. The four main crops grown are cotton, rice, wheat, and sugarcane, representing 87% of the sown area in the area serviced by the Panjnad barrage and 78% of the area serviced by the Trimmu barrage.[3] For simplicity, the total agricultural production was represented by these commodities, and the areas of these four crops were proportionally adjusted.

12. A cumulative probability distribution for failure of each barrage was derived by an expert panel.[4] Other key parameters considered to be random are capital costs and the losses in canal water in years 1–4 following barrage failure, which determines crop area.

13. A Monte Carlo simulation model was developed which was solved to estimate the EIRR and ENPV associated with the project.

G. Data

14. Border prices of tradable commodities for wheat, rice, cotton, and sugarcane were computed on the basis of latest available World Bank commodity forecasts. The exchange rate used was US$1 = PRs100. A 30-year time period was used for the benefit–cost analysis, and a discount rate of 12% was applied. The standard conversion factor (SCF) represents the ratio of prices of all goods within the economy with respective international prices. The SCF was approximated by the weighted average of import and export tariffs, with subsidies excluded. The value used for the SCF was 0.92.

15. The total annual crop area serviced by the Trimmu barrage is 1,085,000 hectares (ha), and by the Panjnad barrage 655,611 ha. Crop yields were derived from average national yields.

16. A triangular probability distribution was used for the other key random parameters of capital cost, the loss in water in canals in the years following barrage failure, and the shutdown price parameter. These are defined by minimum, median, and maximum values. A scalar was

[3] Other crops include fodder, oilseeds, vegetables, and fruit.

[4] The expert panel consisted of the general manager of the Water Resources Division of the National Engineering Services of Pakistan (NESPAK), a water resource engineer (consultant), and the chief engineer and executive engineer of the Punjab Irrigation Department.

used to vary capital costs based upon previous experience of cost overruns in Pakistan infrastructure projects.

17. **Capital costs**. The base financial cost estimated for each barrage was PRs10,448 million for Trimmu and PRs5,636 million for Panjnad. The financial costs were converted to a total economic project cost of PRs16,084 million.

18. **Emergency repair costs**. The cost of emergency repairs was assumed to be PRs92 million for each barrage.

19. **Flood protection benefits**. The rehabilitated barrages are expected to reduce damage from future floods. Losses estimated for the 1992 flood were taken as the flood damage against a 100-year return period. These included damage to agriculture, livestock, housing, roads, electricity, education, fisheries, forests, and human losses. Additional nonquantified indirect damage (e.g., diseases, waterlogging) were assumed to be 20% of the recorded damage values. The financial flood losses were converted to economic values (Trimmu PRs5,594 million, Panjnad PRs724 million), and applying these to a 100-year return period using a Gumbel distribution returned average annual flood benefits of PRs225.60 million for Trimmu and PRs86.09 million for Panjnad.

20. **Recurrent costs**. The annual operation and maintenance costs were estimated to be PRs102 million for Trimmu and PRs55 million for Panjnad.

21. **Poverty impact**. Pakistan census data for 2005 was used to determine the percentage of the population as being extremely poor (income less than $1.25/day), poor (income less than $2.00/day), and nonpoor. Data for Pakistan was used to represent consumers and data for rural Punjab was used for producers.

H. Results

1. Economic surplus analysis

22. There is a PRs101,483 million gain in economic surplus from eliminating the opportunity cost to agriculture following the combined failure of the Trimmu and Panjnad barrages. This value is included as the agricultural benefit within the benefit–cost analysis.

2. Benefit–Cost Analysis

23. The estimated EIRR and ENPV from the benefit–cost analysis are given in Table 1. The results indicate that the project is economically justifiable, with a mean EIRR of 23.4% and ENPV of PRs12,501 million. However, there is significant variability surrounding the means with an EIRR standard deviation of 11.3% (implying a coefficient of variation of 0.49) and the ENPV standard deviation of PRs11,102 million (implying a coefficient of variation of 1.13). The rehabilitation of each barrage was determined to be economically justified, with the Trimmu barrage EIRR at 24.3% and the Panjnad barrage EIRR at 21.9%.

24. The EIRR ranged from a minimum of 6% to a maximum of 65% (median 21%). There is around 15% probability that the project would yield an EIRR less than the 12% threshold. Sensitivity analysis is not applied as the main parameters affecting project benefits and costs are treated as random variables and consequently the variability is captured within the risk analysis.

Table 1: Results of Economic Risk Analysis

	EIRR (%)		**ENPV** (PRs million)	
Item	**Mean**	**SD**	**Mean**	**SD**
Trimmu barrage	24.3	15.2	8,606	9,438
Panjnad barrage	21.9	15.3	3,895	5,507
Total project	23.4	11.3	12,501	11,102

EIRR = economic internal rate of return, ENPV = economic net present value, SD = standard deviation.
Source: Asian Development Bank estimates.

3. Distribution and Poverty Impacts

25. The distribution of the project benefits across poor and nonpoor producers and consumers was estimated. The ENPV of PRs12,501 was derived from the present value of the benefits (PRs26,406 million) less the present value of the costs (PRs13,905 million). The results of the distribution and poverty analysis are given in Table 2.

26. Government costs include the capital costs of the rehabilitation of barrages, less the discounted emergency repair costs (assumed to be a with-project benefit). The distribution of impact upon producers and consumers is based upon the discounted economic surplus analysis and sharing of flood protection benefits between these two groups. Consumers are a substantial beneficiary of the project (79% of the present value of benefits). The poor (PRs15,932 million) and extremely poor (PRs5,974 million) are primary beneficiaries of the project benefits (83% of present value of benefits). A poverty impact ratio of 0.83 is derived from total benefit to the poor of PRs21,900 million and discounted project benefit of PRs26,397 million. Overall, it is concluded that the project will have a positive impact on improving the welfare of poor people in Pakistan.

Table 2: Project Benefit Distribution and Poverty Impact
(PRs million)

Item	**Consumers**	**Producers**	**Government**	**Total**
Government			(13,861)	**(13,861)**
Nonpoor	3,554	902		**4,456**
Poor	12,558	3,375		**15,932**
Extremely poor	4,709	1,264		**5,974**
Total	**20,821**	**5,541**	**(13,861)**	**12,501**

( ) = negative.
Source: Asian Development Bank estimates.

I. Financial Sustainability

27. The Punjab Irrigation Department (PID) has six decades of experience of operation and maintenance (O&M) of 13 barrages serving about 8.4 million ha in Punjab province. The operational management is (i) based on standard and proven national and international practices, (ii) conducted by a team of dedicated full-time experts and skilled staff, and (iii) supported by annual O&M funds. The PID's Barrage Manual provides comprehensive guidance on O&M including periodic inspection and maintenance records. The barrage team within the PID submits annual operation, maintenance, and monitoring reports of each barrage to PID headquarters, where experts analyze the data and arrange for special inspections if required. Independent auditors audit the annual budget.

28. There is no revenue generated in irrigation systems from users in terms of direct water charges, hence financing of O&M is a government responsibility. The government of Punjab allocates annual funds for operation of the irrigation system and barrages in its provincial budget. The budget allocation is based on the department's long experience operating the barrages (updated from time to time). The current allocation is based on estimates derived in 2004–2006 under the development policy loan from the World Bank,[5] which has since been updated in 2010 and 2012. The next revision is scheduled in 2014–2015. The government of Punjab provides additional funds for flood and other emergency situations, when needed. The budget allocation and actual expenses for Trimmu and Panjnad barrages for 2011–2013 are given in Table 3. The operational management of Trimmu and Panjnad barrages is the responsibility of chief engineers and resident executive and assistant executive engineers. Current Trimmu and Panjnad barrage O&M staff are given in Table 4.

Table 3: Punjab Government Operation and Maintenance Allocation and Historical Expenditure

		Actual Expenditures		
Barrage	**Annual Allocation** (PRs million)	**FY2011** (PRs million)	**FY2012** (PRs million)	**FY2013** (PRs million)
Trimmu barrage	111.07	127.84	102.35	94.10
Panjnad barrage	88.97	87.81	85.81	74.91

FY = financial year.
Source: Asian Development Bank estimates.

Table 4: **Punjab Government Operational Management Staff at the Barrages**

Staff Position	**Trimmu barrage**	**Panjnad barrage**
Chief Engineer (Head)	1	1
Executive Engineer	1	1
Assistant Executive Engineer/Subdivisional Officer	1	1
Divisional Accounts Officer	1	1
Divisional Head Draftsman, Draftsman, and Tracers	3	3
Subengineers	5	6
Head Clerk, Accounts Clerk, and Subdivisional Clerk	11	10
Signaler and Telephone Attendants	8	7
Mistries, Electricians, Mates, *Beldars*, Fitters, Gate Operators	169	217
Total Staff	**200**	**247**

Mistries = Skilled labor to help in operation of the barrage, Beldar = skilled technician for maintenance of the barrage
Source: Asian Development Bank estimates.

[5] The World Bank. 2006. Punjab-Irrigation Sector Development Policy Loan. Islamabad.