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Analysis of Sustainable Finance in Financing the Development of an Integrated Drinking Water Supply System

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Abstract: Access to reliable, affordable, and sustainable drinking water remains a major development challenge in Indonesia, while the development of integrated drinking water infrastructure requires substantial long-term investment, appropriate financing structures, and effective risk allocation. This study analyzes the financial feasibility, sustainability, and risk resilience of financing an integrated upstream–downstream Drinking Water Supply System (DWSS) through a consortium-based Build–Operate–Transfer scheme. The research employs an applied quantitative approach with a single-case-study strategy using secondary project data. The analysis includes profit-and-loss projections, cash-flow projections, a 70:30 debt–equity financing structure, and capital budgeting indicators consisting of Net Present Value, Internal Rate of Return, and Payback Period. Project IRR is compared with the Weighted Average Cost of Capital, while Equity IRR is evaluated against the required shareholder return. A deterministic ESG-based sensitivity analysis is conducted under base-case, green investment, social affordability, downside-risk, and ESG-optimization scenarios by varying CAPEX, OPEX, debt, revenue, and Non-Revenue Water. Financial risks are further assessed using a risk matrix covering probability, impact, feasibility consequences, and mitigation measures. The results show that the project is financially feasible in the base case, with a Project IRR of 11.32%, exceeding the WACC of 9.67%, positive project and equity NPVs, and payback periods within the cooperation period. At the equity level, the IRR reaches 13.28%, exceeding the 12.22% target. Sensitivity analysis identifies revenue decline and tariff affordability as the most critical risks, while CAPEX, OPEX, debt, and NRW remain manageable through operational efficiency. The study recommends take-or-pay arrangements, blended finance, tariff-review mechanisms, NRW reduction, financing optimization, and integrated risk governance to maintain bankability, affordability, resilience, and long-term sustainability.

Keyword: Sustainable Finance, Drinking Water Supply System (DWSS), Financial Feasibility, ESG Sensitivity Analysis.

INTRODUCTION

Access to clean water and sanitation remains a major development challenge in Indonesia. As presented in Table 1, Indonesia recorded a Sanitation and Drinking Water score of 28.5 in the 2022 Environmental Performance Index, placing it ninth among the eleven Southeast Asian countries included in the comparison. Indonesia's score was substantially lower than Singapore at 93.3, Brunei Darussalam at 85.7, Malaysia at 57.6, Thailand at 55.9, and Vietnam at 52.8. This regional disparity indicates that Indonesia continues to face structural challenges in providing reliable, safe, affordable, and sustainable drinking water and sanitation services.

Table 1 Environmental Performance Index

Regional Rank	Country	EPI Sanitation and Drinking Water Score
1	Singapore	93.3
2	Brunei Darussalam	85.7
3	Malaysia	57.6
4	Thailand	55.9
5	Vietnam	52.8
6	Philippines	39.0
7	Cambodia	34.3
8	Myanmar	30.9
9	Indonesia	28.5
10	Laos	26.6
11	Timor-Leste	26.0

Source: Kualitas Sanitasi dan Air Minum di ASEAN (Goodstats.id, 2023)

Indonesia's relatively low position demonstrates that the drinking water and sanitation problem is not limited to the availability of physical infrastructure. It also concerns service coverage, water quality, continuity, affordability, operational efficiency, and the financial capacity of water-service providers. Addressing these challenges requires substantial investment in raw-water development, treatment facilities, transmission systems, distribution networks, household connections, and Non-Revenue Water reduction. However, drinking water infrastructure is capital-intensive, involves long investment-recovery periods, and is constrained by tariff affordability and operational risks. These characteristics limit the ability of government budgets and water utilities to finance infrastructure development independently. Therefore, sustainable financing mechanisms that combine public funding, private investment, debt and equity financing, appropriate risk allocation, and Environmental, Social, and Governance considerations are required to accelerate integrated upstream and downstream DWSS development.

In response to these challenges, the Government of Indonesia targeted the construction of 10 million piped household connections during the 2020–2024 period (Nasional/Bappenas, 2020). However, by the end of 2023, only 4,464,627 new household connections had been realized, leaving a shortfall of more than five million connections (Junoasmono, 2024). This substantial gap indicates that achieving national drinking water targets requires more than the construction of physical infrastructure. It also requires stronger policies, long-term funding, financially viable project structures, effective risk allocation, and coordination among the central government, regional governments, water-resource managers, drinking water utilities, investors, and financial institutions. Strengthening these institutional and financing arrangements is also essential to support the achievement of the 2030 Sustainable Development Goals and Indonesia's medium- and long-term drinking water and sanitation development targets.

Table 2 Household Access to Improved Drinking Water and Sanitation in Selected Indonesian Provinces, 2025

Province	Improved Drinking Water Access (%)	Improved Sanitation Access (%)	Difference (Percentage Points)
DKI Jakarta	99.98	93.98	6.00
West Java	95.84	76.20	19.64
Central Java	95.73	87.51	8.22
East Java	97.30	88.26	9.04
Banten	96.03	90.71	5.32
Indonesia	93.22	85.37	7.85

Table 2 (Statistik, 2025) shows that household access to improved drinking water is relatively high across the selected provinces, whereas access to improved sanitation remains more uneven. West Java recorded improved drinking water access of 95.84%, but its improved sanitation access was only 76.20%, resulting in a gap of 19.64 percentage points. This was the widest gap among the selected provinces and was substantially higher than the national gap of 7.85 percentage points. The comparison indicates that relatively high access to improved drinking water does not necessarily reflect balanced and integrated drinking water and sanitation services. It also highlights persistent challenges related to sanitation infrastructure, service quality, continuity, and disparities in service provision.

The provinces presented in Table 2 were selected to provide a regional comparison among several provinces on Java using comparable drinking water and sanitation indicators, not to statistically represent all Indonesian provinces, but to position West Java within a relevant regional context. Among the selected provinces, West Java recorded the widest gap between improved drinking water access, at 95.84%, and improved sanitation access, at 76.20%, resulting in a disparity of 19.64 percentage points, substantially higher than the national gap of 7.85 percentage points. This indicates that relatively high drinking water access in West Java has not yet been accompanied by equally adequate sanitation services. The selection of West Java is further supported by the operational condition of the regional drinking water utility involved in the proposed project, which recorded service coverage of only 34.55%, an NRW level of 34.55%, and unmet water demand of approximately 3,888 liters per second. These conditions demonstrate simultaneous challenges in service coverage, water-loss control, production capacity, infrastructure expansion, and service continuity. Combined with high drinking water demand, rapid urban and industrial development, pressure on existing water resources and infrastructure, and diverse conditions across regencies and municipalities, these characteristics make West Java an appropriate setting for evaluating a sustainable financing mechanism capable of integrating raw-water development, production facilities, transmission and distribution networks, household connections, service expansion, sanitation infrastructure, and NRW reduction within an integrated upstream and downstream DWSS framework.

These provincial-level challenges are also reflected in the operational performance of the regional drinking water utility involved in the proposed project. At the operator level, the fulfillment of drinking water needs still faces a significant service gap, necessitating the development of an integrated Drinking Water Supply System (DWSS) from upstream to downstream. According to the performance report of the Regionally-Owned Water Enterprise (BUMD) Drinking Water (Kementerian Pekerjaan Umum, 2024), one of the Regionally-Owned Water Enterprises (BUMD) in West Java has a service coverage of only 34.55%, with a water loss rate (Non-Revenue Water, NRW) of 34.55%. Of the total community water demand in the service area of 6,677 liters per second, only 2,789 liters per second can be served, or around 42%, leaving a service gap of 3,888 liters per second. This condition is caused, among other things, by the decreasing quantity and availability of raw water,

especially during the dry season due to environmental degradation (Mutiar, Hidayat, & Madiawati, 2024), so that investment is needed to obtain new raw water sources, increase production capacity, build and expand distribution networks, and reduce NRW levels in an integrated manner between the upstream and downstream sides.

An integrated investment approach is therefore required, covering the development of new raw-water sources, additional production capacity, transmission infrastructure, distribution-network expansion, household connections, and NRW reduction. This operational context strengthens the relevance of an integrated upstream and downstream DWSS project in West Java.

PT XYZ was purposely selected as the case-study company because of its strategic position in the water resources sector and its direct relevance to integrated drinking water infrastructure development. The company possesses institutional and operational competence in water resources management, raw-water provision, and the operation of water-related infrastructure. These characteristics distinguish PT XYZ from regional drinking water utilities that primarily focus on water distribution and customer services. Its upstream position in the water supply chain enables the company to contribute to the integration of raw-water sources, production facilities, transmission systems, distribution networks, and drinking water services.

The selection of PT XYZ is also relevant because the proposed project represents the company's strategic development from conventional water resources management toward more integrated drinking water infrastructure services. In this project, PT XYZ participates as a consortium member and equity investor in cooperation with a regional drinking water utility and other strategic partners. This arrangement combines PT XYZ's competence in water resources and infrastructure management with the regional utility's responsibility for water distribution and public-service delivery.

Based on the company's performance over the past decade, PT XYZ needs to pursue operational efficiency and business diversification to improve financial performance. Revenue tends to increase but is followed by rising operational expenses, resulting in relatively stagnant profit. One diversification strategy is to expand clean water supply services through the DWSS project, carried out in collaboration with strategic partners to broaden business coverage, create new revenue streams, and strengthen PT XYZ's financial performance. Collaboration in developing integrated upstream and downstream DWSS is a key strategy to increase clean water availability and advance PT XYZ's business development in the drinking water sector. PT XYZ plays a role as an integrated DWSS developer through investment cooperation with a Regional-Owned Enterprise (BUMD) for Drinking Water, which is carried out on a business-to-business (B2B) basis, with PT XYZ having competence in water resources management and BUMD for Drinking Water as the provider of drinking water services in the region. In its implementation, the development of integrated DWSS faces obstacles in the form of limited funding, operational risks, and limited experience of PT XYZ in building and operating integrated DWSS, so that PT XYZ forms a consortium with several other companies that are planned to form a joint venture or joint venture company that is responsible for financing, building, and operating integrated upstream and downstream DWSS infrastructure through a Build-Operate-Transfer (BOT) scheme with the Regional Owned Enterprise (BUMD) for Drinking Water, before finally all assets are handed over to the local government so that the sustainability of drinking water services to the community is guaranteed.

From an investment perspective, the proposed Integrated DWSS project is capital-intensive, has a long construction and cooperation period, and requires a combination of debt and equity financing. The planned financing structure of 70% debt and 30% equity exposes the consortium and PT XYZ to financing costs, leverage risks, construction risks,

operational-cost escalation, revenue uncertainty, tariff affordability constraints, Non-Revenue Water risks, and long-term investment-return requirements. These characteristics make the project appropriate for evaluating financial feasibility, project bankability, ESG-related financial risks, and risk allocation under a Build–Operate–Transfer arrangement.

The investment needs of the Upstream and Downstream Integrated DWSS project are planned to use a combination of equity and debt so that the consortium is not entirely dependent on its own capital, with a debt:equity structure planned at 70:30, while PT XYZ's funding portion is 10% of the 30% equity project. Strategic projects with large investment needs generally require a combination of debt and equity funding and may involve support from the government or other entities (Mutiarra, Hidayat, & Madiawati, 2024). The certainty of sustainability finance analysis on this investment is needed as a basis for consideration towards the joint venture formation stage, especially covering the Environmental, Social, and Governance (ESG) aspects to ensure that the investment plan is not only financially feasible, but also meets the principles of environmental sustainability, provides social benefits, and is supported by good governance, based on Law 17/2019 concerning Water Resources, PP 122/2015 concerning Drinking Water Supply Systems, Presidential Decree 38/2015 concerning PPP along with PPN/Bappenas Ministerial Regulation 2/2020, and PUPR Ministerial Regulation 27/2016 concerning DWSS Implementation.

Investment is the primary basis for infrastructure project development because it involves current capital investment to obtain future economic benefits (Sharpe, Gordon J. Alexander, & Bailey, 2005). Integrated DWSS development is considered both a real investment and an infrastructure project investment because it requires the construction of long-lived physical assets. Therefore, its feasibility needs to be analyzed through a feasibility study (Overton, 2007) before implementation. A business feasibility study assesses various aspects, including the financial aspect, which assesses the project's ability to generate revenue, cover costs, recoup investment, and provide a reasonable rate of return (Dr. I Made Adnyana, 2020). A financial feasibility analysis is necessary to ensure that capital-intensive infrastructure investments generate added value, maintain sustainable cash flow, meet financing needs, and provide a rate of return commensurate with the investment risk. Therefore, this study uses a quantitative approach through the preparation of profit and loss projections, cash flow projections, and calculations of Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period, in line with Hilman, Kristanti, & Hidayat (2026), who explain that capital budgeting is the main framework in making investment decisions. A project is declared feasible if the NPV is positive, the IRR is greater than the cost of capital, and the Payback Period is shorter than the operating period or concession period, where the Project IRR is compared to the Weighted Average Cost of Capital (WACC) and the Equity IRR is compared to the cost of equity. Financial projections are prepared based on assumptions of revenue, operational costs, depreciation, taxes, and financing structures (Brealey, Myers, & Allen, 2014), with DWSS project revenue calculated based on the volume of water sold multiplied by tariffs that can be sourced from bulk water sales, water sales to end customers, or revenue sharing or profit sharing (Yescombe, Principles of Project Finance, 2nd Edition, 2014), while DWSS operational costs include the costs of raw water, energy, chemicals, labor, maintenance, and general and administrative costs (Dr. Ir. I Gusti Ngurah Kerta Arsana, Dr. Mawiti Infantri Yekti, Dr. Eng. Ni Made Pertiwi Jaya, & Sagung Putri Chandra Astiti, 2024). DWSS planning must also ensure the fulfillment of K4 aspects, namely quantity, quality, continuity, and affordability, with NRW as a factor that directly influences the project's effective income because lost water does not generate income.

In addition to the baseline assessment, this study conducted a sensitivity analysis of changes in costs, revenues, and operational risks to assess the project's resilience to assumptions that could affect investment sustainability. This is reinforced by Yunani &

Firmialy (2025), who used cost-efficiency and sensitivity analyses to link cost efficiency to financial performance. The sensitivity analysis in this study is based on ESG, including green investment, social affordability, and downside risk, as reflected in changes in CAPEX, OPEX, loans, revenues, and NRW, since these variables affect the project's financial sustainability. Selecting the social affordability aspect is relevant because price sensitivity can reduce public interest in sustainable choices despite environmental awareness (Widodo, Rubiyanti, & Madiawati, 2025). Sustainable finance, according to Roncalli (2025), not only focuses on returns and financial risks but also considers ESG risks, cost of capital, sustainable financial products, impact investing, and climate risks in investment decision-making. Therefore, governance aspects are reflected through the WACC, cost of debt, and loan and equity structures. Within the framework of project finance, infrastructure projects are generally structured through Special Purpose Vehicles (SPVs) under a limited recourse principle, in which creditors primarily rely on the project's cash flow to repay the loan (Yescombe, *Public-Private Partnerships: Principles of Policy and Finance*, 2007). These projects face key risks, including increased CAPEX (Capital Expenditure), increased OPEX (Operating Expenditure), decreased revenue, increased NRW (Non-Revenue Water), increased WACC (Weighted Average Cost of Capital), and social affordability risks. These risks are identified and treated in accordance with risk management principles stipulated in ISO 31000:2018.

Although previous studies have extensively examined financial feasibility, project finance, and ESG practices separately, limited research has integrated these perspectives into a single financial decision-making framework for integrated drinking water supply infrastructure. Existing financial feasibility studies generally emphasize conventional investment indicators such as NPV, IRR, and Payback Period, while ESG studies mainly focus on corporate sustainability disclosure rather than project-level financial performance. Furthermore, research addressing consortium-based DWSS investments under Build–Operate–Transfer (BOT) arrangements remains scarce. This gap highlights the need for a comprehensive framework that integrates financial feasibility analysis, ESG-based sensitivity analysis, and financial risk assessment to support sustainable infrastructure investment decisions.

The novelty of this research lies in the ESG-based sensitivity analysis, the identification of key risks, the development of mitigation strategies, and the strategic investment recommendations. This results in a more comprehensive, measurable, and risk-based evaluation framework to support Integrated DWSS investment decision-making. This is relevant to the study (Kartawinata, Hidayat, & Wardhana, 2025), which emphasizes the importance of viewing ESG not only as a non-financial aspect but also as a factor related to company value and investor decisions. Based on the description, this study aims to obtain the results of the financial feasibility analysis of the Upstream and Downstream Integrated DWSS Development based on the NPV, IRR, and Payback Period indicators; obtain project financial performance projections that include profit and loss statements and cash flows during the cooperation period; obtain the results of ESG-based sensitivity analysis that includes aspects of green investment, social affordability, and ESG downside risk in assessing the financial sustainability of the project; obtain identification of financial risks that affect the financial sustainability of the project and mitigation strategies that can be implemented; and obtain strategic recommendations to maintain investment sustainability in the Upstream and Downstream Integrated DWSS Development project.

Beyond addressing this research gap, the study contributes to the sustainable finance literature by operationalizing ESG principles into measurable financial variables within a project finance model. Rather than treating ESG as a qualitative reporting framework, this study demonstrates how environmental, social, and governance factors directly influence

investment feasibility, project cash flow, and financial resilience under different risk scenarios. The proposed framework may therefore serve as a practical reference for infrastructure investors, policymakers, and public-private partnership stakeholders.

METHOD

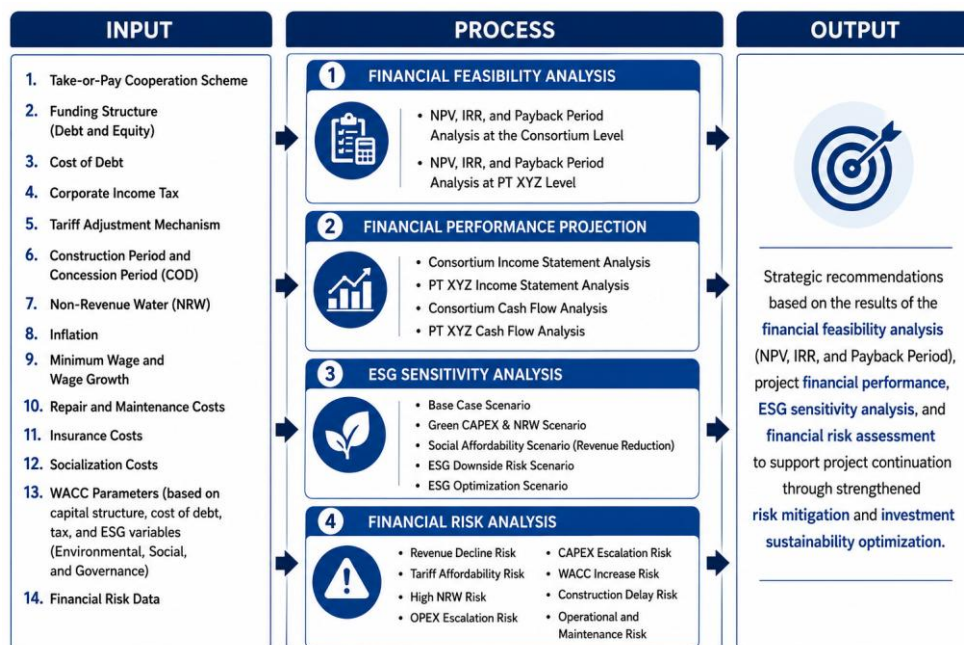


Figure 1. Framework of Thinking

This study uses the Input-Process-Output framework to describe the flow of sustainable finance analysis on financing the development of Integrated DWSS. Input includes all assumptions and project parameters used in the analysis, including the Take-or-Pay cooperation scheme, funding structure (debt and equity), cost of debt, corporate income tax, tariff adjustment mechanism, construction period and cooperation period (COD), NRW, inflation, minimum wages, operational costs (repair & maintenance), insurance costs, socialization costs, ESG-based WACC parameters, and project financial risk data. The process consists of four main analyses, namely financial feasibility analysis (NPV, IRR, Payback Period at the consortium and PT XYZ levels), financial performance projections (profit and loss and cash flow at the consortium and PT), ESG-based sensitivity analysis (base case, green CAPEX & NRW reduction, social affordability, ESG downside risk, and ESG optimization), and financial risk analysis (risk of declining revenue, tariff affordability, NRW, OPEX and CAPEX increases, WACC increases, construction delays, and operational and maintenance risks). The output consists of strategic recommendations based on financial feasibility results, financial performance projections, ESG sensitivity analysis, and financial risk mapping, aimed at strengthening risk mitigation and optimizing the sustainability of project investments.

A research method is a systematic and organized way to investigate a specific problem and find a solution, comprising a series of steps from problem identification to the implementation of research results. Meanwhile, a research strategy is a plan developed to achieve research objectives, help answer research questions, and meet predetermined objectives, and is influenced by the research objectives, the type of research questions, the researcher's views on good research concepts, and practical factors such as access to data and time constraints (Sekaran & Bougie, 2016). This study uses a quantitative approach,

supported by secondary data, including project financial assumptions, funding structure, profit-and-loss projections, cash-flow projections, CAPEX, OPEX, revenue, NRW, WACC, and the results of NPV, IRR, and Payback Period calculations. The approach used is descriptive-quantitative and exploratory: describing the project's financial feasibility based on the calculation results and exploring the impact of changes in key variables through ESG-based sensitivity analysis. The data instruments used are secondary data and processed financial data, including project assumptions, profit-and-loss projections, cash-flow projections, debt-equity financing structures, financial feasibility indicators, ESG sensitivity scenarios, and risk matrices.

This type of research is applied research because it is directed toward providing a basis for investment decision-making and strategic recommendations for financing the development of Integrated Drinking Water Supply Systems (DWSS). The object of the research is the sustainable finance aspect in financing the cooperation project for the development of Integrated Drinking Water Supply Systems (DWSS), PT XYZ was not selected to statistically represent all water companies in Indonesia. Instead, it constitutes an analytically representative and information-rich case of a water resources management company participating in a capital-intensive integrated DWSS project through a consortium-based Build–Operate–Transfer arrangement. Its strategic upstream role, operational competence, collaboration with a regional drinking water utility, and direct exposure to long-term project investment make PT XYZ an appropriate case for examining sustainable finance in integrated drinking water infrastructure development, both at the project/consortium level and the equity level of consortium members, especially PT XYZ, while the subject of the research is PT XYZ as a water resources management company as well as a consortium member/investor in financing the development of Integrated DWSS. The research strategy is a case study focusing on a single Integrated DWSS development project plan and providing an in-depth analysis of financial feasibility, risks, and sustainable financing scenarios. The case-study subject was selected purposively based on four criteria: (1) its strategic role in water resources management, (2) its participation as an equity investor in an integrated DWSS project, (3) the material scale and long-term characteristics of the investment, and (4) the availability of project-level financial and operational data required for an in-depth sustainable finance analysis. The research setting is non-contrived because it uses project conditions, financial assumptions, and financing structures compiled from the real context of Integrated DWSS development, without manipulating the research environment. The researchers' involvement is moderate: they process, model, interpret, and analyze financial data but do not intervene directly in project implementation. The research time setting is cross-sectional because the analysis is based on project data and assumptions for a specific period, then projected over the construction and operation periods to assess feasibility and financial sustainability.

Financial analysis is conducted to assess whether the project is economically viable and can provide value to investors and other parties involved in financing. Net Present Value (NPV) is an investment appraisal method that calculates the difference between the present value of future cash inflows and outflows, taking into account the discount rate; if $NPV > 0$, the project is declared profitable and feasible to run, if $NPV < 0$, the project is declared unprofitable and not feasible to run, while if $NPV = 0$, the capital value is equal to the value obtained so it is better to keep the funds in the bank because it is more profitable. Internal Rate of Return (IRR) is the interest rate that makes the NPV value of all investment cash flows equal to zero, calculated through simulation by trying various interest rates until an interest rate is found that produces zero NPV; if $IRR > \text{opportunity cost of capital}$, the investment proposal is declared feasible, while if $IRR < \text{opportunity cost of capital}$, the investment proposal is declared unfeasible. Payback Period (PbP) is an investment appraisal

method that measures the time required to return all invested funds through cash inflows (proceeds).

A deterministic, scenario-based sensitivity analysis was selected because it provides a transparent and practical approach to evaluating the financial robustness of long-term infrastructure projects under uncertainty. The percentage changes applied to CAPEX, OPEX, revenue, debt, and NRW represent realistic deviations commonly observed in infrastructure investment projects and enable direct comparison across alternative ESG scenarios while maintaining consistency in the financial evaluation framework.

An ESG-based sensitivity analysis was conducted to assess the project's resilience to changes in environmental, social, and governance assumptions through five scenarios. The base case describes the project's baseline conditions based on normal assumptions. Green CAPEX refers to a scenario in which a project uses green investments, efficient technologies, or more environmentally friendly infrastructure. Social affordability refers to a situation in which community affordability affects revenue, tariffs, or the project's ability to generate cash flow. ESG downside risk describes negative risk conditions, such as increased CAPEX, increased OPEX, decreased revenue, increased NRW, or increased WACC. ESG optimization describes a scenario combining improvements in ESG variables simultaneously, such as CAPEX and OPEX efficiency, reduced NRW, and improved financing structure, to assess the potential for increased project financial viability if sustainability principles are optimally implemented.

Risk analysis is conducted to identify the main factors that can hinder the project's financial feasibility and sustainability, including the risk of increasing CAPEX, the risk of increasing OPEX, the risk of decreasing revenue, the risk of high NRW, the risk of increasing WACC, the risk of tariff affordability, the risk of construction delays, and operational and maintenance risks, with mitigation that can be done through cost efficiency, NRW control, appropriate tariff schemes, balanced financing structures, efficient technology selection, and strengthening project governance.

After all analyses are conducted, the results are used to answer the main question: whether the project is feasible. A project is declared feasible if the NPV is positive, the IRR is greater than the WACC, the Payback Period is still within the cooperation period, the project cash flow is able to support financing needs, the main risks can still be mitigated, and the ESG scenario, including ESG optimization, still shows financial sustainability. Conversely, the project is declared not feasible if the NPV is negative, the IRR is lower than the WACC, the Payback Period is too long, the project cash flow is unable to cover investment and financing needs, the project risk is too large, and the ESG scenario shows a significant decrease in feasibility, so that it is necessary to improve assumptions, adjust the financing structure, cost efficiency, improve the tariff scheme, or risk mitigation strategies. The results of the analysis then become the basis for compiling strategic recommendations that include optimizing the financing structure, controlling CAPEX and OPEX, reducing NRW, implementing green investment, adjusting the tariff scheme that still takes into account community affordability, strengthening project governance, and developing financial risk mitigation strategies, to ensure that the Integrated DWSS project can run properly, bankably, and sustainably.

RESULT AND DISCUSSION

Financial Analysis (IRR, NPV, PbP)

A financial analysis was conducted to assess the financing feasibility of developing an Integrated Water Supply System (DWSS) based on a Take-or-Pay scheme with a funding structure of 70% debt (11% interest rate) and 30% equity, 22% corporate tax, 10% tariff increases every two years starting in 2032, a 30-year cooperation period from COD (Cash on

Delivery), a 60-month construction period, a 5% NRW (Non-Revenue Water), and general inflation of 3.78%. The capital structure of 70% debt and 30% equity was adopted as the project's base-case financing assumption, reflecting a typical debt-heavy structure commonly applied in water infrastructure projects under Public-Private Partnership (PPP/KPBU) schemes, where lenders generally require a substantial equity buffer while allowing high leverage to reduce the sponsor's capital burden over a long concession period. Based on this structure, the Weighted Average Cost of Capital (WACC) was calculated as $WACC = (Equity \times \text{Cost of Equity}) + [Debt \times \text{Cost of Debt} \times (1 - \text{Tax})]$, resulting in a nominal after-tax WACC of 9.67%, derived from a debt cost of 11.00% (pre-tax interest rate), a corporate tax rate of 22.00%, and the 70:30 debt-equity composition described above. This calculated WACC of 9.67% was adopted as the discount rate because it directly reflects the project's actual funding composition, and it is also the highest value compared to WACC benchmarks reported for the drinking water sector in other countries, including Brazil (SABESP, 8.10%; ARSESP, 2020), Colombia (Segment 1, 8.23%; Segment 2, 8.55%; Cuesta & Cruz, 2014), Peru (SEDAPAL, 5.78%; Martínez, 2026), the Philippines (MWSS Metro Manila, 7.39%; Yu, 2019), Thailand (PWA, 5.04%; Provincial Waterworks Authority, 2024), and a comparable Indonesian case, SPAM Pekanbaru (8.76% nominal after-tax, with a cost of equity of 13.41%, cost of debt of 9.66%, and tax rate of 30%; Aslantua, Sandhyavitri, & Sutikno, 2018). Being higher than these regional benchmarks, the 9.67% WACC provides a relatively conservative (stricter) discount rate for assessing the investment feasibility of the project compared to similar water infrastructure projects internationally.

The Profit and Loss Projections, both at the consortium and PT XYZ levels, both exhibit a J-curve pattern typical of long-term infrastructure investments: beginning with a zero-loss pre-operational phase, then entering a deficit phase due to the dominance of investment and construction costs (front-loaded costs), reaching the lowest point of losses, then gradually recovering to break-even in the same year, 2036, and then consistently growing until reaching the economic maturity phase with steadily increasing profits until the end of the projection period. This indicates that, despite the project's high initial cost structure, the ability to generate a surplus during the operational phase is strong and sustainable.

Cash Flow Projections also follow a similar J-curve pattern. At the consortium level, cash flow experiences deep negative pressure during the initial construction phase, turns positive in 2033, and then grows steadily to a much larger scale by the end of the period—signaling a successful transition from the investment phase to a productive operational phase. At PT XYZ, cash balances grew more gradually: in the initial period, they were still very minimal, and most of the accumulated cash was used for interest payments, making dividend distribution impossible. Only in the final period, after interest expenses subsided, did liquidity strengthen significantly.

Table 3 Financial Viability

Aspect	Project Benchmark	Equity Benchmark	Consortium (Project)	Consortium (Equity)	PT XYZ (Project)	Remarks
IRR / FIRR	9.67%	12.22%	11.32%	13.28%	11.32%	Feasible
NPV	> 0	> 0	> IDR 700 billion	> IDR 190 billion	> IDR 20 billion	Feasible
Payback Period	≤ Project / Concession Period	≤ Project / Concession Period	12 years 10.43 months	16 years 5.99 months	14 years 10.43 months	Feasible

The feasibility calculations indicated the project was financially viable: Project IRR of 11.32% (>WACC 9.67%), Project NPV of IDR 735.17 billion, Project PbP of 12 years, 10.43

months; while at the equity level, IRR Equity was 13.28% (>target 12.22%), Equity NPV of IDR 190.89 billion, and Equity PbP of 16 years, 5.99 months.

These findings are consistent with capital budgeting theory, which suggests that infrastructure projects are considered financially feasible when the NPV is positive, and the IRR exceeds the project's cost of capital. Compared with previous studies that focus solely on conventional investment appraisal, this study further demonstrates that project feasibility should also consider ESG-related financial risks, as changes in environmental efficiency, social affordability, and governance-related financing structures significantly influence the long-term sustainability of investments.

Integration of Sustainable Finance into the Financial Model

Table 4 Financial Viability

ESG Dimension	Key Indicator	Model Variable	Integration Range	Impact on Financial Model
Environ-mental	Green technology investment & operational efficiency	CAPEX, OPEX	100%–110% of baseline	Higher CAPEX/OPEX reduces NPV and IRR and extends the Payback Period, but improves long-term operational efficiency and resilience
	Non-Revenue Water control & energy efficiency	NRW, energy/maintenance costs	0%–10% (NRW)	Lower NRW increases billable volume and effective revenue; higher NRW reduces revenue and cash flow
Social	Tariff affordability & offtaker payment capacity	Revenue, cash inflow	90%–100% of baseline revenue	Lower revenue improves service affordability but reduces NPV, IRR, and cash flow stability
	Service continuity/expansion & return balance	Sales volume, revenue, Equity IRR	90%–110% of baseline revenue	Higher volume drives FCFF, NPV, and IRR; revenue adjustments must balance affordability against investor return requirements
Governance	Financing structure & cost control	Debt, equity, CAPEX, OPEX	100%–110% of baseline	Higher debt increases interest burden and leverage risk; cost control prevents overruns and NPV/cash flow deterioration
	Revenue certainty	Project revenue	90%–110% of baseline	BOT/take-or-pay schemes reduce demand risk and maintain cash flow stability
	Cost of capital & investor return threshold	WACC, Target Equity IRR	WACC 9.67%; IRR Target 12.22%	WACC serves as the minimum feasibility threshold; Equity IRR above target confirms the project meets shareholder return expectations
	Cost escalation & delay risk	CAPEX, OPEX, debt, cash flow	Increase of up to 10% from baseline	Cost and financing increases reduce NPV and IRR and extend the Payback Period for both Project and Equity

In line with the finding that financial performance and ESG disclosure significantly influence firm value (Avinda, Hidayat, & Kartawinata, 2025), ESG aspects are translated into measurable variables in the financial model. The Environmental dimension is reflected in CAPEX, OPEX, and NRW (green technology investment, operational efficiency, and water loss control); the Social dimension is reflected in revenue (tariff affordability and offtaker

payment ability); and the Governance dimension is reflected in financing structure, cost control, revenue certainty, WACC, and target IRR. The integration range is set at CAPEX/loans/OPEX 100%–110%, revenue 90%–110%, and NRW 0%–10%, with a WACC of 9.67% as the project feasibility limit and a target IRR of 12.22% as the return on equity limit—forming the basis for the subsequent ESG-based sensitivity analysis.

ESG-Based Sensitivity Analysis

Table 5 ESG-Based Sensitivity Analysis

Description	Base Case	Green CAPEX Alt. 1	Social Affordability Alt. 2	Social Affordability Alt. 3	ESG Downside Risk Alt. 4	ESG Downside Risk Alt. 5	ESG Optimization Alt. 6
Capital Investment (CAPEX)	100%	110% (+10%)	100%	100%	110% (+10%)	110% (+10%)	105% (+5%)
Debt Financing	100%	100%	100%	100%	110% (+10%)	110% (+10%)	105% (+5%)
Operating Expenses (OPEX)	100%	100%	100%	100%	110% (+10%)	110% (+10%)	102% (+2%)
Revenue	100%	100%	90% (−10%)	95% (−5%)	100%	110% (+10%)	98% (−2%)
Non-Revenue Water (NRW)	5%	0% (−5%)	5%	5%	10% (+5%)	10% (+5%)	0% (−5%)
WACC	9.67%	9.67%	9.67%	9.67%	9.67%	9.67%	9.67%
Project IRR (> WACC)	11.32%	11.32%	10.16%	10.75%	10.03%	11.08%	10.74%
Project NPV	(Positive)	(Positive)	(Positive)	(Positive)	(Positive)	(Positive)	(Positive)
Project Payback Period	12 yrs 10.43 mos	13 yrs 4.33 mos	13 yrs 10.10 mos	13 yrs 3.93 mos	13 yrs 11.89 mos	13 yrs 1.00 mo	13 yrs 3.98 mos
Target Equity IRR	12.22%	12.22%	12.22%	12.22%	12.22%	12.22%	12.22%
Equity IRR (> Target IRR)	13.28%	12.33%	11.53%	12.43%	11.32%	12.94%	12.39%
Equity NPV	(Positive)	(Positive)	(Negative)	(Positive)	(Negative)	(Positive)	(Positive)
Equity Payback Period	16 yrs 5.99 mos	17 yrs 5.17 mos	18 yrs 5.11 mos	17 yrs 4.64 mos	18 yrs 8.56 mos	16 yrs 10.58 mos	17 yrs 4.01 mos
Conclusion	Feasible	Feasible	Not Feasible	Feasible	Not Feasible	Feasible	Feasible

The analysis was structured into four scenario groups to test the project's feasibility under changes in CAPEX, loans, OPEX, revenue, NRW, and WACC.

The Base Case yielded the most feasible condition, with Project NPV and Equity NPV at their highest levels across all scenarios, and Project IRR and Equity IRR at 11.32% and 13.28%, respectively.

Green CAPEX (CAPEX increases by 10%, NRW decreases to 0%, no tariff increase) remains feasible, despite declining financial benefits: Project IRR holds steady at 11.32% while Project NPV falls below the Base Case level, and Equity IRR decreases to 12.33% with Equity NPV shrinking considerably from the baseline condition.

Social Affordability tested tariff reductions. At a 5% decline (Alt 3), the project remains viable, with an Equity IRR of 12.43% and a positive, though relatively modest, Equity NPV. However, at a 10% decline (Alt 2), Equity IRR drops to 11.53% (below target), and Equity NPV becomes negative on a substantial scale, rendering the project unviable for the consortium, even though Project NPV remains positive. Findings by Widodo, Rubiyanti, &

Madiawati (2025) regarding consumer price sensitivity to sustainability attributes reinforce the importance of maintaining tariff affordability within safe limits.

ESG Downside Risk examines the simultaneous pressure of CAPEX, borrowing, and OPEX rising by 10% alongside NRW rising to 10%. Without a revenue increase (Alt 4), the project remains feasible at the Project level (IRR 10.03%, with Project NPV positive but relatively small) but becomes unfeasible at the equity level (Equity IRR 11.32%, with Equity NPV turning substantially negative). With a 10% tariff increase (Alt 5), the project regains feasibility at both levels, with Project IRR rising to 11.08% and Project NPV recovering significantly, while Equity IRR rises to 12.94% with Equity NPV returning to a solidly positive figure.

ESG Optimization (Alt 6: CAPEX 105%, loans 105%, OPEX 102%, revenue 98%, NRW 0%) remains feasible with a Project IRR of 10.74% and Project NPV approaching the level seen under Green CAPEX, alongside an Equity IRR of 12.39% and Equity NPV that stays positive though moderate — indicating that NRW efficiency gains can offset moderate cost increases.

Overall, the Base Case is the most financially feasible scenario with the widest feasibility margin, while ESG Optimization is the most sustainable option because it balances ESG performance and financial viability. Project feasibility depends on the balance of tariffs, NRW efficiency, and cost control, rather than on any single scenario.

The results indicate that revenue-related variables have a greater influence on project feasibility than cost-related variables. Moderate increases in investment and operating costs can still be compensated through operational efficiency, particularly by reducing Non-Revenue Water (NRW). In contrast, significant revenue reductions immediately weaken equity returns and threaten investment attractiveness. These findings highlight the importance of balancing financial sustainability with service affordability when designing long-term drinking water infrastructure projects.

Financial Risk Analysis

Table 6 Risk Categories

Risk Level	Assessment Criteria	Impact on Financial Feasibility	Recommended Mitigation
Low	Variable changes $\leq 5\%$; Project and Equity IRR remain well above WACC/Target IRR; NPV remains positive.	Project feasibility is unaffected, with only a minor decline in IRR and NPV.	Routine monitoring.
Moderate	Variable changes of $>5\%$ to $\leq 10\%$, or simultaneous changes in 2–3 variables; Equity IRR remains above the target with a reduced margin. Project remains feasible, but Equity NPV decreases and the payback period is extended. Improve operational efficiency, reduce NRW, and optimize the financing structure.	Variable changes of $>5\%$ to $\leq 10\%$, or simultaneous changes in 2–3 variables; Equity IRR remains above the target with a reduced margin. Project remains feasible, but Equity NPV decreases and the payback period is extended. Improve operational efficiency, reduce NRW, and optimize the financing structure.	Variable changes of $>5\%$ to $\leq 10\%$, or simultaneous changes in 2–3 variables; Equity IRR remains above the target with a reduced margin. Project remains feasible, but Equity NPV decreases and the payback period is extended. Improve operational efficiency, reduce NRW, and optimize the financing structure.
High	Change of $>10\%$ in a single key variable (especially revenue/tariff), without simultaneous adverse changes in other variables and without revenue compensation. Equity feasibility is threatened; Equity	Change of $>10\%$ in a single key variable (especially revenue/tariff), without simultaneous adverse changes in other variables and without revenue compensation. Equity feasibility is threatened; Equity	Change of $>10\%$ in a single key variable (especially revenue/tariff), without simultaneous adverse changes in other variables and without revenue compensation. Equity feasibility is threatened; Equity

	IRR falls below the target and/or Equity NPV becomes negative, while Project NPV remains positive. Apply cross-subsidies, Viability Gap Funding (VGF), take-or-pay agreements, blended finance, or tariff adjustments.	IRR falls below the target and/or Equity NPV becomes negative, while Project NPV remains positive. Apply cross-subsidies, Viability Gap Funding (VGF), take-or-pay agreements, blended finance, or tariff adjustments.	IRR falls below the target and/or Equity NPV becomes negative, while Project NPV remains positive. Apply cross-subsidies, Viability Gap Funding (VGF), take-or-pay agreements, blended finance, or tariff adjustments.
Very High	Simultaneous revenue reduction ($\geq 10\%$) combined with increases in CAPEX, OPEX, debt, and NRW. Both Project and Equity feasibility are jeopardized; Project and Equity NPV may become negative, and the Payback Period (PbP) exceeds the concession period. Restructure the financing scheme, renegotiate tariffs/offtake agreements, or postpone additional investments.	Simultaneous revenue reduction ($\geq 10\%$) combined with increases in CAPEX, OPEX, debt, and NRW. Both Project and Equity feasibility are jeopardized; Project and Equity NPV may become negative, and the Payback Period (PbP) exceeds the concession period. Restructure the financing scheme, renegotiate tariffs/offtake agreements, or postpone additional investments.	Simultaneous revenue reduction ($\geq 10\%$) combined with increases in CAPEX, OPEX, debt, and NRW. Both Project and Equity feasibility are jeopardized; Project and Equity NPV may become negative, and the Payback Period (PbP) exceeds the concession period. Restructure the financing scheme, renegotiate tariffs/offtake agreements, or postpone additional investments.

Risk categories are classified as Low, Moderate, High, and Very High based on the sensitivity of variables to IRR, NPV, and Payback Period (PbP). Low to Moderate risks (variable changes of $\leq 10\%$, or a limited combination of variables) can generally be managed through operational efficiency improvements without changing the overall feasibility status, as reflected in the Green CAPEX and ESG Optimization scenarios (see Section 3, Table 5). High to Very High risks — particularly significant revenue declines or simultaneous cost increases without tariff compensation — threaten feasibility, especially at the equity level, as shown in the Social Affordability (Alternative 2) and ESG Downside Risk (Alternative 4) scenarios (see Section 3, Table 5).

Table 7 Financial Risk

No	Financial Risk	Risk Level	Key Impact	Recommended Mitigation
1	Revenue decline	High	A 10% revenue reduction decreases Equity IRR below the target (11.53%) and results in a negative Equity NPV, making the project financially infeasible.	Take-or-pay agreements, revenue diversification, and phased tariff adjustments.
2	Tariff affordability	High	Tariff constraints reduce project revenue and limit financial feasibility due to affordability concerns.	Cross-subsidies, Viability Gap Funding (VGF), and progressive tariff schemes.
3	High Non-Revenue Water (NRW)	Moderate	Higher NRW reduces effective revenue, whereas NRW reduction significantly improves project feasibility.	Network rehabilitation, leakage detection, and smart distribution systems.
4	OPEX escalation	Moderate	Increased operating costs reduce Project IRR and overall financial performance.	Operational efficiency, long-term supplier contracts, and energy optimization.
5	CAPEX escalation	Low–Moderate	CAPEX increases remain manageable individually but weaken feasibility when combined with other adverse factors.	Cost control, phased construction, and fixed-price EPC contracts.
6	WACC increase	Moderate	A higher discount rate lowers Project and Equity NPV, reducing investment attractiveness.	Optimize the debt–equity structure and secure lower-cost financing.

No	Financial Risk	Risk Level	Key Impact	Recommended Mitigation
7	Construction delay	Moderate	Delays extend the pre-operational period, postpone break-even, and increase financing costs.	Strong project management, penalty clauses, and schedule contingency.
8	Operation and maintenance	Low	Limited impact due to the relatively small share of maintenance costs.	Preventive maintenance and digital asset management.
9	Administrative and overhead costs	Low	Inflation-driven cost increases have a limited impact and are incorporated into the financial model.	Administrative efficiency and periodic budget adjustments.

The risk matrix identifies nine risk factors, with revenue decline and tariff affordability risks categorized as High because they have the potential to immediately render the project unviable; NRW, OPEX, CAPEX, and WACC risks categorized as Medium because they can still be managed through efficiency; and operational-maintenance and administrative cost risks categorized as Low because they represent a small proportion of the cost structure.

Recommended mitigation measures include revenue diversification; a minimum offtake (take-or-pay); cross-subsidies; and viability gap funding (VGF) to improve tariff affordability; digitalization and leak detection for NRW; fixed-price EPC contracts for CAPEX; and optimization of the funding structure to reduce WACC.

Strategic Recommendations

Table 8 Strategic Recommendations

No	Strategic Issue	Key Findings	Strategic Recommendation	Expected Outcome
1	Financial Feasibility	The base case is financially feasible, whereas revenue reductions ($\geq 10\%$) or simultaneous cost increases threaten project viability.	Establish the base case as the contractual benchmark with tariff and cost review triggers.	Maintain Project and Equity IRR above WACC and the target IRR throughout the concession period.
2	Project Bankability	Equity returns are more vulnerable than project returns under adverse scenarios, reducing investment attractiveness.	Apply blended finance, take-or-pay agreements, and optimize the debt-equity structure.	Enhance bankability while reducing financing and default risks.
3	Operational and Construction Resilience	Simultaneous increases in CAPEX, OPEX, debt, and NRW, together with construction delays, weaken financial performance.	Implement NRW reduction, fixed-price EPC contracts, and construction delay penalty clauses.	Improve resilience against cost escalation and schedule risks.
4	Tariff Affordability	Moderate tariff reductions remain feasible, whereas larger reductions significantly undermine project viability.	Introduce cross-subsidies, Viability Gap Funding (VGF), and progressive tariff mechanisms.	Preserve affordability while maintaining financial sustainability.
5	ESG Sustainability	ESG optimization improves operational efficiency and maintains financial feasibility despite higher investment costs.	Integrate ESG practices with a focus on NRW reduction and operational efficiency.	Achieve a balanced outcome between financial performance and long-term sustainability.
6	Integrated Risk Governance	Revenue and tariff risks are the most critical, while CAPEX, OPEX, NRW, and WACC remain manageable through appropriate controls.	Develop an integrated risk management framework supported by an early warning system.	Strengthen decision-making and ensure long-term project viability, resilience, and sustainability.

The feasibility of the Integrated DWSS project needs to be reviewed through five interrelated dimensions: financial feasibility, bankability, resilience to operational/construction risks, tariff affordability, and ESG sustainability. Strategic recommendations include: (1) using the Base Case as a contractual reference with a mechanism to trigger tariff and cost reviews when deviations approach 10%; (2) structuring financing through blended finance, take-or-pay guarantees, and optimizing the debt-equity ratio to maintain bankability; (3) implementing network digitalization, fixed-price EPC contracts, and delay penalty clauses to strengthen resilience; (4) implementing cross-subsidies and VGF to maintain tariff affordability; (5) adopting ESG Optimization as a long-term operational strategy focused on reducing NRW and (6) implementing an early warning and monitoring system across the five pillars for integrated risk governance.

Overall, project success depends heavily on maintaining a balanced trade-off among these five pillars. Technical efficiency—particularly NRW reduction—has proven capable of offsetting increases in investment and operational costs, while innovative financing schemes are needed to maintain bankability and tariff affordability without compromising the interests of investors or the community. Conversely, a significant, uncompensated decline in revenue or a simultaneous increase in costs without mitigation could threaten the project's feasibility at both the Project and Equity levels. Therefore, integrated risk governance is key to the sustainability of the Integrated DWSS project throughout the partners.

From a theoretical perspective, this study extends the sustainable finance and project finance literature by demonstrating that ESG factors can be incorporated into quantitative financial feasibility models rather than treated solely as qualitative sustainability indicators. In practice, the proposed framework provides decision support to consortium investors, water utilities, financial institutions, and government agencies for evaluating infrastructure investments under uncertainty. The findings also have policy implications, emphasizing the importance of tariff regulation, blended finance mechanisms, and integrated risk governance for achieving financially sustainable drinking water infrastructure development.

CONCLUSIONS AND RECOMMENDATIONS

This study shows that the Upstream and Downstream Integrated DWSS Development Project is financially viable at both the project and equity levels, both at the consortium and PT XYZ levels, as indicated by positive NPV values and IRRs exceeding the WACC and the required return targets. Financial performance projections show a J-curve growth pattern, characterized by an initial investment and deficit phase, then reaching a break-even point, and ultimately entering a phase that generates sustainable profits and positive cash flows. ESG-based sensitivity analysis indicates that the project's financial sustainability is strongly influenced by the balance between technical efficiency, tariff policy, and cost control. Increasing green investment to reduce NRW can still maintain project feasibility, whereas tariff reductions beyond a certain limit, and combinations of increasing CAPEX, OPEX, and water losses without a corresponding increase in revenue, have the potential to reduce feasibility, especially at the equity level. Risk analysis shows that the risks of declining revenue and tariff affordability are the most significant, while other risks can still be managed through increased efficiency and cost control. Therefore, project management strategies need to focus on strengthening revenue certainty, optimizing funding structures, digitizing systems, controlling construction and operational costs, and implementing ESG principles and integrated risk governance to maintain project feasibility, bankability, resilience, affordability, and sustainability throughout the partnership period.

This study is limited to a single integrated DWSS case and employs deterministic sensitivity analysis based on predefined scenarios. Consequently, the findings may not fully represent the financial characteristics of other infrastructure projects or capture broader

uncertainty. Future research may apply probabilistic approaches such as Monte Carlo simulation, real options analysis, or comparative multi-project studies to improve the robustness and generalizability of sustainable finance evaluation models.

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