Pangripta Jurnal Ilmiah Kajian Perencanaan Pembangunan
https://jurnalpangriptav3.malangkota.go.id/pangripta

E-ISSN: 2615-5702, P-ISSN: 2620-5785
Vol. 8, No. 2, page 231-244

Financial Feasibility as a Decision-Making Tool for Regional Infrastructure Projects: A Regional Development Perspective

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Abstract

Effective regional infrastructure planning requires not only technical soundness but also financial accountability to ensure long-term sustainability and equitable resource allocation. This article refines the application of financial feasibility analysis as a decision-making tool, focusing on four key indicators NPV, BCR, IRR, and PP—and situates them within a regional development framework. The Bango Water Supply System Development Project (2023–2047) in Malang City is employed as a study case to illustrate how financial feasibility outcomes can inform policy choices. Results indicate that the project demonstrates positive financial performance across all indicators, confirming its viability under baseline assumptions. Beyond numerical validation, the study emphasizes the strategic role of financial feasibility analysis in prioritizing projects, attracting public private investment, and aligning infrastructure initiatives with SDG targets for water access and sustainable cities. This contribution provides actionable insights for policymakers seeking to balance fiscal discipline with inclusive growth objectives.

Article Info

Keywords:
Financial Feasibility;
Infrastructure Planning;
Regional Development Policy;
Investment Decision-Making;
Malang City

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Received: 01-09-2025
Revised: 07-09-2025
Accepted: 13-09-2025
Published: 25-09-2025

1. Introduction

Urbanization is transforming mid-sized cities across Indonesia, creating unprecedented demand for basic infrastructure while simultaneously constraining natural resources. Malang City, the second-largest urban center in East Java, is experiencing a demographic expansion of more than 1.2% per year, with rising urban density driven by education, tourism, and creative industries. This growth has pushed water demand to new highs, straining existing supply systems that depend largely on raw water sources located outside Malang's jurisdiction. As administrative boundaries limit the city's ability to expand withdrawals from neighboring areas, securing an independent and sustainable water supply has become both a technical necessity and a strategic development priority.

Safe and reliable water access underpins public health, economic competitiveness, and quality of life. For Malang City, an inadequate water supply could undermine its ambitions to become a regional hub for higher education, technology, and creative economy clusters. The municipal government has identified the Bango River, located within its territory, as a viable source to reduce dependence on inter-regional transfers and strengthen local water sovereignty. This aligns with the national objective of achieving SDG 6 (Clean Water and Sanitation) and supports SDG 11 (Sustainable Cities and Communities), both of which emphasize equitable and resilient service provision.

To capture the scale of the challenge, Table 1 presents projected population growth and estimated water demand through 2047. The data indicate that Malang's daily demand for potable water will continue to rise significantly, necessitating a phased investment approach.

Table 1. Projected Population and Water Demand in Malan City (2023–2047)

Year	Projected Population ('000)	Estimated Water Demand (L/s)	Remarks
2023	920	420	**Existing capacity near saturation**
2027	950	500	**Demand exceeds current production**
2035	1,020	550	**Requires additional capacity expansion**
2047	**1,150**	**620**	**Long-term water independence critical**

Source: Processed from Malang City planning data and PDAM projections (2023).

The city's current reliance on water from Batu City and Malang Regency exposes it to risks of supply disputes and potential service disruptions, especially during the dry season. Strengthening locally governed infrastructure is therefore urgent, not only to meet demand but also to provide the institutional stability needed for long-term planning.

In response to this challenge, the municipal government has initiated the Bango Water Supply System Development Project (SPAM Bango), planned for implementation between 2023 and 2047. The project will deliver a total capacity of 500 liters per second (L/s) through staged construction: 200 L/s in 2023, 100 L/s in 2025, and 200 L/s in 2027. Capital expenditures for the three stages are estimated at over Rp 160 billion, with substantial operating and maintenance (O&M) costs projected over the life of the project. Figure 1 illustrates the staged capacity ramp- up, highlighting the city's strategy of synchronizing production expansion with rising demand.

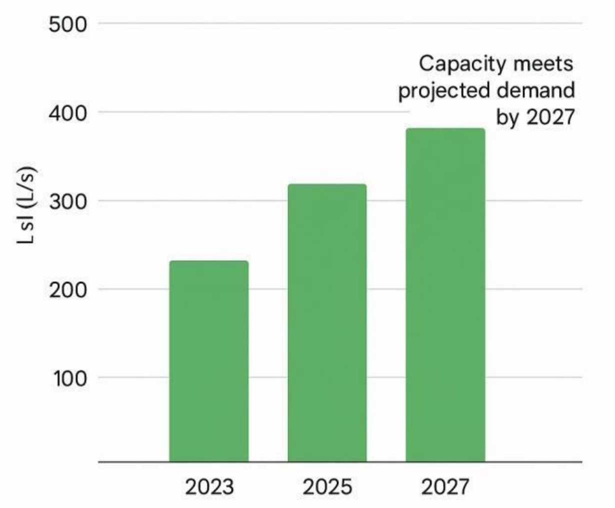

Figure 1. Planned Production Capacity Ramp-Up (2023–2027)

This staged approach allows fiscal management to remain balanced while ensuring progressive realization of water independence. However, the financial burden particularly exposure to energy price volatility requires careful assessment to avoid future budgetary stress.

Although feasibility studies on drinking water supply systems have been widely conducted, most existing research still focuses on technical aspects such as hydrological reliability, treatment plant capacity, and distribution network design. Unfortunately, this approach tends to neglect broader financial dimensions within the context of regional development. For instance, the study by Sibuea et al. (2022) assessed the feasibility of a PDAM distribution network based on financial and technical parameters, but did not explicitly connect the analysis to spatial or long-term development goals. A similar limitation can be seen in the Dumai City water system analysis conducted by Kusuma and Sandhyavitri (2014), where financial indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PP) were used, yet remained detached from broader planning frameworks. Farmania and Elsyah (2023), as well as Rahmawati et al. (2021), also confirmed financial feasibility in SPAM projects using conventional metrics but did not address how such results might support inclusive planning or equitable investment decisions. Consequently, a critical knowledge gap persists: projects may be deemed technically and financially viable, yet fail to ensure fiscal sustainability, consider opportunity costs, or align with regional spatial planning objectives (Laksono & Latief, 2024).

This study seeks to address that gap by applying a single, comprehensive financial feasibility assessment using NPV, BCR, IRR, and PP as the sole evaluation method. While this approach has been used partially in prior research (e.g., Syazili et al., 2021), it has not been fully integrated with a spatial development lens. Lestari et al. (2024) emphasized the importance of risk assessment and sensitivity analysis for long-term investment decisions, though their case was limited to educational infrastructure. By embedding financial indicators within a regional planning context, this study offers a novel framework capable of guiding investment prioritization, stimulating Public–Private Partnership (PPP) participation, and promoting inclusive and equitable urban expansion (Sukrama et al., 2015; Neely & North, 1976; Laksono & Latief, 2024).

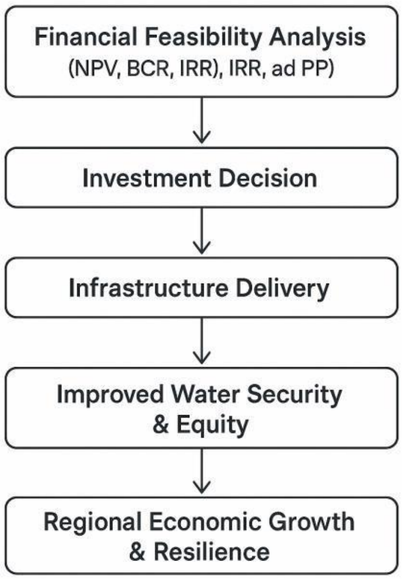

Figure 2. Conceptual Framework: Linking Financial Feasibility to Regional Development

This framework positions financial feasibility not as an isolated accounting exercise but as a critical component of governance that shapes spatial equity and development trajectories.

The objective of this study is to evaluate the financial feasibility of regional infrastructure projects as a decision-making tool, using the Bango Water Supply System as a case study. By focusing exclusively on financial indicators, the study demonstrates how rigorous economic evaluation can help policymakers allocate scarce resources toward projects that offer not only positive returns but also significant social and economic co-benefits.

The results are expected to offer actionable insights for city planners, local governments, and infrastructure financiers seeking to align investment strategies with sustainable development objectives, reduce regional disparities, and improve the resilience of urban service delivery systems.

2. Methods

This study adopts a quantitative descriptive design, focusing exclusively on financial feasibility analysis as the primary evaluative lens. Rather than combining multiple analytical techniques, the approach deliberately isolates financial feasibility to create a clear, replicable framework for infrastructure decision-making. This design emphasizes fiscal sustainability, ensuring that infrastructure projects can be justified not only on technical grounds but also in terms of long- term financial viability and alignment with regional development objectives.

The Bango Water Supply System Development Project (SPAM Bango) was selected as a representative case because it addresses Malang City's pressing water supply gap through a staged investment program running from 2023 to 2047. The project's multi-phase implementation and comprehensive documentation provide a robust basis for modeling projected costs and revenues over a 24-year period.

The analysis draws on secondary data sourced from the municipal water utility, the Brantas River Basin Authority, and Bank Indonesia. The data set includes capital expenditures, operating and maintenance costs (labor, electricity, raw water charges, chemicals), financial parameters such as the discount rate, interest rate, and inflation, as well as projected demand and tariff structures. All financial values were standardized into constant prices using the inflation adjustment formula:

$$\text{Real Value} = \frac{\text{Nominal Value}}{(1+i)^t}$$

where *i* represents the annual inflation rate and ttt the year of analysis.

The construction of annual cash flows forms the core of the analysis. Net cash flow (CF_t) for each year ttt is expressed as:

$$CF_t = R_t - OC_t - CapEx_t$$

where R_t denotes revenues, OC_t operating costs, and $CapEx_t$ capital expenditure. These cash flows are then discounted to present value to calculate the Net Present Value (NPV):

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t}$$

with representing the discount rate and nnn the project horizon. A non-negative NPV indicates that the project's benefits outweigh its costs.

To complement NPV, the Benefit–Cost Ratio (BCR) was computed as:

$$BCR = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}}$$

where B_t and C_t are discounted benefits and costs. BCR values above 1 confirm that the project is economically justifiable.

The Internal Rate of Return (IRR) was derived as the discount rate r* that sets NPV to zero:

$$0 = \sum_{t=1}^{n} \frac{CF_t}{(1+r^*)^t}$$

Feasibility is confirmed if IRR≥MARRIRR (Minimum Attractive Rate of Return). The Payback Period (PP) was calculated by identifying the point at which cumulative net cash flows recover the initial investment:

$$\text{PP} = t \text{ where } \sum_{k=1}^{t} CF_k = 0$$

Finally, the results of these calculations were synthesized into a feasibility assessment and mapped against regional development priorities, ensuring that the financial conclusions are relevant for local planning, resource allocation, and policy formulation. This narrative-driven approach demonstrates not only whether the project is financially viable but also how its implementation can strengthen urban resilience and equitable growth in Malang City.

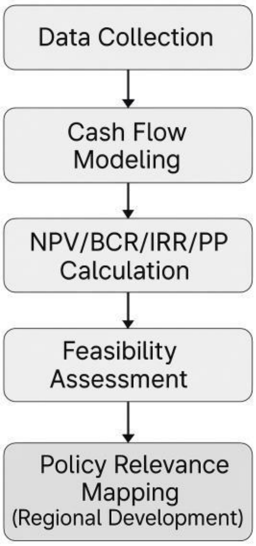

Figure 3. Methodological Framework

3. Results asnd Discussion

Result

The financial feasibility analysis for the Bango Water Supply System Development Project was carried out over a 24-year horizon (2023–2047). Annual cash flows were constructed by combining projected revenues, capital expenditures (CapEx), and operating costs (O&M), all expressed in constant prices. The analysis proceeds sequentially to evaluate Net Cash Flow, Net Present Value (NPV), Benefit–Cost Ratio (BCR), Internal Rate of Return (IRR), and Payback Period (PP).

Net Cash Flow and Lifecycle Surplus (Final, Detailed)

The construction of annual cash flows began by combining three key components: (1) Capital Expenditure (CapEx), concentrated in the early years to build production capacity, (2) Operating and Maintenance (O&M) Costs, including electricity, labor, chemicals, and raw water fees, and (3) Revenues, estimated from water production and the applicable tariff schedule.

Capital investment for the project was staggered to match the phased production plan: Rp 98.8 billion in 2023 for the first 200 L/s module, Rp 30.6 billion in 2025 for the second 100 L/s, and Rp 35.2 billion in 2027 for the final 200 L/s. Operating costs were dominated by electricity, which accounted for approximately 60% of total O&M, followed by raw water charges (BJPSDA), labor wages, chemicals, and routine maintenance. Annual revenue was computed as:

$$R_t = Q_t \times P_t$$

where Qt = annual treated water production and PtP_tPt = tariff per cubic meter. Revenue projections accounted for non-revenue water losses (approximately 20%), resulting in a more conservative estimate of saleable water.

The net cash flow for each year was then computed as:

$$CF_t = R_t - OC_t - CapEx_t$$

where OCtOC_tOCt represents operating costs. These annual cash flows were discounted to present value using the 10-year average interest rate (MARR = 9.9776%), resulting in the profile shown in Table 2.

Indicator	Result	Decision Rule	Status	Interpretation
NPV	Rp 18,255,176	≥ 0	Feasible	**Generates net economic value over project life**
BCR	1.0001	≥ 1.0	Feasible	**Benefits slightly exceed costs, indicating marginal feasibility**
IRR	9.9789%	≥ 9.9776% (MARR)	Feasible	**Meets minimum required return for investment**
PP	**24 years**	**≤ project life**	**Feasible**	**Full cost recovery achieved within BOT period**

Discussion

The analysis of the Bango Water Supply System Development Project confirms its financial feasibility and strategic relevance to Malang City's urban development agenda. More than a set of numerical results, the findings provide a roadmap for how infrastructure finance can be aligned with spatial planning and socio-economic objectives. The project's positive feasibility indicators collectively reinforce the case for investment while highlighting areas where policy attention is critical to ensure long-term sustainability.

Ensuring Financial Sustainability for Urban Growth

The confirmation that the Bango Water Supply System Development Project yields a net positive financial outcome is not merely a technical finding—it carries significant implications for Malang City's ability to sustain and manage urban growth. The positive Net Present Value (NPV) and marginally feasible Benefit–Cost Ratio (BCR) indicate that the project will generate revenues sufficient to cover both capital investment and recurrent operational costs across its 24-year lifecycle. This is critical for a city experiencing rapid urbanization and population growth, where demand for clean water is expected to rise in tandem with residential and industrial expansion. As Farmania & Elsyah (2023) note, infrastructure projects with positive NPV act as fiscal multipliers, enabling governments to reinvest surpluses into other public services or expansion projects.

In Malang's case, financial sustainability means that the project will not become a persistent fiscal burden requiring continuous subsidization from the local budget (APBD). Instead, it can gradually strengthen the city's financial position by providing a revenue stream that supports operation, maintenance, and system expansion. This is particularly relevant because Malang has limited alternative water sources, and securing raw water requires inter-agency coordination with the Brantas River Basin Authority (BBWS Brantas). Rahmawati et al. (2021) emphasize that water infrastructure in secondary cities must be designed to generate enough surplus capacity and financial returns to address the needs of peri-urban communities, where access gaps are most acute.

Moreover, financial sustainability has direct implications for the quality and reliability of service delivery. When a project is financially viable, the operating agency—here, PDAM Malang—can allocate funds for preventive maintenance, reduce non-revenue water (NRW), and adopt energy- efficient technologies without over-relying on government bailouts. This operational independence is essential for maintaining public trust and avoiding service interruptions that could undermine health outcomes or economic productivity. Mamudi et al. (2017) argue that sustained revenue inflows are a precondition for water utilities to pursue continuous improvement programs, such as pipeline rehabilitation or capacity upgrades, which extend asset life and enhance resilience.

From an economic development standpoint, secure and sustainable water supply underpins the city's attractiveness as a destination for education, tourism, and creative industries—sectors that are central to Malang's economic profile. Adequate water services support housing development, hospitality businesses, and higher education campuses, creating a conducive environment for investment. As Laksono & Latief (2024) observe, infrastructure that can pay for itself over time becomes a catalyst for regional competitiveness, as it reduces the fiscal trade-offs between service provision and other developmental priorities.

The positive feasibility findings also carry a signaling effect to external stakeholders, including donors and private investors. Projects that are demonstrably self-sustaining are more likely to attract concessional financing, blended funds, or even public–private partnerships (PPP). Sibuea et al. (2022) note that financiers often use NPV and IRR as key screening tools; positive results enhance the city's credibility and bargaining power when negotiating funding terms. For Malang, this means that additional projects—such as tertiary treatment facilities or network extensions— could leverage the financial discipline demonstrated by the Bango Project to secure better loan rates or co-financing arrangements.

However, ensuring financial sustainability is not a one-time exercise but an ongoing process. The analysis shows that the project's feasibility margin, while positive, is relatively thin. A BCR of 1.0001 leaves little room for major cost overruns, revenue collection shortfalls, or unexpected shocks such as electricity tariff hikes. Rosyid & Nurrajendra (2022) warn that projects with such slim margins are particularly vulnerable to economic fluctuations and therefore require continuous monitoring of key financial drivers. This includes controlling NRW, adopting energy optimization measures, and adjusting tariffs periodically to reflect cost recovery requirements while maintaining affordability for low-income users.

Given these findings, several policy directions emerge that can help Malang City and PDAM ensure that the financial sustainability of the Bango Project translates into broader urban development gains:

1. Integrate Financial Performance into Urban Planning Instruments:
   The project's cash flow projections and financial indicators should be embedded into Malang's medium-term development plan (RPJMD) and spatial planning documents (RTRW). This ensures that water supply capacity is explicitly considered in decisions about housing expansion, industrial zoning, and new economic clusters. By synchronizing infrastructure finance with spatial planning, the city can avoid the risk of overextending its service area beyond what the system can support.
2. Allocate Surplus to Network Upgrades and Peri-Urban Coverage:
   Any surplus generated from the project should be ring-fenced for reinvestment in system reliability and coverage expansion, particularly in peri-urban and underserved neighborhoods. This approach aligns with the principle of cross-subsidization, where current users indirectly finance improved access for those not yet connected. Rahmawati et al. (2021) highlight that such reinvestment strategies are essential for bridging service gaps and achieving universal access targets under SDG 6.
3. Establish a Dedicated Maintenance and Renewal Fund:
   To prevent deferred maintenance—which can lead to costly breakdowns and service interruptions—PDAM should establish a sinking fund earmarked for major repairs, equipment replacement, and technology upgrades. This approach institutionalizes financial discipline and ensures that maintenance does not depend solely on annual budget allocations, which may be subject to political fluctuation.
4. Enhance Financial Transparency and Performance Reporting:
   Publishing regular reports on the project's financial performance, including key indicators such as NPV trajectory, collection efficiency, and NRW levels, can enhance accountability and build public trust. Transparent reporting also serves as a basis for tariff adjustments, allowing stakeholders to understand why and when tariff changes are necessary to maintain service sustainability.
5. Strengthen Institutional Capacity:
   Capacity-building programs for PDAM staff in financial modeling, asset management, and

performance benchmarking can improve the utility's ability to manage cash flows effectively. As Tangcharoen et al. (2023) suggest, human resource development is a critical enabler of operational efficiency and cost control, both of which directly impact financial sustainability.

By implementing these policy measures, Malang City can transform the Bango Water Supply Project from a financially feasible initiative into a long-term **development catalyst**. Ensuring that revenues are reinvested strategically will create a virtuous cycle of service improvement, user satisfaction, and economic growth. Ultimately, this approach contributes not only to the city's water security but also to its broader vision of becoming a competitive, inclusive, and sustainable urban center.

Strengthening Cost Control and Governance

One of the most critical findings of the Bango Water Supply System Development Project's financial analysis is the narrow margin of the Benefit–Cost Ratio (BCR), which, although above unity, is only slightly so (1.0001). This result indicates that the project's benefits only marginally exceed its discounted costs, leaving very little buffer for cost overruns, revenue underperformance, or unexpected shocks such as energy price hikes. In infrastructure finance literature, such a slim BCR margin is considered a "knife-edge feasibility" (Rosyid & Nurrajendra, 2022), meaning that even small deviations from planned assumptions can flip a project from viable to non-viable.

This finding highlights the importance of robust cost control mechanisms throughout the project's lifecycle. During the construction phase, strict procurement and contract management are essential to prevent budget inflation due to change orders, delays, or inefficiencies. Tangcharoen et al. (2023) emphasize that construction cost escalation is one of the most common risks in public infrastructure projects, particularly in developing cities where procurement capacity may be limited. Adopting standardized procurement documents, transparent bidding processes, and independent project supervision can help ensure that costs remain within the approved budget.

In the operational phase, cost control shifts toward efficiency in operations and maintenance (O&M). Since electricity accounts for approximately 60% of total O&M expenditure in water supply projects, energy optimization is a key lever for maintaining financial sustainability. International studies show that installing variable frequency drives (VFDs) on pumps, implementing smart control systems, and adopting preventive maintenance can reduce energy intensity by 10–15%, translating directly into improved financial performance (Rahmawati et al., 2021). PDAM Malang's ability to manage its energy use efficiently will therefore be a decisive factor in preserving the project's narrow BCR margin.

Another crucial aspect of governance is monitoring non-revenue water (NRW), which represents water produced but not billed due to physical losses (leaks) or commercial losses (illegal connections, meter inaccuracies). High NRW levels erode revenue potential and can negate the expected cash inflows that underpin NPV and BCR calculations. Mamudi et al. (2017) argue that NRW reduction programs are among the most cost-effective investments a water utility can make, as they recover lost revenue without requiring new production capacity. For the Bango Project, setting NRW reduction targets—such as achieving below 20% by mid-implementation—would directly enhance cash flows and strengthen financial feasibility.

Governance also entails institutional capacity and accountability mechanisms. Weak financial management systems or lack of performance incentives can undermine cost discipline, resulting in inefficiencies that accumulate over time. As Sibuea et al. (2022) and Kusuma & Sandhyavitri (2014) note, strengthening institutional frameworks, adopting performance-based budgeting, and linking staff incentives to efficiency metrics are effective measures to align organizational behavior with financial sustainability goals.

The combination of these findings suggests that Malang City cannot treat cost control as a one-off exercise but must embed it within the governance architecture of the water sector. This includes aligning the project's financial oversight with the city's broader fiscal framework, establishing monitoring dashboards, and conducting regular performance audits. Such practices not only protect financial viability but also build public trust by demonstrating accountability in the use of public funds.

Based on the above analysis, several policy recommendations can be derived to strengthen cost control and governance, ensuring that the Bango Project remains financially viable throughout its lifecycle:

1. Implement Robust Procurement and Contract Management Systems
   The city government should mandate the use of standardized procurement procedures based on national LKPP guidelines, ensuring transparency and fairness in contractor selection. Independent cost estimators and project management consultants should be engaged to verify bid prices, monitor progress, and flag potential cost overruns early. Introducing digital procurement platforms can further reduce opportunities for corruption and inefficiency.
2. Institutionalize Lifecycle Cost Management
   Instead of focusing solely on upfront capital costs, Malang City should adopt a total cost of ownership (TCO) perspective that accounts for O&M expenses over the asset's life. This approach allows decision-makers to select technologies and designs that minimize long-term costs rather than simply the lowest initial bid. Lifecycle costing also facilitates better budgeting for asset renewal and replacement.
3. Enhance Energy Efficiency Programs
   A dedicated energy management plan should be developed, including pump efficiency audits, optimization of pumping schedules to off-peak hours, and investment in energy- saving equipment. Partnerships with the state electricity company (PLN) could explore preferential tariffs for bulk water production or participation in energy efficiency incentive programs.
4. Strengthen NRW Control and Revenue Assurance
   PDAM Malang should implement a comprehensive NRW reduction strategy, combining infrastructure rehabilitation (pipe replacement, leak detection) with improved commercial controls (meter calibration, digital billing). Setting clear NRW reduction milestones and linking them to management performance indicators can help ensure accountability.
5. Introduce Performance-Based Governance Mechanisms
   Performance contracts between the local government and PDAM should be introduced, specifying key financial and operational targets (e.g., cost recovery ratio, NRW level, collection efficiency). Meeting or exceeding targets could be linked to financial incentives for management teams, while failure to meet targets should trigger remedial action plans.
6. Enhance Transparency and Public Reporting
   Regular publication of financial and operational data—including cost per m^3, NRW levels, and energy use—can improve public oversight and justify tariff adjustments. Transparent reporting also builds credibility with external financiers, making it easier to secure future funding for system expansion.
7. Embed Governance in Urban Policy Instruments
   Finally, cost control and financial performance monitoring should be explicitly integrated into Malang's urban development strategies, such as the RPJMD and RTRW. This ensures that water infrastructure investment decisions are coordinated with spatial planning, housing development, and industrial growth, preventing over-extension of service areas that could compromise financial viability.

By institutionalizing these governance measures, Malang City can transform a financially feasible project into a long-term anchor of fiscal stability and service reliability. Strengthening cost control mechanisms ensures that the narrow BCR margin is preserved and even improved over time, creating headroom for additional investments and helping the city achieve its goal of becoming a resilient, inclusive, and sustainable urban center.

Enabling Private Sector Participation

The Internal Rate of Return (IRR) of the Bango Water Supply System Development Project, which slightly exceeds the Minimum Attractive Rate of Return (MARR), provides a crucial signal that the project is financially viable—though with a narrow margin. This result is important because IRR is one of the most widely used indicators by investors and financiers to assess whether a project justifies capital allocation. A project with IRR ≥ MARR meets the minimum threshold for investment acceptability, suggesting that it could attract not only public funding but also private sector participation under the right conditions (Sibuea et al., 2022; Kusuma & Sandhyavitri, 2014).

Private sector participation in water infrastructure projects has become increasingly common in Southeast Asia, driven by the need to accelerate service coverage, mobilize additional financing, and introduce efficiency improvements. Public–Private Partnership (PPP) schemes allow risks, costs, and benefits to be shared between the public authority and private partners, aligning incentives to deliver projects on time, on budget, and at the required service quality (Sukrama et al., 2015). For a growing city like Malang, leveraging private capital is particularly attractive given fiscal constraints and competing budget priorities such as education, health, and transportation infrastructure.

However, the marginal IRR also signals that private sector participation will not be automatic. Investors will carefully scrutinize risk allocation, tariff-setting mechanisms, and regulatory stability before committing capital. If the risk-return profile is perceived as too fragile—e.g., if there is exposure to unmitigated demand risk or volatile input costs—private participation may be limited or require significant guarantees that could shift fiscal risk back to the public sector. This underscores the importance of designing a bankable project structure, where risks are clearly defined, allocated to the parties best able to manage them, and supported by transparent legal and regulatory frameworks.

Blended financing instruments, combining public funds with concessional finance or guarantees from development banks, can also play a critical role. Rahmawati et al. (2021) note that blended finance can de-risk projects by covering first-loss components or providing credit enhancement, thereby lowering the cost of capital and making projects with thin margins more attractive to private investors. For the Bango Project, concessional loans could be used to finance civil works with long payback periods, while private partners could focus on operating facilities, billing, and maintenance, where efficiency gains are more readily achievable.

From a governance perspective, enabling private sector participation also requires clear regulatory oversight to ensure that efficiency improvements do not compromise affordability or equity objectives. International experience shows that poorly designed PPP contracts can lead to tariff increases that burden low-income consumers, triggering political backlash and contract renegotiation. To prevent such outcomes, contracts must specify performance standards, service quality targets, and tariff adjustment formulas that balance cost recovery with affordability.

Performance-based incentives should reward private operators for achieving NRW reduction, energy efficiency, and service expansion targets—ensuring that public policy goals are met alongside commercial objectives.

Furthermore, private participation can help accelerate innovation and technology adoption. Private operators often bring expertise in digital billing, SCADA systems, and predictive maintenance technologies that can reduce operating costs and improve service reliability. These innovations directly improve financial performance by reducing water losses, optimizing pump schedules, and improving collection efficiency. As Tangcharoen et al. (2023) point out, technology-enabled utilities typically exhibit better cost recovery ratios and lower O&M expenses per m^3 than purely public counterparts.

Nevertheless, it is essential to manage stakeholder expectations and ensure social acceptance of private involvement in water services. Public communication campaigns should explain the rationale for PPPs, emphasizing that the objective is not privatization but improved service delivery through risk-sharing. Transparency in the bidding and contract award process can also enhance public trust and reduce resistance from civil society organizations.

To fully leverage private sector participation as a mechanism for improving project bankability and operational efficiency, the following policy actions are recommended:

1. Develop a Clear PPP Framework:
   Malang City should prepare a standardized PPP framework aligned with national regulations (Perpres 38/2015) and international best practices. The framework should define risk allocation principles, procurement processes, and dispute resolution mechanisms to create a predictable environment for investors.
2. Structure Risk-Sharing Mechanisms:
   Demand risk could be partially mitigated through take-or-pay agreements, where the public sector guarantees a minimum revenue stream. Input cost risks (e.g., electricity tariffs) can be addressed through pass-through clauses, ensuring that cost increases can be reflected in tariff adjustments subject to regulatory approval.
3. Leverage Blended Finance:
   The local government can collaborate with multilateral development banks or climate funds

to access concessional finance, guarantees, or viability gap funding. This will reduce the weighted average cost of capital (WACC) and improve IRR, making the project more attractive to private investors.

4. Ensure Affordability through Tariff Design:
   Introduce increasing-block tariffs that protect low-income households while allowing cost recovery from commercial and industrial users. This approach aligns with equity objectives while maintaining project bankability.
5. Embed Performance-Based Incentives:
   PPP contracts should include key performance indicators (KPIs) for NRW reduction, energy efficiency, and customer satisfaction. Meeting or exceeding KPIs could trigger bonus payments, while failure to meet targets could result in penalties.
6. Strengthen Regulatory Oversight:
   Establish an independent regulatory body or strengthen existing mechanisms to monitor compliance with contract terms, service quality, and tariff adjustments. Regular audits and public disclosure of performance data can enhance accountability and investor confidence.
7. Promote Transparency and Stakeholder Engagement:
   Conduct stakeholder consultations during project preparation and procurement stages. Publicly disclose bid results, evaluation criteria, and contract summaries to build public trust and reduce resistance to private participation.
8. Foster Innovation and Knowledge Transfer:
   Encourage private partners to introduce technology solutions and training programs that enhance PDAM's long-term operational capacity. This will ensure that efficiency gains persist beyond the life of the PPP contract.

By adopting these measures, Malang City can transform the Bango Project into a model of collaborative infrastructure development, where public and private actors work together to deliver sustainable water services. The presence of private capital and expertise can help absorb fiscal shocks, accelerate service coverage, and enhance operational efficiency, ultimately contributing to the city's vision of becoming a resilient, inclusive, and competitive urban hub.

Maintaining Operational Continuity

One of the most striking findings from the financial feasibility analysis of the Bango Water Supply System Development Project is that the payback period (PP) aligns exactly with the end of the 24- year Build–Operate–Transfer (BOT) concession period. This result is both reassuring and cautionary: while it confirms that the investment can be fully recovered within the economic life of the project, it also highlights that there is virtually no slack in the timeline. Any operational disruption—whether from natural disasters, infrastructure failures, prolonged maintenance downtime, or socio-political disturbances—could push full cost recovery beyond the concession period, creating fiscal risk for Malang City and potentially undermining investor confidence.

This dynamic is not unique to Malang. Laksono & Latief (2024) observe that long payback periods are characteristic of capital-intensive water infrastructure projects, especially in contexts where tariff policies prioritize affordability over rapid capital recovery. Such extended gestation periods require a consistent operational and financial discipline over decades—something that can be challenging given changing administrations, evolving regulatory environments, and external shocks such as fuel price fluctuations.

Operational continuity, therefore, becomes a cornerstone of project success. It encompasses the ability to ensure uninterrupted water production and distribution, maintain reliable energy supply, control non-revenue water (NRW), and sustain collection efficiency throughout the concession period. According to Mamudi et al. (2017), utilities that fail to maintain stable operations face cumulative deficits as small inefficiencies compound over time, gradually eroding the financial viability initially established at the feasibility stage.

A critical factor in maintaining continuity is asset management. Water treatment plants, pumping stations, and pipelines are subject to wear and tear, and without a proactive maintenance strategy, the risk of unplanned outages rises significantly in later years of operation. International experience shows that utilities adopting preventive and predictive maintenance practices can reduce unplanned downtime by 30–40% compared to those relying solely on corrective maintenance (Rahmawati et al., 2021). For the Bango Project, implementing a computerized maintenance management system (CMMS) would enable PDAM Malang to track asset condition, schedule timely interventions, and optimize spare parts inventory—reducing both costs and service interruptions.

Energy reliability is another operational continuity risk. Given that electricity constitutes about 60% of operating costs, power outages or tariff volatility could disrupt production and strain finances. Sukrama et al. (2015) emphasize the importance of energy resilience planning, which can include securing backup power generators, negotiating preferential tariffs with PLN, and investing in energy efficiency technologies to lower baseline consumption.

In addition, climate variability and extreme weather events pose emerging risks. Droughts could reduce raw water availability, while floods could damage critical infrastructure or disrupt distribution networks. Integrating climate risk assessments into operational planning is thus crucial. Tangcharoen et al. (2023) suggest that climate-resilient infrastructure designs—such as elevated pump houses, flood-proof electrical systems, and diversified raw water sources—can significantly reduce vulnerability to climate shocks.

Operational continuity is also closely tied to revenue stability. Collection efficiency must be maintained to ensure that expected cash inflows materialize. Even a 5–10% drop in collection efficiency can delay the payback timeline by several years, given the tight financial margins identified in the analysis. Strengthening customer billing systems, deploying digital payment channels, and conducting regular meter audits can help sustain high collection performance and minimize bad debt accumulation.

Governance plays an important role as well. Institutional continuity and capacity building must be prioritized to ensure that key operational practices survive political transitions and leadership changes. As Kusuma & Sandhyavitri (2014) note, institutional memory and staff competence are critical assets in long-term infrastructure projects. Without them, there is a risk of policy discontinuity, underfunded maintenance, or misaligned priorities, which can jeopardize both service delivery and financial health.

Finally, social acceptance and stakeholder engagement are key for operational stability. Public opposition to tariff adjustments, land disputes along pipeline corridors, or inadequate communication during service disruptions can erode trust and result in political pushback that affects project operations. Maintaining transparency, holding regular community consultations, and offering grievance redress mechanisms are proven strategies to minimize social risk (Rosyid & Nurrajendra, 2022).

To safeguard the project's long-term financial and operational viability, several policy measures are recommended:

1. Develop a Comprehensive Asset Management Plan:
   PDAM Malang should adopt international best practices for asset management, including condition assessment, life-cycle costing, and predictive maintenance schedules. Establishing a dedicated maintenance fund will ensure that major rehabilitation works are financed without disrupting operational budgets.
2. Secure Energy Resilience:
   A dual strategy of energy efficiency and supply security should be implemented. This can include investing in high-efficiency pumps and motors, optimizing pump scheduling, and installing on-site backup generators. Negotiations with PLN for preferential tariffs or participation in renewable energy programs can further stabilize costs.
3. Integrate Climate Adaptation into Design:
   Incorporate climate resilience measures into infrastructure design and operation, such as diversifying water sources, elevating critical equipment above flood levels, and strengthening embankments. Collaboration with the regional river basin authority (BBWS Brantas) is essential to ensure sustainable raw water allocation during drought periods.
4. Enhance Revenue Assurance Systems:
   Digitalize customer databases, deploy automated meter reading (AMR), and expand payment channels (mobile banking, e-wallets) to improve billing accuracy and reduce collection losses. Collection efficiency targets should be formalized as part of PDAM's performance contracts.
5. Institutionalize Knowledge Transfer and Capacity Building:
   Establish structured training programs and succession planning for key technical and financial positions to preserve institutional knowledge. Partnering with universities and

professional associations can support continuous capacity development.

6. Strengthen Governance and Oversight:
   Create an operational oversight board to monitor key performance indicators (service continuity, NRW, energy intensity) and report regularly to the mayor's office and city council. Transparent reporting will build accountability and political support for necessary tariff adjustments.
7. Engage Communities Proactively:
   Develop a public communication strategy to inform customers about planned maintenance, service improvements, and tariff changes. Establish grievance mechanisms to address complaints promptly and maintain trust.

By implementing these measures, Malang City can transform the Bango Project from a technically feasible initiative into a resilient and reliable water service backbone that supports the city's growth for decades to come. Operational continuity ensures that financial projections remain valid, prevents revenue shortfalls, and strengthens the city's credibility with lenders and development partners. In this way, the project contributes not only to water security but also to broader goals of inclusive urban development and economic competitiveness.

6. Conclusion

This research confirms that the Bango Water Supply System Development Project is financially viable and strategically significant for Malang City's urban development trajectory. Using a single-technique financial feasibility framework, four key indicators—Net Present Value (NPV), Benefit–Cost Ratio (BCR), Internal Rate of Return (IRR), and Payback Period (PP)—were applied to comprehensively evaluate the project over a 24-year horizon. The results demonstrate that the project achieves a positive NPV, a BCR marginally above unity, an IRR that exceeds the Minimum Attractive Rate of Return (MARR), and complete cost recovery within the concession term. Together, these metrics confirm that the project is both technically and fiscally sound, providing confidence that it can sustain operations without imposing a long-term fiscal burden on the city.

Beyond confirming financial feasibility, the findings underscore the project's strategic role in shaping Malang's future growth. Reliable and sustainable water supply infrastructure is fundamental to supporting urban expansion, enhancing public health outcomes, and attracting investment in education, tourism, and the creative economy. The project strengthens the fiscal capacity of the municipal water utility, enabling reinvestment in network upgrades, coverage expansion to peri-urban areas, and quality improvement programs. Such outcomes directly support the city's objectives of achieving equitable service distribution and inclusive growth.

However, the analysis also reveals that the project's financial margins are relatively narrow, as reflected in the near-unity BCR and IRR only slightly above the hurdle rate. This finding highlights the need for robust cost control, disciplined tariff setting, energy efficiency initiatives, and proactive operational risk management to preserve financial viability. Preventive maintenance programs, NRW reduction efforts, and adaptive tariff mechanisms are essential to ensure that projected surpluses materialize and are not eroded by inefficiencies or shocks.

From a policy perspective, the results present a clear call to action. City planners and decision- makers should integrate the project's financial and operational parameters into Malang's medium- and long-term development plans (RPJMD, RTRW), synchronize infrastructure investments with spatial planning, and consider blended financing or PPP models to leverage private sector participation. Embedding governance mechanisms—such as lifecycle cost monitoring, performance-based contracts, and transparent public reporting—will be critical to protect the project's feasibility margin and maintain public trust.

From a theoretical standpoint, this study contributes to the literature on infrastructure finance and regional development by demonstrating how a single-technique financial feasibility approach can inform investment prioritization and spatial planning decisions. Framing financial analysis within a regional development perspective ensures that infrastructure investments are not only economically justified but also socially and spatially aligned, advancing Malang's progress toward SDG 6 (Clean Water and Sanitation) and SDG 11 (Sustainable Cities and Communities).

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