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The Fiscal Paradox and the Performance of Irrigation Infrastructure: A National Analysis of the Relationship Between Operational and Maintenance Funding and the Sustainability of Local Irrigation Assets

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Abstract

Irrigation operation and maintenance (OP) management is a key factor in the sustainability of water resource infrastructure services and national food security. In Indonesia, the gap between actual maintenance needs and regional budgeting capabilities remains a major issue. This study analyzes the relationship between regional fiscal capacity, the fulfillment of the Actual Operation and Maintenance Needs (AKNOP), and the achievement of the Irrigation System Performance Index (IKSI) in irrigation areas under regional authority during the 2023–2025 period. Using a mixed-methods approach, the study combines quantitative analysis of national data with a literature review, a survey of OPD perceptions, and practitioner assessments. The results show that high fiscal capacity does not always correlate with irrigation system performance; some regions with large budgets still have low IKSI, while regions with limited budgets are able to maintain services by utilizing the remaining life of the infrastructure. This phenomenon reflects a fiscal paradox, where the problem is more about governance weaknesses than budget limitations. Using the Risk Quadrant Matrix, the study identifies four typologies of irrigation management: acute crisis, governance inefficiency, latent risk, and sustainable zones. The weak integration of AKNOP technical data with the regional budgeting system has created information asymmetry between technical and fiscal units. Recommendations include digital integration of e-AKNOP with the Regional Government Information System (SIPD), strengthening mandatory spending based on infrastructure risk, and revitalizing irrigation OP institutions. These reforms are expected to drive the transformation of irrigation management from a construction-oriented paradigm to an asset-management one.

INTRODUCTION

Infrastructure irrigation is bone back resilience food national, because support part big production Indonesian agriculture. With wide area irrigation authority centers and regions that reach millions of hectares, sustainability service irrigation become factor strategic in guard stability production food, control inflation, and resilience economy area. Management irrigation no only related with aspect technical irrigation, but also related directly with a strategic agenda national like self-sufficiency food and development agriculture sustainable. Decline sustainability service irrigation and increasing risk to resilience food become challenge serious that requires attention policy in a way systemic. Although government has invested budget big

for development and rehabilitation network irrigation, success development physique not yet fully followed by quality sustainable service (Alaerts, 2019; Gany et al., 2019). This shows paradox in governance infrastructure public, where development asset new keep going done, but ability guard performance assets that have been built still relatively weak (Detter & Fölster, 2016; Irazábal, 2018; K. Kim, 2023; Lewis, 2019).

From the perspective management assets, governance irrigation still dominated by a construction-oriented approach that focuses on development physique new and not yet fully shift towards asset management-oriented governance, which places operation and maintenance as the core of sustainability service. Maintenance infrastructure often overlooked, because project new own visibility more politics tall compared to routine maintenance, so that happen accumulated deferred maintenance that decreases condition asset in a way gradually (Guo, 2025; J. Kim, 2022; Ramakrishnan et al., 2021). The Life Cycle Costing (LCC) approach shows that irrigation as asset public experience depreciation mark economy along time, so that sustainability function service is highly dependent on the operation and maintenance performed in a way periodic. Delay maintenance can speed up damage and improve cost future rehabilitation, making operation and maintenance as form protection to mark economy state assets (Frangopol & Liu, 2019; Zidan et al., 2016).

Problems management irrigation is also related close with capacity fiscal regions and governance budget. In terms of theoretical, area with capacity fiscal tall should capably guard quality service infrastructure public. However, empirical show that capacity high fiscal no always correlated with achievements performance system irrigation, while a number of areas with capacity fiscal limited still can maintain service certain phenomena. This signifies existence paradox fiscal, where governance and priority weaknesses more budget nature political or administrative compared to need real infrastructure, causing failed budget conversion and information asymmetry between technical units and decision makers decision fiscal. As a result, the decision budgeting no fully based need real, but rather tend nature historical or administrative, strengthening development bias new (new construction bias) compared to maintenance asset existing.

Validation empirical use USG method (Urgency, Seriousness, Growth) based on perception practitioners manager irrigation show three problem main: gap financing operation and maintenance, limitations allocation OP budget which becomes residual expenditure, and a decrease performance system irrigation due to deferred maintenance. Decline performance system irrigation get score highest and has character progressive and accelerative, indicating that part big network irrigation has enter phase deterioration that requires intervention serious. Problem Tree analysis shows that low performance system irrigation is results interaction between dimensions fiscal, data governance, and capacity institutional OP management, so that governance reform need directed at integration aspect financing, system information technical, and capacity institutional in a way sustainable for guard sustainability service irrigation.

The novelty of this research lies in four key contributions. First, it develops and applies a Risk Quadrant Matrix that simultaneously integrates fiscal (budget fulfillment ratio) and technical (IKSI) indicators, providing a diagnostic tool for classifying local government irrigation management into four distinct typologies. Second, it empirically demonstrates the "fiscal paradox" phenomenon at the national level across 485 local governments, showing that high budgets do not guarantee high performance and that low budgets can sometimes sustain

performance through residual asset life. Third, it identifies information asymmetry between technical and fiscal units as a central causal mechanism, rather than merely budget limitations. Fourth, it proposes a concrete policy solution the integration of e-AKNOP with SIPD as a mechanism to reduce this asymmetry and enforce needs-based budgeting.

Based on description background back and structure problems that have been identified, research this designed for answer a number of question critical related management irrigation operation and maintenance (OP) area. First, research this aim for understand condition national irrigation OP financing area, so that can know to what extent is the allocation budget has sufficient need real maintenance infrastructure. Second, research explore connection between capacity fiscal area, level fulfillment of the Number of Needs Real Operation and Maintenance (AKNOP), as well as achievements System Performance Index Irrigation (IKSI), for evaluate to what extent capacity fiscal impact to performance service irrigation. Third, research make an effort identify typology risk management irrigation area through Matrix Risk Quadrant, so that characteristics risk can mapped in a way systematic. Fourth, research formulate direction of governance reform management irrigation based on need real, sustainability financing, technical data integration, and management asset infrastructure, with objective give recommendation strategic for strengthening operations and maintenance irrigation at the level area.

METHOD

Flow diagram methodology study following describe stages analysis used in this study. The approach used was mixed-method sequential explanatory, i.e integration analysis quantitative and qualitative in a way sequentially for understand relatedness between financing operation and maintenance, governance budgeting and performance system irrigation.

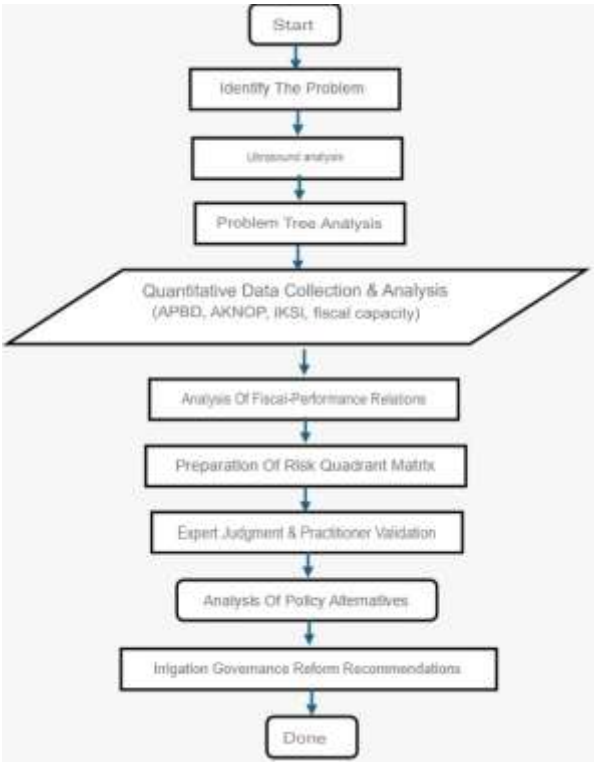

Figure 2. Methodology Study

RESULTS AND DISCUSSIONS

Theoretical Discourse: Paradigms of Public Infrastructure Management

Based on the results of *the Problem Tree Analysis* in Chapter I, the decline in irrigation system performance is not solely caused by physical damage to the network, but is the result of the interaction between weak fiscal priorities for operations and maintenance, the lack of integration of technical data in the budgeting process, and limited institutional capacity for irrigation management. The structure of the problem indicates that the irrigation sustainability crisis is essentially a matter of public infrastructure asset governance. Therefore, this study uses three main conceptual pillars, namely *Life Cycle Costing* (LCC), *Needs-Based Budgeting* (NBB), and Information Asymmetry theory, to explain the relationship between operation and maintenance financing, the fiscal decision-making process, and the decline in irrigation system performance.

In this context, the theoretical approach is not used merely as a conceptual basis, but as an analytical framework to explain the root causes of deferred maintenance, financing gaps, and the ineffectiveness of converting budgets into irrigation service performance.

Life Cycle Costing (LCC) and the Phenomenon *Deferred Maintenance*

In perspective management modern assets, infrastructure No understood as investment one - time *investment*, but rather as commitment cost throughout cycle life assets (*life cycle*). Concept *Life Cycle Costing* (LCC) confirms that efficiency management infrastructure determined by ability guard performance asset through maintenance proper preventive measures time and sustainability (Flanagan & Norman, 1983).

However, in practice, management irrigation area often faces the phenomenon of deferred maintenance, namely delayed maintenance that causes accumulation of damage in a progressive manner (Grigg, 2010). At the early stage, damage still can be handled at low cost. However, when intervention is postponed, assets enter a phase of accelerated deterioration, where the rate of damage increases in a non-linear and accelerated manner, causing decline in infrastructure condition.

In this framework, the draft cost of inaction appears, namely the economic consequence of not performing timely maintenance. Reduction in maintenance cost in the short term does not produce efficiency, but rather has the potential to become an infrastructure liability in the future (OECD, 2021). Various studies show that every unit of cost maintenance neglected in preventive measures can increase rehabilitation costs up to 4–10 times in the advanced phase (ASCE, 2021).

In the context of this study, the irrigation area with IKSI below threshold 55 indicates that the system has entered a phase of critical deterioration, resulting in a dominant reliance on rehabilitative approaches compared to preventive ones. The phenomenon of deferred maintenance becomes the main connector between low-priority financing of operations and maintenance and the decline in irrigation system performance.

Findings show that the crisis in irrigation management is not only caused by technical problems, but also by how budget priorities are formed in the public infrastructure management

system. In this context, the analysis needs to be expanded to include the economic and political budget dimensions that form a preference for new development compared to preservation of existing assets.

***New Construction Bias* and the Political Economy of the Budget**

Literature on political economy development shows the existence of a trend of new construction bias in infrastructure budget allocation, namely a systematic preference for developing new infrastructure compared to maintaining existing assets (Pasandaran, 2018). This phenomenon is not only technical in nature, but also political, because new development projects have high visibility and provide productive short-term electoral incentives. Temporary activities in operation and maintenance (OP) tend to have low policy visibility, offering direct political benefits (Flyvbjerg, 2014).

In this context, OP is often positioned as residual expenditure in the area budget structure, rather than as a main component determining the sustainability performance of infrastructure. This explains why AKNOP documents often do not function as the main instrument in determining fiscal priorities, but are instead treated as administrative support documents.

Conceptually, the ideal approach to infrastructure budgeting is needs-based budgeting, in which budget allocations are based on measurable objectives according to the actual condition of assets, rather than historical trends or political considerations (Robinson, 2015). However, in practice, financial management at the regional level is still dominated by incremental budgeting, where budget allocations are determined based on adjustment percentages from the previous year, without deep evaluation of actual field conditions (Wildavsky, 1986). This causes a structural mismatch between technical infrastructure needs and budget realization.

In the irrigation sector, AKNOP is generally designed as a normative instrument to operationalize the principles of needs-based budgeting, as it estimates the real needs for operation and maintenance based on the physical condition of the network. Therefore, AKNOP should serve as a rational basis for budget compilation. However, empirical findings show that AKNOP has not functioned as a determinant variable in fiscal decision-making. Instead, the documents are often treated as administrative formalities rather than as a binding budget allocation, resulting in a systemic financing gap where real maintenance needs are not fully accommodated in the APBD.

Table 2. Causal Factors The gap Irrigation OP Financing

Limitations fiscal area	50
Priority development other sectors	**61**
budgeting process is not AKNOP based	53
Lack of understanding the importance of OP in budgeting	47
AKNOP data that is not updated	52
Limited human resources for OP management	49
Limitations support center in financing	44

Source : Questionnaire Results, 2026

Findings show that the main problem in irrigation management does not only lie in the magnitude of fiscal capacity, but also in how fiscal priorities are formed in the budget decision-making process. Its dominant priority factors for the development of other sectors show that operation and maintenance activities have not yet become a main priority in the fiscal decision-

making structure. This condition strengthens the indication of the existence of a new construction bias, namely the trend of allocating more budget to new development-oriented infrastructure compared to the preservation of existing assets.

Thus, the main problem in governance and financing of irrigation does not lie in the absence of technical instruments, but rather in institutional weaknesses in integrating these instruments into an effective budgeting mechanism. This shows the existence of a disjunction between the technocratic rationality represented by AKNOP and the economic-political logic that dominates the budget allocation process.

In the context of the problem tree study, this phenomenon of new construction bias explains why the need for operation and maintenance often does not receive adequate fiscal priority, even though it plays an important role in safeguarding the sustainability of irrigation services.

Information Asymmetry in Fiscal Decision Making

In addition to technical and fiscal factors, weaknesses in irrigation management are also influenced by structural issues in the flow of information between levels of government. From an *information asymmetry perspective* , information imbalances between technical actors and fiscal decision-makers can lead to significant policy distortions. Stiglitz and Rosengard (2015) emphasize that public policy failures often stem from the lack of symmetrical information that can be effectively processed in the decision-making process.

In the context of irrigation management, information on the actual condition of the network resides with technical units in the field, such as irrigation inspectors and observers, who have direct access to the physical condition of the assets. However, in bureaucratic processes, this information is not always fully conveyed to decision-makers, such as the Public Works and Housing Agency (PUPR), the Regional Development Planning Agency (Bappeda), or the Regional Government Budget Team (TAPD). This aggregation and bureaucratization of information often leads to simplification, delays, or even the loss of critical data before it can be used in the budget planning process.

The absence of an integrated data system exacerbates this asymmetry, so that budgeting decisions are not entirely based on the actual condition of assets, but rather are influenced more by perceptions, partial information, or historical data. In such situations, budgeting mechanisms tend to shift from a *needs-based budgeting approach* to *incremental budgeting* , where budget allocations are determined based on the previous year's pattern without adequate correction for the existing infrastructure condition.

As a result, there is *a disjunction* between budget size and service performance. In some cases, including in regions with relatively high budget allocations, irrigation system performance remains low because the technical information used as the basis for decision-making does not fully reflect actual needs on the ground. Thus, information asymmetry is not only a bureaucratic communication issue but also a key factor explaining the inaccurate conversion of budget allocations into improved infrastructure service performance.

Without a transparent, *real-time*, and standardized data integration mechanism, budget increases will not automatically be directly proportional to improvements in service quality, because fiscal decisions remain built on an information base that is not entirely accurate and fragmented.

This situation indicates that the problem of irrigation management lies not only in limited data, but also in the lack of a mechanism for integrating technical information into the fiscal decision-making system. In this context, digitalization and integration of e-AKNOP become relevant as instruments for reducing *information asymmetry* in irrigation budget governance.

Non-Linear Degradation Risk (Infrastructure *Half-Life*)

Besides the dimensions of efficiency costs, economic-political budget, and information asymmetry, the dynamics of irrigation management also need to be understood in the context of the technical characteristics of infrastructure, which is non-linear. Givoni and Perl (2017) explain that infrastructure has a non-linear degradation pathway, where assets can maintain performance relatively stable for a certain period before experiencing a sharp decline when approaching a critical point (cliff-edge effect).

In this context, the condition of an irrigation system that is still functioning does not always reflect sustainable services. Infrastructure can appear operationally stable, but actually may have entered a phase of service life decline (residual service life), which is increasingly short. As a result, without proper maintenance intervention, the system can experience a sudden and massive decline in function, rather than a gradual one.

This phenomenon strengthens arguments in previous sub-chapters that delayed maintenance, budget allocation bias, and weak integration of information work simultaneously to accelerate asset deterioration. In other words, the risk in irrigation management is not only fiscal in nature, but also systemic, because it can trigger service weaknesses in a relatively short time when assets pass the critical point.

In this study context, the risk of non-linear degradation explains why low financing for operation and maintenance not only gradually lowers service quality, but can also accelerate the system's transition to a critical condition. Therefore, the existence of a minimum fiscal protection mechanism, including mandatory spending for operation and maintenance, is important to prevent the accumulation of deferred maintenance and to safeguard the sustainability function of irrigation infrastructure.

Thus, the crisis in irrigation management can be understood as the accumulation of: (i) inefficiency in the asset life cycle (Life Cycle Costing and deferred maintenance), (ii) distortion in economic-political budget (new construction bias), (iii) weak integration of information (information asymmetry), and (iv) risk from non-linear infrastructure degradation. The fourth dimension forms a framework of mutual explanation related to the systemic decline in irrigation system performance.

Regulatory Framework and Integration of Irrigation Management Governance

Contrary to the common assumption that irrigation management problems in Indonesia are caused by a lack of regulation, this research analysis shows that most normative and technical instruments are already in place. The main problem lies in the weak integration between policy instruments and the suboptimal translation of technical requirements into regional fiscal decision-making systems.

In the context of this research problem tree, the root causes of problems such as the low priority of operational and maintenance funding, the lack of integration of AKNOP into

budgeting, and weak institutional coordination essentially have their own regulatory basis. However, these instruments are still partially operational, thus failing to establish integrated and asset-based irrigation management governance.

Therefore, the solution approach in this research is not directed at the formation of new regulations, but rather at strengthening implementation, institutional synchronization, and integration between normative mandates, technical instruments, and data-based budgeting systems.

Sustainability Mandate in Constitution Number 17 of 2019 concerning Water Resources

Constitution Number 17 of 2019 places the management of water resources, including irrigation, as part of the state's responsibility to ensure the sustainability of water services and to support national food resilience. From this perspective, the sustainability function of irrigation infrastructure is not only a technical problem, but also a strategic normative mandate.

However, the implementation at the regional level still faces a gap between normative mandates and actual fiscal priorities. Maintenance of infrastructure often does not receive equal priority compared to new development, so that sustainable service has not yet fully become the main orientation in regional budgeting.

In the context of the research problem tree, this condition is directly related to the low priority of financing for operation and maintenance, which then triggers deferred maintenance and a decline in irrigation system performance. Thus, the SDA Law should not only be understood as a general norm for water management, but also as a base of legitimacy for strengthening fiscal priorities for the preservation of irrigation assets.

Revitalizing the Role of AKNOP in PUPR Ministerial Regulation No. 12/PRT/M/2015

Ministerial Regulation No. 12/PRT/M/2015 provides an important technical instrument in the form of Needs Figures for Real Operation and Maintenance (AKNOP), which is conceptually designed as a basis for calculating budget needs based on the actual condition of assets. In an ideal framework, AKNOP works as a bridge between the technical conditions in the field and the budgeting processes.

However, in practice, AKNOP has not yet functioned as a binding reference in the budgeting process. This document tends not to be strongly integrated into the planning and budgeting cycle, thus losing its influence in determining fiscal allocations.

This condition shows the existence of an implementation gap, where the technical instrument is available but not supported by institutional mechanisms that tie it to fiscal decision-making. In addition, the absence of a data verification system causes AKNOP's quality to be highly dependent on the capacity of individual compilers, leaving room for variation in data quality, bias, and inconsistency.

Therefore, it is necessary to transform AKNOP from just an administrative document into a binding fiscal instrument (binding technical reference), through integration with the budgeting system as well as strengthening validation based on standardized data.

Integration of SIPD as Lock Fiscal and Deductions Discretion

The System Information of Regional Government (SIPD) has strategic potential as an integration platform between technical data and the fiscal decision-making process. In the context of irrigation management, SIPD can function as a policy integration platform that connects IKSI, AKNOP, and budget planning data in one standardized and integrated system. Integration of AKNOP into SIPD allows every proposal for financing operation and maintenance to have its justification documented and its technical applicability explored. Thus, the budgeting process no longer fully depends on administrative and historical approaches, but begins to move toward a mechanism based on real asset infrastructure needs.

In addition to improving transparency and accountability, this integration also has the potential to become a fiscal locking mechanism that limits discretionary reductions in the operation and maintenance budget without a verifiable technical basis. In this context, SIPD does not only function as a financial administration system, but also as an instrument for strengthening synchronization between technical needs and fiscal decisions. In the problem tree study context, the integration of SIPD becomes relevant to address the root problem of weak technical data integration in fiscal decision-making, as well as the occurrence of information asymmetry between institutional levels. Therefore, strengthening technical data integration into SIPD becomes one of the important prerequisites to support irrigation management based on real needs and sustainable asset infrastructure.

Synchronization Institutional in Law No. 23 of 2014 concerning Local government

Constitution Number 23 of 2014 regulates the distribution of authority for irrigation management between the central, provincial, and district/city governments based on service area. This design is normatively aimed at increasing management efficiency in accordance with the scale of authority. However, in practice, the division of authority often causes fragmented coordination, especially in irrigation systems that are cross-regional. Asynchronization of planning and budgeting between levels of government causes partial interventions that do not always have an overall impact on system performance.

In this context, the Irrigation Commission should play a role as a cross-sector coordination forum. However, its effectiveness is still limited and highly dependent on regional commitment, so it has not yet fully functioned as a connector between technical and fiscal aspects. Strengthening institutional coordination is required so that planning and budgeting can be carried out in an integrated manner, especially in cross-authority irrigation systems.

Synthesis Regulation: From Fragmentation to System Integration

Analysis of regulations shows that the main problem in irrigation management does not lie in the absence of policy instruments, but rather in the fragmented implementation among available instruments. The sustainability mandate is arranged in the SDA Law, the technical instrument is available through AKNOP, and the fiscal integration platform is facilitated through SIPD. However, all three are not yet connected into one integrated governance system.

As a result, technical needs are not fully translated into fiscal priorities, while fiscal decisions are not yet fully based on the condition of current irrigation assets. This condition shows that the main problem in irrigation management is more a systemic governance failure than a regulatory vacuum.

Thus, irrigation management reform needs to be directed at strengthening connectivity among normative, technical, fiscal, and institutional aspects in one data-based management system. In this context, e-AKNOP integration, strengthening mandatory spending for operation and maintenance, and strengthening institutional capacity become key leverage points toward sustainable asset-based irrigation governance.

Analysis Empirical: Risk Mapping and the Paradox of Irrigation Performance in Local Government

Although regulatory frameworks for irrigation management are available, their implementation effectiveness needs to be tested against the current condition of irrigation management areas. Therefore, this research conducts empirical analysis across 485 local government regions in Indonesia during the period 2023–2025 to map the connection between financing for operation and maintenance and irrigation system performance.

The analysis uses the Risk Quadrant Matrix approach, which integrates two main variables: the Irrigation System Performance Index (IKSI) as a technical performance indicator and the budget fulfillment ratio based on AKNOP as a representation of the adequacy of financing for operation and maintenance. This approach allows identification of the connection pattern between financing capacity and sustainable irrigation services at the national level, while also revealing systemic mismatches between fiscal allocation and infrastructure performance. Analysis results show the existence of a fiscal paradox, namely the condition in which improvement in financing capacity does not always lead to an increase in irrigation system performance.

Critical Threshold and Structure Risk Quadrant

As a basis for mapping, this research sets two operational thresholds: an IKSI of 55 as the critical limit for the decline in irrigation service function, and a budget fulfillment ratio of 30% as the operational threshold for financing operation and maintenance. The determination of the 30% threshold is based on empirical national data, where the average budget fulfillment ratio of government AKNOP areas is approximately 29.6%. In addition, areas with a fulfillment level below 30% tend to have lower average IKSI compared to areas above this threshold. Thus, these thresholds are used as a base for risk classification to differentiate underfunding levels in irrigation management areas. The combination of both parameters produces four risk quadrants as follows:

- Quadrant I (*Low Budget – Low Performance*): 235 local governments
- Quadrant II (*High Budget – Low Performance*): 119 local governments
- Quadrant III (*Low Budget – High Performance*): 69 local governments
- Quadrant IV (*High Budget – High Performance*): 62 local governments

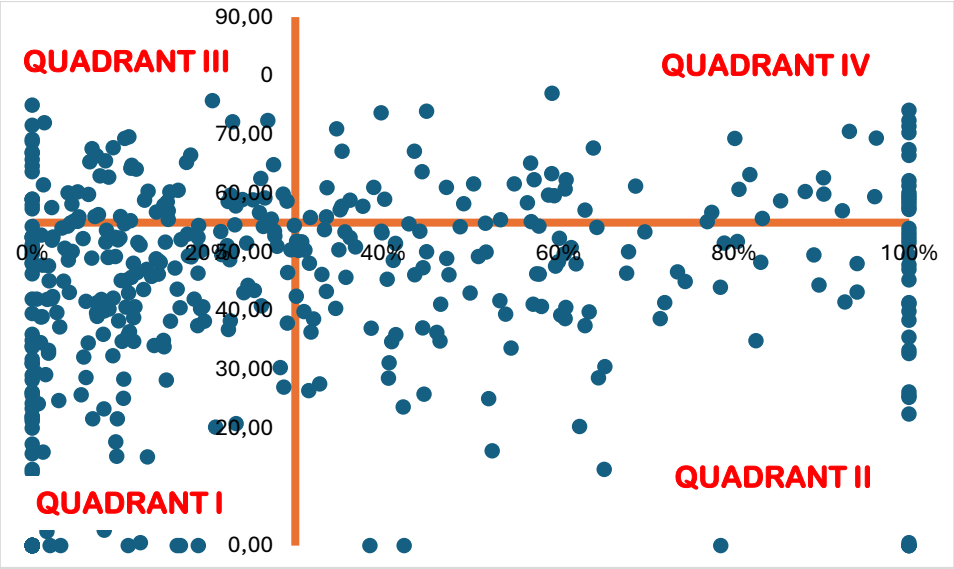

Figure 2. Matrix National Irrigation Performance Risk Quadrant

Source: Research Data Processing Results (2026).

Distribution the show that majority government area Still be in condition not optimal (Quadrants I and II). Findings This indicates that problem management irrigation in Indonesia is of a nature systemic and not Again can understood as cases isolated local.

Interpretation Empirical: Four Risk Typology

Quadrant I – Double Crisis (*Low Budget – Low Performance*)

Quadrant This is group the biggest with 235 governments areas facing combination limitations fiscal and low performance technical. Condition the show that system irrigation has is in phase degradation carry on consequence accumulation ongoing *underinvestment* and *deferred* maintenance in term long. Low fulfillment need operation and maintenance cause activity preservation asset No can done in a way adequate, so that decline condition network ongoing more fast compared to ability handling.

In context *problem tree* study this quadrant This represent relatedness direct between low priority financing operation and maintenance with decline quality service irrigation. In managerial group This own level risk highest Because without intervention significant fiscal and technical systems potential experience decline function service in a way progressive and widespread.

Quadrant II – Inefficiency Structural (*High Budget – Low Performance*)

A total of 119 governments area is in the quadrant this, which shows phenomenon *failed budget conversion*, ie condition when capacity relative fiscal tall No capable converted become improvement performance service irrigation in a way proportional. Findings This show that problem main No lies in the availability budget, but rather on the weakness technical data integration, quality planning and governance budgeting-based need real.

In context said, the height allocation budget Not yet Of course reflect effectiveness management if decision fiscal Still dominated approach administrative and not yet based condition current assets. With thus, the quadrant This represent form inefficiency structural,

where dysfunction transformation budget cause available shopping No capable produce improvement performance service optimally.

Quadrant III – Latent Risk (*Low Budget – High Performance*)

A total of 69 governments area is in the quadrant this, namely condition when performance system irrigation Still relatively Good although support budget operation and maintenance be under threshold minimum sufficiency. In empirical, conditions This show that achievements performance moment This more Lots supported by quality asset historical (*inherited asset quality*) compared sustainability financing maintenance.

In perspective *life cycle costing*, conditions the nature pseudo and save latent risk due to system Still operate with utilize remainder age service infrastructure (*residual service life*). Without support financing adequate maintenance, system potential experience decline condition in a non-linear manner when enter phase *accelerated deterioration*.

With thus, the quadrant This show that height IKSI achievements in a time No always reflect sustainability service in term long. The main risk in the group This No weaknesses that have been happened, but rather potential decline sharp that appears consequence delay intervention maintenance.

Quadrant IV – Sustainable Zone (*High Budget – High Performance*)

A total of 62 governments area is in the quadrant this, which represents the most ideal conditions in management irrigation area. In the group this, sufficiency financing operation and maintenance capable converted in a way effective become performance system relative irrigation Good.

Condition the show existence more connectedness Good between need technical, budgeting process, and capacity implementation institutional. In other words, the areas in the quadrant This relatively more succeed apply principle *asset management-oriented governance*, where sustainability service become part from priority management fiscal area.

However Thus, the proportion government area in the quadrant This Still relatively small compared to the total population research. Conditions the show that practice management irrigation data- based, needs real, and sustainability asset Not yet become the dominant norm in governance irrigation national.

Phenomenon Critical: Absence of Technical Database

Findings empirical also show the existence of a number of government areas with a very low budget fulfillment ratio for operation and maintenance, approaching 0%. This condition does not fully reflect limitations in fiscal capacity, but also indicates the unavailability of the latest technical data of AKNOP in the budgeting system. In this situation, real operation and maintenance needs cannot be translated into a measurable and structured budget allocation. As a result, the budgeting process continues without an adequate technical information base, making operation and maintenance activities highly vulnerable to residual spending reductions.

This condition strengthens arguments in previous sub-chapters about the occurrence of information asymmetry between technical units and fiscal decision-makers. When asset data is not adequately integrated into the budgeting system, fiscal decisions lose the ability to represent the level of risks and current infrastructure needs. From an asset management perspective, this condition shows that part of the irrigation system is operating at the minimum limits of

sustainability service (residual service life) and is vulnerable to sudden functional decline when entering a phase of critical deterioration.

Synthesis Empirical: Paradox National Fiscal

The distribution of 485 government areas shows that irrigation management problems in Indonesia are a systemic phenomenon on a national scale. Each quadrant represents different forms of ineffectiveness, from fiscal limitations (Quadrant I), governance inefficiency (Quadrant II), latent sustainability risks (Quadrant III), to relatively optimal but still limited management (Quadrant IV). Although each has different characteristics, all typologies show the same pattern: suboptimal integration between technical needs, fiscal priorities, and institutional implementation capacity. In this context, low irrigation system performance cannot be explained solely by budget limitations, but also by weak governance in connecting technical information with fiscal decision-making.

Findings strengthen results from the Problem Tree Analysis and previous theoretical analyses, indicating that the main problem in irrigation management is a form of systemic governance failure, where the budgeting system is not fully based on real assets and sustainable service infrastructure. Thus, the fiscal paradox in irrigation management shows that improvement in fiscal capacity will not automatically increase service quality unless accompanied by strengthened technical data integration, protective financing mechanisms for operation and maintenance, and institutional implementation capacity.

Policy Implications: Point Leveraging Systemic Reform

Findings from empirical studies show that partial intervention policies are not sufficient to improve sustainable irrigation governance. Additional budget without strengthening governance may enlarge inefficiency, as reflected in Quadrant II. On the other hand, strengthening technical capacity without adequate financing cannot prevent system degradation, as seen in Quadrants I and III. Therefore, irrigation management reform needs to focus on developing a mechanism capable of integrating technical, fiscal, and institutional dimensions simultaneously. In this context, integrating AKNOP into a data-based budgeting system through SIPD becomes a main leverage point for reducing information asymmetry, strengthening needs-based budgeting, and increasing accountability in fiscal decision-making.

At the same time, a minimum fiscal protection mechanism through mandatory spending for operation and maintenance is necessary to prevent systemic deferred maintenance. Strengthening human resources and institutional operational capacity is also important to ensure that budgets and technical data are translated into real service quality improvements. Thus, the direction of reform requires not only an increase in budget magnitude but also governance transformation toward a data-driven, sustainability-oriented irrigation asset management system capable of connecting technical needs with fiscal decisions effectively.

Synthesis and Formulation Alternative Policy: Towards Evidence-Based Governance

The root of the problem in irrigation management does not solely lie in fiscal capacity limitations, but in the low prioritization of operation and maintenance financing in the budgeting system, exacerbated by weak technical data integration in fiscal decision-making. Analysis results previously show that information asymmetry between technical and fiscal units

causes AKNOP data to not fully serve as a budgeting base, leading fiscal decisions to rely on historical and administrative approaches rather than actual conditions and real infrastructure needs.

In this situation, the dislocation between what is needed, what is planned, and what is funded ultimately produces systemic inefficiency, as reflected across all risk quadrants. Following Sirait (2024) regarding infrastructure governance transformation, this research emphasizes that fiscal efficiency can only be achieved if there is strong synchronization between technical needs and budget planning documents. Without this synergy, irrigation infrastructure remains trapped in a cycle of early damage, burdening state finances.

Therefore, policy reform needs to focus on systemic transformation, including:

1. Strengthening mandatory spending for operation and maintenance as a minimum fiscal protection,
2. Integration of e-AKNOP into SIPD as a mechanism for technical–fiscal synchronization,
3. Strengthening institutional capacity and human resources to ensure effective implementation.

This transformation represents a paradigm shift from construction-oriented governance to asset management-oriented governance, placing sustainability of service at the core of irrigation infrastructure management.

AKNOP Digital Integration (e-AKNOP) as Lock Technical–Fiscal Synchronization

The first alternative focuses on strengthening technical data integration in the budgeting process through the transformation of AKNOP into an integrated digital system (e-AKNOP) connected with SIPD. In this approach, IKSI data, asset conditions, maintenance needs, and cost estimates are no longer treated as static administrative documents but become a periodically updated and verified database.

The integration strengthens a needs-based budgeting approach because the budgeting process becomes more aligned with current infrastructure conditions. From the perspective of information asymmetry, e-AKNOP can also reduce the gap of information between technical units and fiscal decision-makers by providing more standardized and documented data.

Operationally, these alternative covers asset data digitalization based on IKSI, integration of AKNOP into planning and budgeting systems, and strengthening data validation. The main strength of this approach lies in increasing transparency, accountability, and synchronization between technical needs and fiscal decisions. However, its implementation requires readiness in digital systems, data standardization, and human resource management capacity.

Table 3. Matrix Evaluation Eligibility Alternative Policy (Scale 1-10)

No	Alternative Policy	*Technical Feasibility*	*Economic & Financial*	*Political Feasibility*	*Administrative Operability*	Total Score
1	Digital Integration of e-AKNOP into SIPD	35	30	25	29	119
2	Determination *Mandatory Spending* OP	35	31	24	33	123

No	Alternative Policy	*Technical Feasibility*	*Economic & Financial*	*Political Feasibility*	*Administrative Operability*	Total Score
3	Certification & Stabilization of Technical Human Resources	35	29	25	31	120

Source: Primary Data Processing Results (2026).

CONCLUSION

This study confirms that the management of irrigation operations and maintenance (OP) in Indonesia faces a fiscal paradox, where high fiscal capacity is not always directly proportional to the performance of the irrigation system. The results of the empirical analysis show that most regions are still in suboptimal conditions, both due to budget limitations and governance weaknesses that hinder the conversion of budgets into real service quality. The phenomenon of deferred maintenance, new construction bias, and information asymmetry between technical and fiscal units are the main causes of the progressive decline in irrigation system performance. Through the Risk Quadrant Matrix approach, the study identified four types of irrigation management: double crisis (low budget–low performance), structural inefficiency (high budget–low performance), latent risk (low budget–high performance), and sustainable zone (high budget–high performance). Most regions fall into the first and second quadrants, signaling the need for systemic interventions to improve integration between technical data, fiscal priorities, and institutional capacity. To answer these problems, the research recommends gradual and integrated governance reforms: first, the establishment of mandatory spending for OP as a minimum fiscal protection mechanism; second, digital integration of AKNOP (e-AKNOP) with SIPD to reduce asymmetric information and support data-driven decision-making; third, strengthening institutional capacity and technical human resource stability through certification, training, and revitalization of the role of P3A. In conclusion, the success of national irrigation management reform is highly dependent on the paradigm transformation from construction-oriented governance to asset-management-oriented, where operations and maintenance are no longer residual expenditures, but become the main instrument in maintaining the sustainability of irrigation infrastructure services and national food security. The reform emphasizes the integration of three key fiscal, technical, and institutional dimensions as the foundation of adaptive, sustainable, and data-driven irrigation management.

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