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Assessing the Economic Impact of Jhelum Basin's River Water Resources in Kashmir

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Abstract

This study endeavors to ascertain the quantifiable value attributed to the utilization of river water for potable purposes within the Jhelum basin of Kashmir. A meticulous investigation was conducted, centering on the Kakapora Water Treatment Plant located in the Pulwama district, for the purpose of executing a comprehensive cost-benefit analysis. Drawing insights from the Jammu and Kashmir census report of 2011, alongside data provided by the Jammu & Kashmir Infrastructure Development Finance Corporation Limited (JKIDFC) in 2019, it is established that a substantial 0.0563 million households rely on river water for consumption. The aggregate volume of water consumed by the entirety of this populace translates to a staggering 1.552 million gallons per day. Notably, the government's investment in this endeavor emerges as a financially advantageous venture, as evidenced by a favorable benefit-cost ratio (BCR) of 1.014. In-depth scrutiny of the costs involved revealed that annual variable expenses account for Rs.1.934 million (31.3%), while fixed costs amount to Rs.4.246 million (68.7%). Moreover, the precise evaluation of the cost and associated value (price) per liter of filtered water culminates in figures of Rs.0.0499 and Rs.0.0504 respectively. Further magnifying the significance of these findings, the total water consumption by an estimated 0.301 million individuals over a year equates to a voluminous 566.3 million gallons, carrying an estimated valuation of Rs.108 million. By quantifying the pivotal role played by river water in the Jhelum basin, this study contributes significantly to the existing body of scholarly literature. It marks a pioneering effort within the region, holding the potential to inform and shape judicious policies aimed at optimizing the management of this precious resource.

Keywords:
Valuation, River Jhelum, Freshwater, Ecosystem services, Cost-benefit analysis

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Introduction

With just 4% of the world's water resources accessible, India covers 2.45% of the Earth's land area and supports 16% of the global population. By 2050, it is estimated that the nation's population will reach 1.5 billion, maintaining its current annual growth rate of 1.9% (CPCB, 2023). As per the Planning Commission of India, the demand for water is projected to increase from 710 BCM (Billion Cubic Metres) in 2010 to over 1180 BCM by 2050, with a nearly 2.5-fold rise in both domestic and industrial usage. The process of urbanization in India is placing pressure on local authorities to provide necessary infrastructure and essentials such as clean drinking water (CPCB, 2023). The essential need for potable water has surged due to the rapid population growth, underscoring the assessment of natural water sources and the establishment of water treatment and supply systems. The quality of raw water varies significantly across India, necessitating modifications to the conventional water treatment process that includes sedimentation, filtration, coagulation, aeration, and

disinfection (Handbook on Drinking Water Treatment Technologies, 2023). Furthermore, it is imperative to evaluate the operational status of water treatment facilities and identify the most efficient approach to ensure the production of safe drinking water while minimizing waste and improving management. In response to these challenges, India's Central Pollution Control Board (CPCB) has set up drinking water treatment plants at appropriate locations nationwide.

Investments in river water treatment plants will not only help society, but also the economy and environment. This can be achieved by identifying the cost-effective approach to designing and operating the water treatment plant. It will help the decision-makers to identify and generate more significant economic benefits at the lowest possible cost. However, rapid population growth threatens the sustainable use of natural resources and is a significant cause of environmental damage (Maja and Ayano, 2021). In this regard, the government aims to provide everyone with a basic life facility. Due to limited natural freshwater resources, the institutions are left with nothing except to rejuvenate the deteriorated resources (rivers) and harvest the benefits judiciously for the present population. Economic valuation is the best option to use and manage these resources so that people and the institution may come to know how to use and distribute these resources for the present and future generations.

The present study focuses on the case of Jhelum River, the sole river traversing Kashmir valley rising from "Veri nag" in the Anantnag district and passing through Pulwama, Srinagar, Ganderbal, Bandipora, and Baramulla districts. With a total length of 221 km in India (IWAI, 2017), the river is located between the latitudes of 32°58'42" to 35°08'02" N and the longitudes of 73°23'32" to 75°35'57'' E (Dar *et al*., 2023). The river Jhelum basin is home to over 91% of the urban population (J&K Census, 2011; WI report, 2017) and is provided with the primary living facility of clean water directly from glacial sources (WI report, 2017). With the burgeoning population, it has become complex and costly for the government to provide every household with a glacial water source for drinking purposes. Hence, along the river Jhelum, many water treatment plants have also been installed at suitable places from time to time to meet the increasing water demands of the region. The government is dedicated to leaving every household with the basic life facility of clean drinking water. It works under the slogan "Har Ghar Jal" (Handbook on Drinking Water Treatment Technologies, 2023). Nevertheless, it comes with costs, which depend on the investment level. More the pollution level in the river Jhelum, more will be the investment required. The endeavour to remediate contaminated water intended for potable consumption is contingent upon the degree of pollution it harbours. Against this contextual backdrop, an economic assessment was conducted to ascertain the value of treated water sourced from the Jhelum River, destined for human consumption. This study serves as a foundational framework, offering

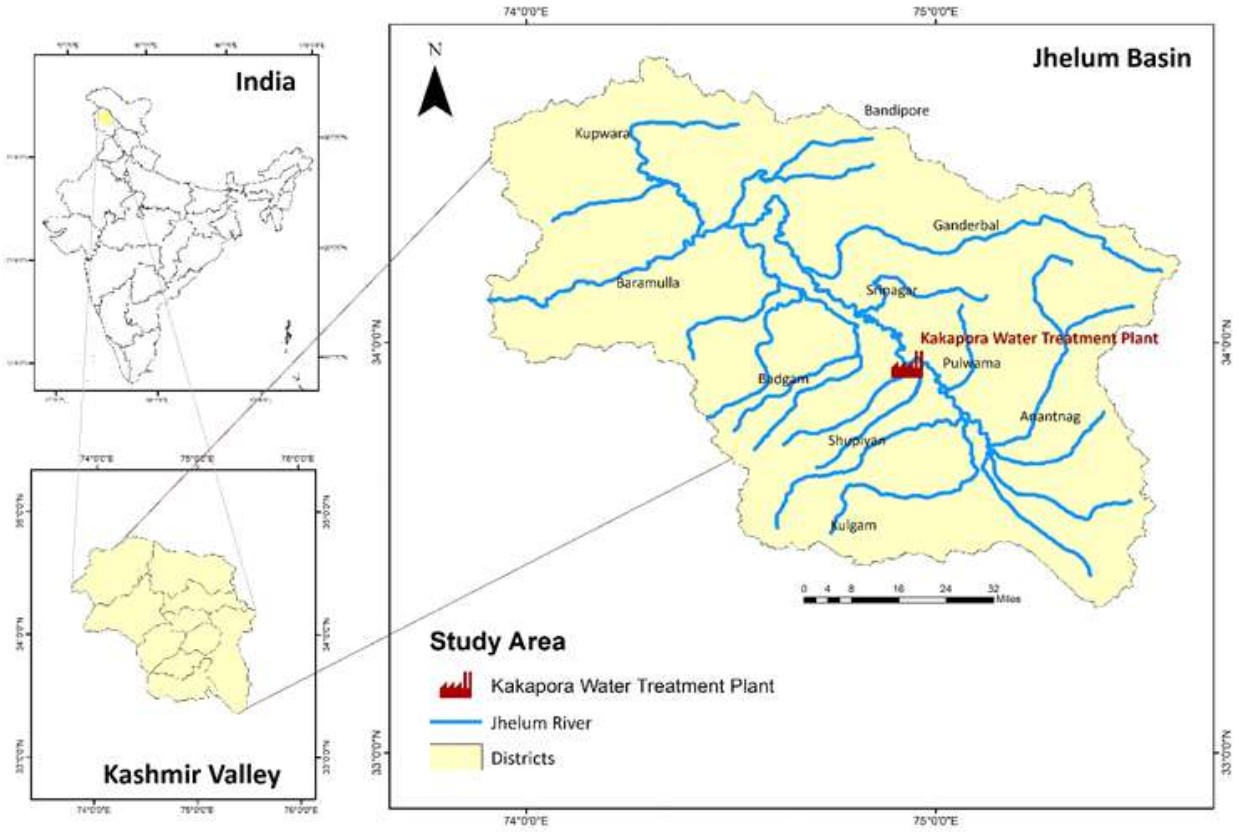

Fig. 1. A: Location of Jammu & Kashmir on the map of India, B: Kashmir valley, C: Catchment area of river Jhelum along with Kakapora Water Treatment Plant

insights into the prospective allocation of resources essential for forthcoming investments, as well as facilitating the prudent and sustainable stewardship of this invaluable resource.

Materials and methods

Data collection

Many water treatment plants are installed along the entire river Jhelum to supply potable water to the surrounding population. Due to the lack of data availability, cost-benefit analysis of the water treatment plant at the Kakapora area of district Pulwama was done for the present study (Fig. 1).

The unit price (value) per gallon of filtered water from river Jhelum was calculated and multiplied by the whole population to get the overall value of all the water used for drinking purposes from river Jhelum. Besides revenue, annual variable and fixed costs were calculated using below formulas:

1. Total variable cost (TVC) = Cost of bleaching powder and alum + Electricity charges + Casual labour charges + Repair and maintenance + Interest on working capital
2. Total fixed cost (TFC) = Depreciation + Permanent human labor + Interest on fixed capital
3. Total cost of water treatment, TC = TVC + TFC
4. Gross revenue = Annual fee per household × Total number of households
5. Net revenue = Gross revenue – Total cost
6. Total gallons of water filtered in a year = Total gallons of water filtered per day × Number of days in a year
7. Water used per capita per day (Gallons) = (Total gallons of water filtered per day)/(Total population)
8. Water filtration expenditure per gallon = (Total cost per year)/(Total gallons of water filtered in a year)
9. Price per gallon of filtered or portable water= (Total annual revenue)/(Total gallons of water filtered in a year)
10. Price or value per litre of portable water= (Price or value per gallon of portable water)/3.785
11. Price or value for annual quantity of filtered (portable) water = Annual quantity of portable water used × Price or value of 1 gallon of portable water

Results and discussion

As previously elucidated, owing to the unavailability of comprehensive data encompassing all water treatment facilities established along the banks of the River Jhelum, the quantification of the intrinsic value of Jhelum water employed for potable consumption necessitated a methodology involving the multiplication of the aggregate beneficiary population by the prevailing unit price or valuation per gallon of meticulously filtered water. Drawing from the empirical data extracted from the Jammu and Kashmir Census of 2011, in conjunction with the data furnished by the Jammu and Kashmir Infrastructure Development Finance Corporation (JKIDFC) in 2019, a substantive total of 0.0563 million households were identified as reliant upon Jhelum water for their drinking requisites. This population extrapolation, detailed in Table 1, delineates that approximately 0.3013 million individuals routinely avail themselves of Jhelum water for their daily hydration needs. Evidently, within this sample demographic, the mean size of a household was computed at 5.35 members.

Table 1. Total population residing on river Jhelum for potable purposes

District-Block	*Households (m)*	*Population (m)*
Pulwama		
Kakapora	0.0060	0.0175
Awantipora	0.0124	0.0500
Pampore	0.0076	0.0217
Srinagar		
Lasjan	0.0009	0.0044
Bag e mehtab	0.0012	0.0063
Khonmoh	0.0002	0.0027
Budgam		
B.K. Pora	0.0085	0.0573
Kralpora	0.0014	0.0139
Sumbhal	0.0096	0.0685
Baramulla		
Sopore	0.0085	0.0593
Total population	**0.0563**	**0.3013**

Source: J&K Census report, 2011; JKIDFC, 2019.
(m = million)

The outlay associated with the establishment of the Kakapora Water Treatment Plant is appraised at Rs. 72.8 million, as illustrated in Table 2. Predominantly, the most substantial proportion of expenditure emerges from the disbursement towards pipe and pipe specials, accounting for Rs. 20.351 million, constituting 27.95% of the total. Subsequent in magnitude are the miscellaneous expenditures, totalling Rs. 18.6 million, equivalent to 25.55% of the aggregate, closely followed by the allocation for electrical and mechanical equipment, at Rs.10.343 million, representing 14.21% of the entire budget.

Further budgetary delineations encompass the cost allocation for the Rapid Sand Filter (RSF) plant, inclusive of the clariflocculation tank, amounting to Rs. 7.963 million, signifying 10.94% of the total expenditure. A proportion of Rs. 6.5 million, accounting for 8.93% of the financial outlay, is attributed to the overhead tank component, with other pertinent expenditures similarly apportioned within the framework of the comprehensive budgetary distribution.

Table 2. Investment pattern of the water treatment plant Kakapora, Pulwama

Particulars of items	Amount in million (%)
Cost of pipe and pipe specials	2.0351 (27.95)
Rapid sand filter (RSF) plant including clariflocculation tank	0.7963 (10.94)
Washout chamber and sluice chamber	0.0320 (0.44)
Intake or protection works	0.0882 (1.21)
Operator quarter cum pump shed	0.070 (0.97)
Overhead tank (0.90 lakh gallons capacity)	0.650 (8.93)
Inspection hut	0.0940 (1.29)
Cold galvanized iron (CGI) shed for diesel generator (DG) set and chemical store	0.0695 (0.95)
Floating structure in river Jhelum	0.2 (2.75)
Electrical and mechanical equipment's	1.0343 (14.21)
Elevated pressure sand tank (PST)	0.350 (4.81)
Other expenditures including land compensation, levelling of ground, construction of buildings, quarters, roads, washout drains, fencing, painting, fitting charges of pipes etc.	1.860 (25.55)
Total	7.28 (100)

Cost structure

The financial composition of the Kakapora Water Treatment Plant was classified into two distinct categories: variable costs and fixed costs. Detailed examination of Table 3 reveals a discernible pattern wherein, within the realm of variable expenditures (amounting to ₹1.93 million), the most prominent component resides in the domain of casual labor, commanding a substantial sum of ₹0.84 million, which equates to 43.43% of the entire variable cost structure. This is closely trailed by the allocation for electricity charges, tallying to ₹0.70 million or 36.36% of the variable costs. Additionally, the charge for interest on working capital accounts for ₹0.17 million, corresponding to 9.09% of this fiscal segment.

Further dissection delineates that the expenditure linked to the procurement of bleaching powder and alum is valued at ₹0.15 million, occupying an 8.02% portion, while the cost ascribed to repair and maintenance is assessed at ₹0.06 million, representing a 3.1% allotment of the total variable cost. Turning attention to the realm of annual fixed expenses (₹4.24 million), the most substantial allocation is ascribed to permanent human labor, reaching ₹2.04 million, a proportion equivalent to 48.05% of the overall fixed cost structure. The assessment is followed by the stipulated depreciation sum, which accounts for ₹1.82 million, standing at 42.86% of the fixed costs. Finally, the charge denoted as interest on fixed capital concludes this segment, commanding an amount of ₹0.17 million, representing 9.09% of the comprehensive fixed cost framework.

Table 3. Cost structure of Kakapora water treatment plant in river Jhelum

Cost components	Amount in million (%)
Annual variable cost	
Bleaching powder and alum cost	0.15 (8.02)
Electricity charges	0.70 (36.36)
Casual labour	0.84 (43.43)
Repair and maintenance cost	0.06 (3.10)
Interest on working capital (10%)	0.17 (9.09)
Sub total	1.93 (100)
Annual fixed cost	
Depreciation	1.82 (42.86)
Permanent human labour	2.04 (48.05)
Interest on fixed capital (10%)	0.38 (9.09)
Sub total	4.24 (100)

The comprehensive annual expenditure attributed to the operational maintenance of the Kakapora Water Treatment Plant aggregates to a sum of Rs. 6.18 million, as precisely tabulated in Table 4. The facility, characterized by its water purification capacity of 0.90 million gallons per day, confers its benefits upon a populace of 0.017 million individuals, spanning across 0.006 million households in the region, as meticulously documented by the Jammu and Kashmir Infrastructure Development Finance Corporation (JKIDFC) in the year 2019.

In accordance with the established figures provided by the JKIDFC (2019), the tariff levied annually upon each household is denoted as Rs.0.001 million, culminating in an accrued revenue stream of Rs.6.264 million, emanating from the entirety of the beneficiary households. The governmental investment in this

initiative is notably rewarding, substantiated by a Benefit-Cost Ratio (BCR) of 1.014. The equitable distribution of the processed water within the area translates to an allocation of 5.15 gallons (equivalent to 19.48 liters) per individual on a daily basis. Consequently, the Kakapora Water Treatment Plant is accountable for the purification of a grand total of 32.85 million, gallons of water annually, extracted from the Jhelum River, to serve the purposes of potable consumption. Calculations, rooted in the quotient derived from dividing the aggregate annual cost by the cumulative gallons of water treated, yield an expenditure of Rs.0.188 per gallon. Given the conversion factor of 1 gallon being equivalent to 3.785 liters, the equivalent unit cost and value per liter of treated water manifest as Rs.0.0499 and Rs.0.0504, respectively.

Table 4. Cost and returns of Kakapora Water Treatment Plant in river Jhelum

Parameters	Value estimated	Source
Total annual cost (million Rs.)	6.180	Author estimates
Population benefited per year (million)	0.017	JKIDFC, 2019
Number of households benefited (million)	0.006	
Annual fee (revenue) per household (million Rs.)	0.001	
Annual revenue from all households (million Rs.)	6.264	Author estimates
Water treatment capacity per day (Gallons) in million	0.90	JKIDFC, 2019
Water availability/ used per capita per day (Gallons)	5.15	Author estimates
Water availability/ used per capita per day (litres)	19.48	
Total gallons of water filtered in a year	32.85	
Net profit per year (million Rs)	0.084	
Net profit per gallon (Rs.)	0.003	
Water treatment cost per gallon (Rs.)	0.188	
Water treatment cost per litre (Rs.)	0.0499	
Price or value of 1 Gallon of portable water (Rs.)	0.191	
Price or value per litre of portable water (Rs.)	0.0504	
Benefit cost ratio (BCR)	1.014	

Taking the Kakapora Water Treatment Plant as a base, it inferences that the government provides 5.15 gallons (19.48 litres) of filtered water for every individual who resides on the river Jhelum water source for drinking, cooking, washing and other domestic uses. Table 5 shows that the total number of water gallons used by the whole population is 1.552 million per day. Similarly, the total volume of water used per year by 3.01 lakh people residing on river Jhelum water was 566 million gallons. Therefore, the value or price for all the amount of filtered water (566 million gallons) used for drinking and other domestic purposes from river Jhelum per year is Rs.108 million. This value is the service the river Jhelum provides in the form of potable water used for drinking and other domestic purposes.

Table 5. Economic valuation of river Jhelum water used for potable purposes

Parameters	Value estimated	Source
Total population which use filtered water from river Jhelum for drinking purpose (m)	0.301	Census 2011
Total number of water gallons used by the whole population per day (m)	1.552	Author estimates
Total number of water gallons used by the whole population per year (m)	566.394	
Value or price for all the quantity of filtered water used for drinking purpose from river Jhelum per year (Rs)	108.003	

Conclusion

The economic valuation of filtered water used for drinking purposes from river Jhelum was done using the cost-benefit analysis method. It was found that the government provides 5.15 gallons (19.48 litres) of potable water for every individual who resides in the river Jhelum water source. The value per gallon of potable water worked out to be ₹0.191 (₹ 0.0504 per litre). In other words, the value of 566 million gallons of river water used for drinking and other domestic purposes from river Jhelum per year was ₹108 million. Quantifying the importance of river water in the Jhelum basin will add to the literature and also helps in designing suitable policies for better resource management. Earlier, people ignored the value of services provided by the river, like water for irrigation and other domestic purposes, sand and boulders for construction. But as the population size of the Kashmir valley expands, it becomes complex and costly for the administration to provide every individual with a glacial potable water resource. The best option available to the local government is the approximate investment in sustainably reusing the harnessed riverine resource. It will benefit both economically, socially, culturally, and environmentally.

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