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Cost–Benefit Analysis of Rainwater Harvesting Systems in Bangladesh: A Case Study of Mongla Upazila

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ABSTRACT

Coastal areas in Bangladesh are finding it harder to get safe, cheap drinking water because saline water is getting in, rainfall is unpredictable, and other water sources are pricey. This study looks at whether it is worthwhile for families to set up Rainwater Harvesting (RWH) systems in Mongla, a salinity area in Bagerhat. This study used a Cost-Benefit Analysis (CBA) to figure out if it pays off. This study looked at things like Net Present Value (NPV) of 293938.6 BDT, Benefit-Cost Ratio (BCR) of 20.9, Internal Rate of Return (IRR) of 236.09%, Health Cost and how long it takes to get money back. The study got info from surveys of 100 people who use RWH and 100 who don't, including costs for setting up, maintenance, health, and time spent. RWH systems really cut down on the time and money people spend getting water and going to the doctor because of unpurified water. Even if initial costs go up or benefits go down, the system still works well. RWH looks like a cheap and easy way to deal with the drinking water problem in coastal Bangladesh. The study says RWH should be included in the country's water plans, give poor families money to set up these systems, and train people to keep them running.

INTRODUCTION

Rolling up and storing rain is a highly demanded for drinking water management, particularly in topographic regions that are running succinctly due to weather changes. The inhabitants of the Mongla Upazila in Bagerhat District have access to a source of water which is actually very fresh for drinking. The report I've been reading from the Bangladesh Government shows that chloride (CL) concentrations in the aquifer can reach up to 9500mg/L. WHO states that anything exceeding 250 mg/L refers to, and anything between 600 and 1000 mg/L is already evaluated as excessively saline for drinking. Nevertheless, many people drink the unpurified water, so they have no other option when it comes to meet their daily water needs. While it is clear that rain harvesting benefits the conditions and communities, little information is available on its fiscal effects at the household level, especially in rural areas, such as Mongla, which is helpless in relation to climate change. In Bangladesh, the main investigative focus is either on the technical side or on the manner in which the rainwater frameworks help the inhabitants or on the manner in which they are low cost to the families. The mandatory monetary index appreciation Net Present Value (NPV), Benefit-Cost Ratio (BCR), and intrinsic Return Estimate (IRR) has not been given sufficient attention here. Consequently, a number of judgments on procedures and community undertakings lack strong indications that the rain collects wages for the family.

Objectives of the Study

The purpose of this study is to assess the financial usefulness of household RWH systems in Mongla through a detailed cost-benefit analysis. Initial investments, labour costs, nestlings in water, and structure longevity exceeding 20 years are considered in this assessment. The impact of key financial factors such as water prices, care costs, inflation and discount rates on the resilience of such arrangements will also be examined.

Research Questions

There has a full questionnaire set of survey questionnaire, FGD and KII questionnaire, the main focus of the questionnaire is:

1. Is household rainwater harvesting systems economically viable in Mongla, Bagerhat?
2. What are the main financial indexes (NPV, BCR, IRR, and repayment time) associated with a typical RWH system in the current region?
3. How do variations in cost, rainfall, or maintenance affect the economic sustainability of RWH systems?

LITERATURE REVIEW

Rainwater Harvesting (RWH) is regarded as a long-term water supply solution, particularly in regions where reliable access to pure groundwater or piped water is lacking. Family RWH frameworks typically include rooftop catchment surface, storage tank (ranging from 1,000 to 5,000 liter), gutter, and first flushing devices in technical clauses. Investigations in the South Orient, including Bangladesh and India, reveal that RWH systems can supply between 30 % and 60 % of household water supply during the monsoon period (Chowdhury & Rahman, 2010; Pande *et al.,* 2019). In the context of the riverine of Bangladesh, institutions like BRAC deploy

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over 5,000 family and society RWH systems in Mongla, which significantly improves access to local water for approximately 72,000 inhabitants. Economically, a number of studies have assessed the viability of RWH leveraging parameters such as Net Present Value (NPV), Internal Measure of Return (IRR), and the Payback era. For instance, (Islam *et al.* 2015) carried out a financial assessment of the RWH arrangements in Khulna and found them to be financially viable alongside an IRR exceeding 10% and a repayment period of less than 7 years. Similar discoveries were made in the research conducted in Chennai, India, where rooftop RWH systems resulted in a reduction in municipal water costs and a decrease in the force used to extract groundwater (Chandrasekar *et al.*, 2018). These questions underline the double support of cost reserves and green conservation. Cost–benefit analysis (CBA) is a necessary tool for water provision economics enabling partners to Analyze the long-term monetary and interpersonal addition of intervention to their capital and working costs. CBAs have been used to assess the various water system undertakings, including irrigation systems, desalination plants, and community water supply schemes. Haque and Siddique, who had been introduced to CBA in the year 2012-12 in order to measure the sand filter in the saline-prone region of Satkhira and discover a robust benefit-cost ratio and a net tax return, had been acquainted with CBA in the year 2012-12. KC *et al.* (2016) permitted CBA to justify investments in gravity-fed water supply systems, demonstrating higher tax returns on duration reserves and better welfare outcomes. However, its use, the use of strict CBA paradigm to establish RWH frameworks in climate-vulnerable areas of Bangladesh remains limited. Most prevalent surveys either prioritized technical viability or applied an easy economic prosody lacking a rejection of the approaching cash flow, faltering in order to translate the costs of organizational life, operation and maintenance (O&M) costs, or inflation adjusted nest egg. Nearby is a significant lack of region-specific fiscal evaluation for family RWH in southwest Bangladesh, especially in coastal upazilas such as Mongla. Furthermore, a small number of investigations integrate applied statistics from NGO intervention (BRAC's RWH program under conventional financial appraisal standards). Moreover, sensitivity analyses, a key element in assessing the resilience of undertakings under cost variability or rain uncertainty, are largely missing.

The present Sheet addresses these shortcomings by overseeing the comprehensive design of the family RWH framework in Mongla, integrating installation and operation and maintenance costs, water saving, and a 20-year structure life. We take a look at publicly available BRAC information and domestic water price benchmarks and estimate a key monetary index, including the NPV, BCR, IRR, and Payback Period. Furthermore, sensitivity tests were conducted to examine how fluctuations in cost and benefit parameters affect fiscal outcomes. By providing a resilient and context-specific economic evaluation that explores the real world for policymakers, NGOs, and donors to understand RWH investments in the coastal of Bangladesh.

MATERIALS AND METHODS

The present study aims to assess the financial feasibility of Rainwater Harvesting (RWH) arrangements at the family stage in Mongla Upazila, a salinity-prone region in maritime Bangladesh, by adopting a mixed methods study design integrating equally quantitative and qualitative data. Mongla, located in the district of Bagerhat, had been chosen due to their acute water shortage, salinity, and dependence on alternative water sources. The second rain variability and socioeconomic vulnerabilities make it a key location for the implementation of RWH as a climate adaptation plan.

The primary facts were gathered from 200 families (100 RWH users and 100 non RWH users) through the structural survey, covers: demography, water usage and access, installation and maintenance cost of RWH systems, time spent on water collection, incidence and cost of waterborne diseases, willingness for future expansion

The Bangladesh Meteorological Department (BMD), local NGOs, and a printed report provided additional information on rainfall patterns, water quality, and rural wages.

The study applies a Cost–Benefit Analysis (CBA) framework using: Net Present Value (NPV), Benefit–Cost Ratio (BCR), Internal Rate of Return (IRR), Payback Period

We are familiar with a discount rate of 6 %, which is constant with the public sector evaluation in Bangladesh. In order to assess the robustness of the consequences under a changing fiscal state, sensitivity analysis was carried out with 4% and 8%.

Ethical Considerations: During the conception and operation of the study facility, the analysis facility shall comply with moral criteria. The following procedures were taken into account. Prior to the facts cluster, each participant in the inspection was the object of a light sanction. The respondent was informed of the purpose of the analysis, the voluntary setting of loyalty, and the correct way of removing it from each span.

- Neither individual identification information (PII) nor statistical anonymity has been ensured for statistical data. Each statistic was stored in an encrypted electronic format which could only be accessed by the review partnership.
- The scope of the investigation does not include all clinical procedures or vulnerable populations. A virtuous recommendation for group investigation and use of facts has been approved, in line with the investigative protocol of the Individuals of Bangladesh and the comment of Helsinki.
- No financial incentives were provided that could have biased responses; participation was entirely voluntary.

The present moral technique was developed with regard to the autonomy of the participants and to guarantee the reliability and honor of the findings of the research.

Tools and Software: Data analysis and financial modeling were conducted using a combination of statistical and spreadsheet tools. For the initial data entry, tabulating, and basic calculations, including the accumulation of accumulated cash flows, the era of repayment, and the calculation of the time cost, Microsoft Excel was used. Using the npf.npv and npf.irr functions, it was used to calculate excess high-tech economic prosody, such as net current value (NPV) and internal appraisal of return (IRR) STATA was used to generate a visual image, including a bar chart, an accumulated NPV graph, and a sensitivity analysis plot. QGIS (for Spatial Data) was a study on recognizing roof region power in relation to rainfall statistics and catchment functions. All calculations were validated by cross-checking results using at least two independent methods.

RESULTS AND DISCUSSION

Components of Rainwater Harvesting System:

- Catchment surface: Gutters, downspouts and roof drains, Leaf screens, first-flush diverters and roof washers, Storage tanks,
- Treatment/purification systems
- Catchment Area: Rooftop area of 30–50 m²
- Storage Tank: 2,000-liter capacity, polyethylene or ferrocement
- Components: Gutter system, first-flush diverter, downpipe, filtration unit, storage tank, and tap outlet
- Installation Cost: BDT 30,000 per unit (includes materials, labor, training, and basic maintenance setup)
- Operational & Maintenance Cost: BDT 1,500 per year (includes cleaning, minor repairs, and filter replacement)
- Expected Lifespan: 20 years the system shall be designed to collect and store rain during a monsoon calendar month and provide safe drinking water to an average family of 4–6 members during a dry period.

The average storage capacity of the rain harvesting tank in the 100 survey families was strategic so as to have approximately 2,217.17 liters. It should be noted that commercially convenient family rain tanks are usually manufactured in standard capacities, e.g., 500 L, 1,000 L, 1,500 L, 2,000 L, or otherwise 3,000 L). Thus, the measured average corresponds exactly to a single tank size but rather represents the aggregate mean through the various storage configurations in the sample. The current finding indicates that the majority of cooperating families use tanks with a nominal capacity higher than 2,000 liters, indicating a preference for medium in order to provide large family storage solutions within the limits of penetration into locality. 'It's not about the money'.

Table 1: Annual Water Purchase Cost (AWPC)

Parameter	Unit	Value	Notes
Average daily water purchase cost	BDT/day	35.12	(1,053.64 ÷ 30 days)
Average monthly water purchase cost	BDT/month	1,053.64	Survey data
Annual water purchase cost	BDT/year	12,643.68	1,053.64 × 12 months

- The daily cost (≈ BDT 35.12) reflects the average household's out-of-pocket expenditure for water.
- This is scaled up linearly to produce the monthly and annual equivalent for budgeting and cost–benefit analysis.
- This simple linear annualization assumes constant demand and stable prices, which is reasonable for basic CBA unless seasonal price fluctuations are significant.

The annual household expenditure on purchased water is estimated using the average monthly cost (BDT 1,053.64), derived from primary survey data. This cost is assumed constant throughout the year, resulting in an annual water purchase cost of BDT 12,643.68 per household, following the model: AWPC = Cm × 12.

Table 2: Transportation Cost

Parameter	Unit	Value	Notes
Average daily transportation cost	BDT/day	7.71	(231.39 ÷ 30 days)
Average monthly transportation cost	BDT/month	231.39	Based on household survey
Annual transportation cost	BDT/year	2,776.68	231.39 × 12 months

$ATC = C_{tm} \times 12$
$= 231.39 \times 12$
$= 2,776.68$ [tm= Transportation per year]

In the study area (Mongla), local transportation for moving goods typically relies on several common modes. Rickshaw vans are the most widely used for short distances, while manual pedal rickshaws are preferred for carrying smaller containers. Easy-bikes, which are battery-powered three-wheelers, and tomtoms, locally adapted electric or diesel three-wheelers, are also frequently used due to their availability and low operating cost. In riverside or canal areas, boats become the primary mode of transport, especially during high tide. Occasionally, motorbikes or even manual head-loading are used for transporting small volumes when other options are not feasible.

The above-mentioned neighborhood conveyance method reflects the ease and convenience of the water accumulation points with respect to the location of the dwelling. From the average monthly family expenditure of BDT 231.39, which is equivalent to approximately BDT 7.71 a day, the annual transport costs of transporting rolled-up water shall be reduced by the amount of BDT 231.39 per month. The current cost reflects the common practice in Mongla of hiring small public transport vehicles, such as the jinrikisha avant-garde, manual jinrikisha, easy motorcycle, Tom-Tom, and boat, depending on the distance and seasonality. Therefore, the annual moving costs per family are BDT 2,776.68 and are planned as follows: $ATC = C_{tm} \times 12$.

In addition to the main monetary expenditure, the families who do not have Rainwater Harvesting (RWH) schemes in Mongla incur significant hidden costs by using intervals to obtain safe drinking water. Based on the examination response, the family spends an average of 616 minutes and 12 minutes atop the water collection a year. In order to take into account, the real monetary burden, the present study uses the possibility of cost manipulation, i.e. loss of time using the local average daily wage for low skilled workers. The hourly wage shall be BDT 56.25, together with the prevailing rural wage of BDT 450 per day (working time of 8 hours). Using this rate, the annual cost of cleaning a water cluster is approximately BDT 34,198 per family per year. This figure represents revenue that could have been gained if the family member had been engaged in productive work instead. It also points out that the era has been misplaced in tuition, attention fatigue, or rest—factors that are not always captured by conventional financial analysis. Integrating that prospect cost strengthens the scenario for RWH arrangements by exemplifying nay is not used in academic writing only for their welfare and environmental benefits although, apart from their ability to significantly reduce indirect monetary burden. This comprehensive assessment is in line with the important task of renewable energy and social equity, in particular in the case of low income and climate-vulnerable communities.

A household without RWH spends 616 hours a year collecting water, which is worth BDT 34,158.75 per year, based on community wages in rural areas. The cost component measures under the current scrutiny include the managing economic expenditure on water procurement; transport, medical equipment, and the opportunity cost associated with the eradication of waste water. According to the information checked, the average family spends a monthly outlay of BDT 1,053.64 on water, resulting in an annual cost of BDT 12,643.68. The associated transport costs amounted to a total of BDT 231.39 per calendar month, amounting to BDT 2,776.68 per year. Apart from these straightforward costs, households without rain collection (RWH) organizations spend an estimated 616 intervals per year on collecting water. The equivalent hourly wage would be BDT 56.25, which is close to the regional average of 450 BDT per day for 8 hours of work per week. Accordingly, the annual cost of duration spent on water harvesting is estimated to be approximately BDT 34,158.75. Medical expenditure related to the treatment of waterborne diseases adds further to the family burden. In comparison with an annual cost of BDT 25,619.52, each family incurs on average BDT 2,134.96 per calendar month in clinical expenditure. In the absence of a RWH structure, the annual cost calculated per family is approximately BDT 75,198.63. This figure provides a baseline for the economic evaluation of the potential savings that can be achieved through the implementation of rain harvesting innovations.

Table 2: Medical Cost

Parameter	Unit	Value
Average monthly medical cost	BDT/month	2,134.96
Average daily medical cost	BDT/day	71.16
Annual medical cost	BDT/year	25,619.52

Lack of access to safe drinking water, such as diarrhea, dysentery, cholera, typhoid, and skin diseases, is significantly increasing the incidence of waterborne diseases in coastal Bangladesh, including Mongla. Such diseases require a direct financial burden on the family through out-of-pocket expenditures on medical visits, medicines and misplaced duty days. Beyond general illness, lack of secure water access and climate stressors have hidden gendered impacts: Women and adolescents are confronted with a need for monthly cleaning leadership, with a large number of them adopting wrong strategies of coping. During an ecological catastrophe, for instance, cyclone, and flood when safety water entry and privacy are compromised, females regularly use contraception to delay the period of time when they do not have access to water for bathing and hygiene. C-section births are reported in the current exploratory zone by 72.39 % of female respondents, a figure far higher than the federal average, and are partially correlated with underprivileged health conditions, undernutrition, and stress caused by water insecurity. Non-religious households incur significant medical costs related to waterborne diseases in addition to managing family expenditure on water acquisition and transit. The average monthly healthcare expenditure report for a family is BDT 2,134.96, corresponding to an annual financial responsibility of BDT 25,619.52 per family (AMC = Cmm 12). These costs are primarily intended to protect treatment of diarrhea, dysentery, and other waterborne diseases which remain widespread in order that dangerous or incoherent drinking water will not be introduced.

Women and adolescents bear disproportionately the health burden of water insecurity. In the present study, 72.39 % of female respondent reports delivered cesarean delivery, a finding significantly superior to regional recommendations, echoing the increasing challenges of maternal health. Moreover, the lack of safe water and sterile resources forces many women to suppress menstrual cycles through the use of hormonal contraceptives and exposes them to additional health uncertainty during an innate catastrophe. The restricted option for menstrual purity exacerbates the diseases and entails a greater dependency on the coveted medical attention. These results show that the real cost of insufficient water intake extends sufficiently beyond the immediate monetary loss, the significant gender-specific fitness, and the social outcomes that need to be addressed through combined water, hygiene, and fitness interventions.

Household-Level Cost–Benefit Analysis of Rainwater Harvesting (RWH)

1. Storage Tank Capacity and Seasonal Use The average storage tank capacity surrounding the 100 survey RWH family was assessed together with 2,217 liters. Although this figure does not correspond to a specific market tank size (typically 500 L to 3,000 L), it represents an aggregate average of the various family storage arrangements. The average number of family reports using harvested rain is approximately 4.14 calendar months per calendar year. The current seasonal pattern of use is consistent with regional rainfall allocation, stockpile restrictions, and operational efficiency of rooftop harvesting systems.

2. The initial assets stake the initial assets expenditure for the RWH installation, designated C_0, includes the procurement and installation of the storage tank, gutter, first flush diverter, and basic filtration unit of measurement. The average shareholding in the assets was discovered to remain BDT 31,377.90 per family. In the CBA skeleton, the current cost shall be treated as an old fixed cost. Economic expression: $C_0 = C_{tank} + Cg_{utters} + Cfirst\ flush + Cfiltration$

3. Annual maintenance expenditure: households incur annual maintenance expenditure (Cm) to maintain structural functionality and water quality. The expenses mentioned above, the average cost of 506 BDT per family per year, cover cleaning, minor repairs, and replacement of a plain filter or pipe. The current expenditure shall be treated as a recurring operating expenditure in the financial model. Economic expression: Cm = Mj (j = 1 to nitrogen), wherein Mj = cost of human care item.

4. Quantifiable annual savings (Sa) arising from the implementation of RWH are primarily intended to reduce dependence on purchased water and related transportation expenses during the useable storage era. Estimated average annual reserves per family were approximately BDT 4,864.60. Economic expression: Sa = (Cw + Ct) savings, where Cw = water purchase cost avoided, Ct = transport cost avoided

5. Fitness Cost Assets and Co-benefits the reduction in family expenditure on medical treatment for waterborne diseases is an essential co-benefit of RWH adoption. The average monthly cost of BDT 2,134.96 is reported by the non-RWH family, while the RWH family reports a very low monthly cost of BDT 617.94. This disparity is estimated to have an annual healthcare cost economy of BDT 18,204.24 per family. The fiscal model treats this as an indirect benefit (Bh). Economic expression: = (Cm, non RWH − Cm, RWH) × 12

6. Gender specific vitality burden Besides the usual monetary implications, the conclusions reveal significant gender-specific vitality burden. Restricted access to clean water when climate extremes force females and adolescents to adopt detrimental strategies, similar to using hormonal contraception to delay periods when cleanliness is poor. The current delves into, in addition to creating a disproportionately higher cesarean division (C-section) determine in the middle of female respondent 72.39 % report delivering via C-section — significantly above the patriotic average. These data highlight the combined risks associated with subpar water entry, including maternal morbidity and underprivileged procreant health outcomes.

Cash Flow & Valuation

For the purpose of assessing the monetary viability of the Rain Harvesting Organization over a 20-year operating lifecycle, a detailed cost-benefit analysis was carried out. The initial purchase price was assessed in addition to 31,377.9 BDT, which represents an annual 0. The structure has been generating reliable annual bonuses of 74,078.8 BDT from the first quarter onwards, which has resulted in a steady increase in the net cash current beyond the limit.

Accumulated cash current of approximately 818,300.1 BDT per annum using a discount rate of 6 %. In contrast, the accumulated nominal cash flow (nay account for the span value of money) amounts to 1,450,198 BDT, in addition to stressing the continuing monetary rewards of the organization. The firm achieved a repayment in less than one annual period, together with an accumulated reduction in aid which exceeded the initial stake as early as annually 1. This rapid repayment reflects the higher annual earnings stream compared to the lower capital costs of implementation. As a result of the decline in the annual bonus from 69 885.66 BDT a year 1 to 23,098.12 BDT a year 20, the discounted perk beliefs have been gradually worsening over the course of the fiscal year in order to affect the overall effect of the widening of the market value.

However, the effective cash movement remains stable and robust throughout the business cycle. Such discoveries, confirmed by a steady flow of cash and a positive ratio of benefits to costs, clearly indicate the economic viability and sustainability of rain harvesting systems in the examined location. It significantly outperforms the initial costs and provides an attractive solution for household and community water security strategies in Bangladesh.

Cumulative Cash Flow: $CGFT = \sum_{(t=0)}^{T} CF_t$

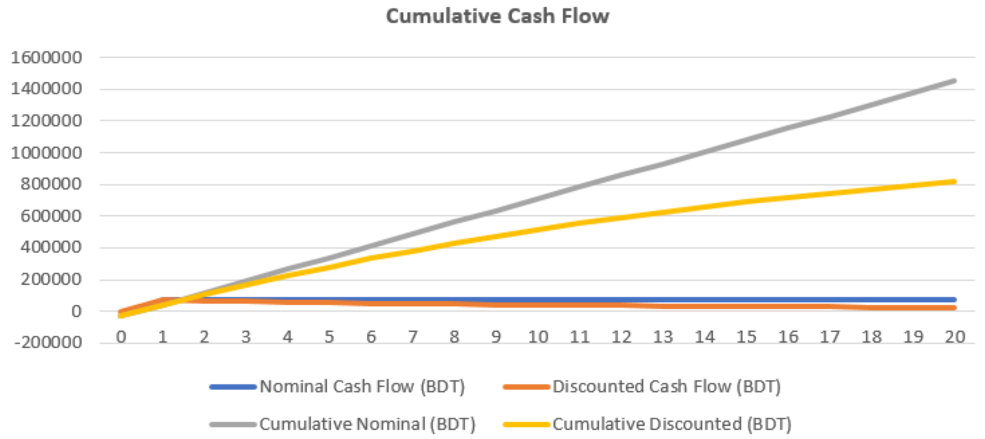

Table 1: Cumulative Cash Flow (Highlight the year NPV crosses zero (≈ year 7))

Net Present Value (NPV)

The Net Present Value (NPV) of switching from a non-RWH system to a RWH system is: BDT 404,714 over a 20-year period (at 6% discount rate). "This analysis uses a 6 % discount rate in accordance with the standards for public sector acquisitions and evaluation of NGOs in Bangladesh. It takes into account moderate inflation, resource prospect costs, and realistic risk levels for household RWH undertakings. To check the robustness of the findings, a sensitivity review shall be conducted between 4 % and 8 %. 'It's not about the money."

NPV Formula: $NPV = \sum_{(t=1)}^{n} (B_t/(1+r)^t)$

=11.47

NPV = 25619 × 11.47 = 293938.6 BDT

Approximately BDT 293,939 represents the net present value of the avoided clinical costs over 20 years as a result of the use of the RWH system. Tank installation cost: Average cost 31377.9 BDT. They can harvest 4.14 month. The annual cost of treatment: 1767.18 BDT. Max. 2990 BDT, last 506 BDT; current includes tap, pipe damage by default and inherent catastrophe. So, if this cost accounts for 20 years, then cost will be 35,343.6

So, NPV= 293939 – 35343.4 = 258,595.4

Inflation (5%) adjusted cost = 258,595.4 - 12929.77 = 245,665.23

NPV = 258,595.40

Inflation rate = 5%

Time= 20 years

$FV = PV \times (1 + f)^n$

FV = 686,134.64

Table 3: Cost-Benefit (Yearly)

Year	Inflation Adjusted Benefit	Inflation Adjusted Annual Cost
0	258595.4	------------
1	271525.17	41060.15
2	285101.43	43113.15
3	299356.5	45268.81
4	314324.32	47532.25
5	330040.54	49908.86
6	346542.57	52404.31
7	363869.7	55024.52
8	382063.18	57775.75
9	401166.34	60664.54
10	421224.66	63697.76
11	442285.89	66882.65
12	464400.18	70226.78
13	487620.19	73738.12
14	512001.2	77425.03
15	537601.26	81296.28
16	564481.33	85361.09
17	592705.39	89629.15

18	622340.66	94110.61
19	653457.7	98816.14
20	686130.58	103756.9

BCR

BCR = $(\sum(B_t/(1+r)^t))/(\sum(C_t/(1+r)^t))$

$= PV_b/PV_c$

= 777180/37180

BCR ≈ 20.90

A BCR of 20.9 means:

For every BDT 1 invested in RWH, you get BDT 20.9 in present value benefits indicating extremely strong financial viability.

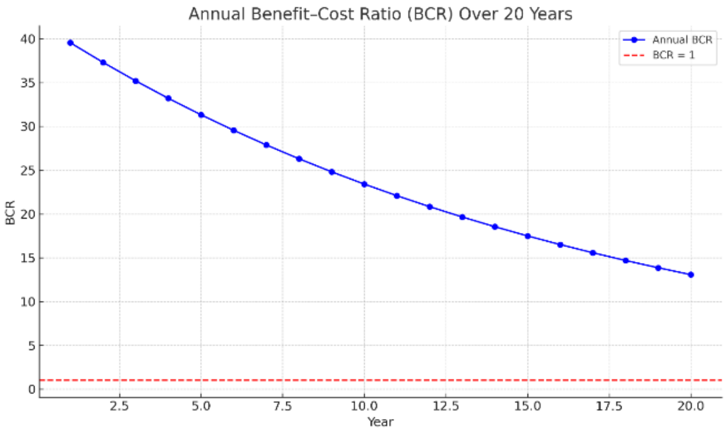

Table 2: Annual benefit-cost ratio(BCR) over 20 years

IRR

Internal Rate of Return IRR = 236.09%

Payback Period (Nominal & Discounted)

Time (in years) when cumulative net cash flow ≥ 0

- Nominal Payback = 1 year.
- Discounted Payback = 1 year

• The internal rate of return (IRR) for the rain harvesting (RWH) framework was strategic to be approximately 236.09 %, which is significantly above the normally used discount rate of 6 %. The current exceptionally high IRRs indicate that the venture is economically feasible, generating a rapid tax return on the initial investment. The identical tax return demonstrates that, for each legal tender unit invested in the RWH organization, more than two units of measure are recovered annually in the form of water reserves, avoidance of water procurement, and related socio-economic support.

• This effect shows that the structure has been able to recover costs very quickly, possibly within the first otherwise following year of operation, and has continued to provide significant net benefits throughout the duration of its planned life. Although IRRs exceeding 100% are relatively rare in Foundation undertakings, the result is plausible given the combination of low initial investment costs, high rainfall, and uninterrupted gains in the analyzed area.

• However, the unusually high level of IRR requires careful interpretation. It is recommended that the estimates remain contextualized in local situations, structure, and assumptions on the distribution of benefits and care fidelity. However, the findings strongly support the economic defense for a wider and wider RWH deployment and expansion in the water-stressed and salinity-prone regions of Bangladesh.

Findings

• A comparative assessment of 100 families that do not use Rainwater Harvesting (RWH) systems to determine their water costs, era burden, and vitality impacts.

• Demographics and household characteristics surrounding the survey non-RWH users, 60 % were male-headed households and 40 % were female-headed households, with an average household size of 5.58 persons.

• The economic costs relating to the purchase of water by the aforementioned family amounted to BDT 1,053.64 a month and amounted to approximately BDT 12,643.68 a year. Furthermore, the family incurs an average monthly transport cost of BDT 231.39 to transport water otherwise bought, compared to an annual cost of BDT 2,776.68. An average of 1.69 hours a day, a total of approximately 20 hours and 16 minutes a month is needed to select water intervals. In particular, a low-income family relying on habitual work is subject to mandatory risk costs.

• In terms of well-being, 76% of respondents reported experiencing waterborne diseases compared to 25% who did not experience any. The average monthly healthcare costs related to waterborne illnesses amounted to BDT 2,134.96 or approximately BDT 25,619.52 per year.

• The total annual cost of purchasing, transporting, and treating water, non-reverse hydrant users face an average annual cost of BDT 41,060.15 is a reminder of the significant fiscal burden on accessing safe water without rain harvesting structures.

• Users of RWH in maritime Bangladesh have high fiscal and time costs related to water procurement and a significant health burden due to waterborne diseases. The above discoveries highlight the urgent need to improve access to water, such as RWH arrangements, which can reduce economic strain, reduce the incidence of diseases, and allow the free tenure of productive projects.

Table 4:

Parameter	RWH Users (Average)	Non-RWH Users (Average)
Installation Cost	BDT 31,377.90 (one-time)	N/A
Annual Maintenance Cost	BDT 1,767.18	N/A
Annual Water Savings	BDT 4,864.60	N/A
Monthly Water Purchase Cost	Minimal/Zero (harvested)	BDT 1,053.64
Monthly Transportation Cost	Minimal	BDT 231.39
Annual Water & Transport Cost	Low (included in savings)	BDT 15,420.36
Annual Medical Cost	BDT 617.94 (monthly)	BDT 2,134.96 (monthly)
Time Spent Collecting Water	Not significant (on-site)	~1.69 hours daily (20h 16m monthly)
Waterborne Diseases	Majority unaware if RWH reduced medical costs (65%) but 26% reported reduction	76% reported waterborne diseases
Medical Expenses	BDT 617.94 monthly	BDT 2,134.96 monthly
Recommendation of RWH	93% Yes	N/A
Intent to Expand RWH	28% Yes	N/A

CONCLUSION

This study shows that household-level rainwater harvesting systems are a financially sound and socially advantageous adaptation strategy for addressing water insecurity in coastal regions of Bangladesh. The findings indicate that the adoption of rainwater harvesting notably lowers household water expenses, alleviates health-related expenditures, and diminishes the considerable opportunity costs tied to water collection, especially for women and low-income individuals. The findings are consistent with current literature, suggesting that rainwater harvesting systems can improve water security and alleviate the socio-economic challenges caused by climate-induced salinity and groundwater degradation. The economic evaluation reinforces the long-term financial sustainability of RWH systems, showcasing high internal rates of return, favorable net present values, and payback periods that are competitive with similar studies in South Asia. The interplay of direct financial savings, decreased disease occurrence, and enhanced household efficiency highlights the extensive developmental possibilities of rainwater harvesting, extending far beyond mere water supply. Overall, the results indicate that RWH systems can play a critical role in strengthening climate resilience in vulnerable coastal communities. The demonstrated economic and social benefits highlight the need for policy interventions that support wider adoption, including targeted subsidies for low-income households, community-based training on system management, and integration of RWH within local and national climate adaptation frameworks. Future research should examine long-term system performance across diverse climatic conditions and assess the institutional factors that influence sustained RWH utilisation. Through coordinated policy and programmatic support, RWH can contribute meaningfully to Bangladesh's broader objectives for water security, public health improvement, and climate adaptation.

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