# Cost–Benefit Analysis of the Chashma Barrage and Chashma Canal Project in Pakistan

JSPM
JOURNAL OF STRATEGY & PERFORMANCE MANAGEMENT

Author:
Javed Iqbal Awan
*Sir Syed CASE Institute of Technology, Islamabad*

**Abstract**

Large-scale water infrastructure projects play a critical role in addressing the intertwined challenges of water scarcity, food security, energy shortages, and flood management in developing economies. Pakistan's dependence on irrigated agriculture and hydropower makes such investments particularly strategic. This paper presents a comprehensive cost–benefit analysis (CBA) of the Chashma Barrage and Chashma Canal Project, a major component of Pakistan's Indus Basin irrigation system. Using a 30-year analytical horizon and applying time value of money principles, the study evaluates the project's economic viability through Net Present Value (NPV) and Benefit–Cost Ratio (BCR) metrics. The analysis incorporates capital costs, operating and opportunity costs, and indirect environmental and social costs, alongside quantified benefits from increased agricultural productivity, hydropower generation, flood mitigation, and social welfare gains. Results indicate a strongly positive economic performance, with a BCR exceeding unity and a substantial positive NPV under baseline assumptions. Sensitivity analysis further demonstrates the robustness of the project's economic justification under variations in discount rates, costs, and benefit realizations. The findings underscore the strategic importance of multipurpose water infrastructure investments in Pakistan and support continued public sector engagement in large-scale water resource development as a driver of long-term economic and social sustainability.

Keywords: Cost–Benefit Analysis, Water Infrastructure, Irrigation, Hydropower, Pakistan.

## 1. Introduction

Water resource management represents one of the most pressing structural challenges confronting Pakistan's economy. Rapid population growth, urbanization, and industrial expansion have placed increasing pressure on finite water resources, while climate variability has intensified the frequency and severity of floods and droughts. Agriculture, which remains a cornerstone of the national economy, is particularly vulnerable to these dynamics due to its heavy reliance on irrigated water supplies. At the same time, persistent energy shortages and rising fuel import costs have elevated the importance of domestic renewable energy sources, especially hydropower.

Within this context, large-scale multipurpose water infrastructure projects have historically played a central role in Pakistan's development strategy. Barrages, canals, and reservoirs constructed under the

Indus Basin Irrigation System have enabled the expansion of cultivated land, improved cropping intensity, and contributed to flood regulation and power generation. However, such projects involve substantial public investment and long operational lifespans, making rigorous economic evaluation essential to ensure efficient allocation of scarce resources.

The Chashma Barrage and Chashma Canal Project constitutes one of Pakistan's most significant multipurpose water infrastructure investments. Located on the Indus River, the project integrates irrigation supply, hydropower generation, and flood management functions. While its physical and operational contributions are widely recognized, a systematic economic assessment is required to evaluate whether the long-term benefits justify the associated costs under realistic financial and policy assumptions.

This paper presents a cost–benefit analysis of the Chashma Barrage and Chashma Canal Project, with the objective of assessing its economic viability and strategic value. Employing standard CBA methodology grounded in time value of money principles, the study estimates the project's Net Present Value (NPV) and Benefit–Cost Ratio (BCR) over a 30-year horizon. In addition, sensitivity analysis is used to examine the robustness of results to variations in key parameters, including discount rates, costs, and benefit streams. By doing so, the paper contributes to the empirical literature on public-sector infrastructure appraisal in developing economies and provides policy-relevant insights for future water resource investments in Pakistan.

**2. Policy and Analytical Context**

Water scarcity and infrastructure investment have become central policy concerns in many developing economies, particularly those with agrarian foundations and rapidly expanding populations. Pakistan exemplifies this challenge, as declining per capita water availability coincides with rising demand for food, energy, and urban services. In such contexts, public-sector investment in large-scale water infrastructure is often justified not only on economic grounds but also on strategic and social considerations.

Cost–benefit analysis (CBA) has long been employed as a primary analytical tool for evaluating public investment decisions in infrastructure projects. By systematically comparing discounted streams of costs and benefits over a project's life cycle, CBA provides a structured basis for assessing whether societal benefits exceed opportunity costs. In the water sector, CBAs are particularly important due to the long lifespans, capital intensity, and multi-dimensional impacts of hydraulic infrastructure, which often extend beyond purely financial returns.

In Pakistan, water infrastructure appraisal has historically emphasized engineering feasibility and physical capacity expansion, while economic evaluation has played a more limited role in policy debates. However, increasing fiscal constraints and competing development priorities have heightened the need for rigorous economic justification of large public investments. This has elevated the relevance of formal CBA frameworks that incorporate time value of money principles, opportunity costs of capital, and sensitivity to uncertainty.

The analytical framework adopted in this study aligns with standard public investment appraisal approaches used by multilateral development institutions. It recognizes that large water projects generate a combination of market-based benefits, such as agricultural output and electricity revenues, and non-market benefits, including flood mitigation and social welfare improvements. Capturing these diverse impacts within a unified evaluative framework is essential for informed policy decision-making in the water and energy sectors.

## 3. Project Background and Strategic Relevance

The Chashma Barrage and Chashma Canal Project occupies a strategic position within Pakistan's Indus Basin irrigation and water management system. Situated on the Indus River in the Mianwali district of Punjab, the project was conceived to regulate river flows, expand irrigated agriculture, support hydropower generation, and reduce downstream flood risks. Its multipurpose design reflects the broader development philosophy underpinning Pakistan's post-independence water infrastructure expansion.

The barrage serves as a critical control structure, enabling the diversion of water into an extensive canal network that irrigates agricultural land across Punjab and adjoining regions. By stabilizing water availability, the project supports cropping intensity, enhances farm productivity, and reduces the vulnerability of agricultural output to seasonal variability. These functions are particularly important in a country where agriculture remains a major source of employment and rural livelihoods.

In addition to its irrigation role, the project contributes to Pakistan's energy mix through hydropower generation. The integration of power production within irrigation infrastructure allows for the utilization of regulated water flows to generate renewable electricity, thereby reducing dependence on imported fossil fuels and mitigating exposure to energy price volatility. This dual-use characteristic enhances the overall economic value of the investment.

Flood management constitutes a further dimension of the project's strategic relevance. Seasonal monsoon flooding has historically imposed significant economic and social costs in downstream regions. By moderating river discharges and facilitating controlled releases, the Chashma Barrage plays a preventive role in reducing flood damage to agricultural land, infrastructure, and settlements. Collectively, these functions position the Chashma Barrage and Canal Project as a cornerstone of Pakistan's integrated approach to water, food, and energy security.

## 4. Methodology: Cost–Benefit Analysis Framework

This study applies a cost–benefit analysis (CBA) framework to evaluate the economic viability of the Chashma Barrage and Chashma Canal Project. CBA is particularly well suited to large-scale public infrastructure projects because it enables the systematic comparison of costs and benefits accruing over extended time horizons. The analysis adopts a societal perspective, incorporating both direct financial flows and broader economic effects associated with the project.

The analytical horizon is set at 30 years, reflecting the long operational lifespan typical of major water infrastructure assets. All costs and benefits are evaluated using time value of money principles and discounted to present values. A real discount rate of 12 percent is applied in the baseline case, consistent with prevailing public-sector appraisal practices in Pakistan and reflecting the opportunity cost of capital in a capital-constrained economy.

Project costs are categorized into four main components: initial capital expenditure, annual operating and maintenance costs, opportunity costs of invested capital, and indirect environmental and social costs. Benefits are similarly classified into quantifiable economic returns from agricultural production and hydropower generation, as well as monetized estimates of flood mitigation and social welfare gains. Where direct market prices are unavailable, benefits are estimated using conservative proxy values derived from sectoral data and policy studies.

The primary evaluation metrics employed are Net Present Value (NPV) and the Benefit–Cost Ratio (BCR). NPV measures the absolute economic contribution of the project by subtracting the present value of costs from the present value of benefits, while BCR provides a relative efficiency indicator by expressing benefits per unit of cost. Together, these metrics offer complementary insights into project viability and comparative attractiveness.

**5. Results: Economic Evaluation**

The cost–benefit analysis results indicate that the Chashma Barrage and Chashma Canal Project delivers substantial net economic benefits over its operational life. Under baseline assumptions, the present value of total project costs is estimated at approximately USD 709 million, while the present value of aggregate benefits amounts to roughly USD 1,456 million. This yields a positive Net Present Value of about USD 746 million.

The corresponding Benefit–Cost Ratio is estimated at 2.05, indicating that each dollar invested in the project generates more than two dollars in economic benefits. Such a ratio is well above the threshold commonly used to justify public-sector investment and reflects the project's multipurpose design, which allows irrigation, energy generation, and flood management benefits to be realized concurrently.

Agricultural productivity gains constitute the largest share of quantified benefits, reflecting the expansion and stabilization of irrigated acreage enabled by the canal system. Hydropower revenues represent a significant secondary benefit, contributing both direct financial returns and broader energy security advantages. Flood mitigation and social benefits, while more difficult to quantify precisely, further enhance the project's overall economic contribution.

Taken together, these results provide strong evidence that the Chashma Barrage and Chashma Canal Project is economically justified under baseline conditions and represents an efficient allocation of public investment resources within Pakistan's water and energy sectors.

**6. Sensitivity and Robustness Analysis**

While the baseline cost–benefit results demonstrate strong economic viability, large-scale infrastructure projects are inherently subject to uncertainty. Variations in macroeconomic conditions, implementation costs, benefit realization, and policy environments can materially affect long-term outcomes. To address these uncertainties, a sensitivity analysis was conducted to test the robustness of the cost–benefit results under alternative assumptions.

The sensitivity analysis focuses on three key parameters: the social discount rate, total project costs, and aggregate benefits. Discount rates of 10 percent and 15 percent were evaluated alongside the baseline rate of 12 percent to reflect alternative assumptions regarding the opportunity cost of capital. In addition, cost overruns and savings of up to 20 percent were simulated, as were corresponding increases and decreases in benefit realization.

Across all tested scenarios, the Net Present Value of the project remains positive, and the Benefit–Cost Ratio remains above unity. Even under conservative assumptions involving higher discount rates or reduced benefit streams, the project continues to generate net economic gains. This outcome indicates a high degree of robustness and suggests that the project's economic justification is not overly sensitive to plausible variations in key parameters.

The results of the sensitivity analysis strengthen confidence in the project's long-term economic performance and underscore the value of multipurpose design in mitigating risk. By generating diverse benefit streams across agriculture, energy, and flood management, the project reduces its exposure to volatility in any single sector.

## 7. Discussion

The findings of this study highlight the strategic importance of integrated water infrastructure in economies facing simultaneous challenges of water scarcity, food security, and energy deficits. The strong economic performance of the Chashma Barrage and Chashma Canal Project reflects not only the scale of the investment but also its multipurpose configuration, which allows complementary benefits to be realized across sectors.

Agricultural productivity gains emerge as the dominant source of economic value, reinforcing the centrality of irrigation reliability in sustaining rural livelihoods and national food supply. Hydropower generation provides an important secondary benefit, contributing to energy diversification and reducing dependence on imported fuels. Flood mitigation benefits, though more difficult to quantify precisely, play a critical role in reducing economic losses and enhancing climate resilience.

From a policy perspective, the results suggest that well-designed water infrastructure projects can deliver returns substantially exceeding their economic costs, even in capital-constrained settings. However, the analysis also underscores the importance of rigorous project appraisal, realistic assumptions, and ongoing performance monitoring to ensure that projected benefits are fully realized over time.

## 8. Conclusion and Policy Implications

This paper has evaluated the economic viability of the Chashma Barrage and Chashma Canal Project using a comprehensive cost–benefit analysis framework. The results indicate that the project generates substantial net economic benefits over its operational life, with a positive Net Present Value and a Benefit–Cost Ratio well above unity under baseline assumptions.

Sensitivity analysis confirms the robustness of these findings under a range of alternative scenarios, suggesting that the project remains economically justified even in the presence of uncertainty. These results support the continued role of public investment in large-scale multipurpose water infrastructure as a cornerstone of Pakistan's development strategy.

Policy implications arising from this analysis include the need to prioritize integrated project design, strengthen economic appraisal capacity within public institutions, and ensure sustained investment in operation and maintenance to preserve long-term benefits. As pressures on water and energy systems intensify, evidence-based investment decisions grounded in robust economic analysis will remain essential for achieving sustainable and inclusive growth.

## References

1. Asian Development Bank. (2019). Pakistan water resources assessment. Asian Development Bank.
2. Board of Investment Pakistan. (2022). Infrastructure and investment opportunities in Pakistan. Government of Pakistan.
3. Government of Pakistan. (2021). Pakistan economic survey 2020–21. Ministry of Finance.

4. Hanley, N., & Barbier, E. B. (2009). Pricing nature: Cost–benefit analysis and environmental policy. Edward Elgar Publishing.
5. Little, I. M. D., & Mirrlees, J. A. (1974). Project appraisal and planning for developing countries. Heinemann.
6. Pakistan Bureau of Statistics. (2023). National accounts and agricultural statistics. Government of Pakistan.
7. World Bank. (2016). High and dry: Climate change, water, and the economy. World Bank Group.
8. World Bank. (2020). Pakistan: Water security diagnostic. World Bank Group.
9. World Commission on Dams. (2000). Dams and development: A new framework for decision-making. Earthscan.
10. WAPDA. (2023). Water resources and hydropower development in Pakistan. Water and Power Development Authority.