World Journal of Innovation and Technology
Volume 06 Number 01 October 2025

ISSN : 2963-1637
(Online - Elektronik)

An Analysis of Cost Efficiency and Budget Distribution in the Cipari Makmur Irrigation Network Improvement Project

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Citations: Prastiyo, Kukuh Budi., Nur, Alpian., & Arifin, Benny Mochtar Effendi., (2025). An Analysis of Cost Efficiency and Budget Distribution in the Cipari Makmur Irrigation Network Improvement Project. *World Journal of Innovation and Technology*, 06(01), 30-35.

Academic Editor:

Received: 28 August 2025 Accepted: 21 October 2025 Published: 30 October 2025

Abstract: This section consists of single paragraph and about 250 words maximum. For research articles, abstracts should give a pertinent overview of the work. We strongly encourage authors to use the following style of structured abstracts, but without headings: This study aims to analyze cost efficiency and budget distribution in the Cipari Makmur irrigation network improvement project located in Muara Kaman District, Kutai Kartanegara Regency. A quantitative descriptive method was used based on the project's Bill of Quantities (BoQ), including calculations of budget percentage, unit cost efficiency, cost variation coefficient (KV), and cumulative cost efficiency index (CCEI). The results show that from a total budget of IDR 5,467,027,900, reinforced concrete work accounted for IDR 4,439,726,600 (81.21%), pile work IDR 753,900,000 (13.79%), and earthwork IDR 90,108,700 (1.65%). Unit cost analysis revealed consistent and reasonable values such as IDR 2,380,000/m³ for concrete K-250, IDR 150,000/m¹ for timber piling, and IDR 60,000/m³ for soil excavation. A high KV value indicates an uneven cost distribution, while the CCEI shows that over 95% of the budget is absorbed by the top three work components. These findings emphasize the need to prioritize oversight on dominant cost components. Evaluating the BoQ proves to be a strategic tool in identifying budget control priorities and improving technical efficiency in irrigation project implementation.

Keywords: Budget Distribution; Cost Efficiency; Irrigation Project

1. Introduction

The development and rehabilitation of irrigation networks play a strategic role in enhancing agricultural productivity and food security (Jamil et al., 2023). The effectiveness of an irrigation system is largely determined by cost efficiency and budget distribution during the planning and implementation stages of a project (Abdelhaleem et al., 2025). Inaccurate budget allocation may lead to resource wastage and a decline in the quality of the constructed infrastructure (Daoud et al., 2023; Flyvbjerg, 2007). Several studies emphasize the importance of a measured approach in cost management and technical analysis of irrigation projects to ensure that each work component aligns with technical requirements and field conditions (Ashour et al., 2024; ElGamal et al., 2019; Mwendwa et al., 2025).

This study aims to analyze cost efficiency and budget distribution based on the Bill of Quantities (BoQ) of the continuation project for improving the Cipari Makmur irrigation network in Muara Kaman District. By examining the structure and weight of each work item, this study seeks to identify dominant cost allocations, evaluate technical alignment with field needs, and provide strategic recommendations for more efficient and sustainable irrigation project management.

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2. Materials and Methods

2.1. Research Location and Object

This study was conducted in Muara Kaman District, Kutai Kartanegara Regency, East Kalimantan. Geographically, Muara Kaman is located at 0°3'59.77"S and 116°53'27.72"E, with the research object being a continuation project to improve the surface irrigation network in the Cipari Makmur Irrigation Area. The project includes several construction activities such as earth excavation, pile installation, and reinforced concrete structures, all of which are documented in detail within the Bill of Quantities (BoQ). The selection of this project is based on its urgency in supporting sustainable agricultural irrigation and the availability of comprehensive financial planning documents (ElGamal et al., 2019).

Figure 1. Study Location

2.2. Data Type and Sources of Information

The type of data used in this study is secondary data in the form of the project's Bill of Quantities (BoQ), which includes details such as work volumes, units, unit prices, and total costs for each work item. The data were obtained from the project implementing agency and supplemented by supporting information from scientific literature and technical guidelines on construction cost standards. The data were classified into major work categories: preliminary works, construction safety management (SMKK), earthworks, piling, concrete structures, and complementary structures (such as sluice gates).

2.3. Cost Efficiency Calculation Method

Cost efficiency was calculated using the formula for the percentage contribution of each work item to the total project budget:

$$\boldsymbol{Cost\ Weight\ Percentage} = \frac{\boldsymbol{Item\ Cost}}{\boldsymbol{Total\ Project\ Cost}}\ \boldsymbol{x}\ \mathbf{100\%} \tag{1}$$

This formula was used to determine the contribution of each type of work and to identify components with a significant share of the project budget (Elmousalami et al., 2025). In addition, unit cost efficiency was calculated to evaluate the cost per volume of work:

$$\boldsymbol{Unit\ Cost\ Efficiency} = \frac{\boldsymbol{Total\ Item\ Cost}}{\boldsymbol{Work\ VOlume}} \tag{2}$$

This formula helps compare the efficiency across different types of work, such as between pile installation and concrete casting for irrigation channels (Allam et al., 2023).

2.4. Budget Distribution and Cost Dominance Analysis

Budget distribution was analyzed using a job cost weighting approach, which involves calculating the percentage distribution of costs among work categories. To identify the most financially dominant components, the Job Dominance Ratio (JDR) was applied:

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$$JDR = \frac{Total\ Cost\ of\ Group\ A}{Total\ Cost\ of\ Group\ B} \quad (3)$$

This ratio is used to compare the relative magnitude of costs, such as between major structural works like reinforced concrete and preliminary works or construction safety management (Wael et al., 2024).

2.5. Coefficient of Variation and Cumulative Cost Efficiency Index

To measure the variation in cost allocation across work items, the Coefficient of Variation (KV) was used, calculated as follows:

$$KV = \frac{Standard\ Deviation\ of\ Item\ Costs}{Mean\ Item\ Cost}\ x\ 100\% \quad (4)$$

Meanwhile, to identify priority work groups that contribute the majority of the total project cost, the Cumulative Cost Efficiency Index (CCEI) was applied as follows:

$$CCEI_n = \sum_{i=1}^{n}\left(\frac{Cost\ of\ Item\ i}{Total\ Project\ Cost}\right) \quad (5)$$

These two formulas help classify which work components have the greatest influence on the overall project budget (Eshete et al., 2020).

2.6. Validation and Limitations of the Study

This study did not require ethical approval as it did not involve human or animal subjects. All data were obtained from official sources and were openly available for analysis. However, a limitation lies in the unavailability of actual project implementation data (realization) for comparison. Therefore, the analysis results are evaluative in nature, focusing on the planning phase and do not include assessments of time efficiency or physical execution quality.

3. Results

3.1. Project Composition and Total Budget

Based on the Bill of Quantities (BoQ), the total budget for the Cipari Makmur irrigation network improvement project in Muara Kaman District amounts to IDR 5,467,027,900. The components listed in the BoQ include preliminary works, Construction Safety Management System (SMKK), earthworks, piling, reinforced concrete for irrigation channels, and complementary structures. The entire cost reflects the technical planning of irrigation infrastructure works at two different locations (STA 0+000–0+373 and STA 0+200–0+488).

3.2. Cost Weight Distribution by Work Category

The cost distribution analysis shows that reinforced concrete work is the most dominant component, contributing 47.61% in location 1 and 33.60% in location 2. This is followed by piling works, contributing 8.21% and 5.58% in locations 1 and 2, respectively. Other components, such as earthworks, SMKK, and preliminary works, contribute relatively small portions to the total budget.

ISSN : 2963-1637
(Online - Elektronik)

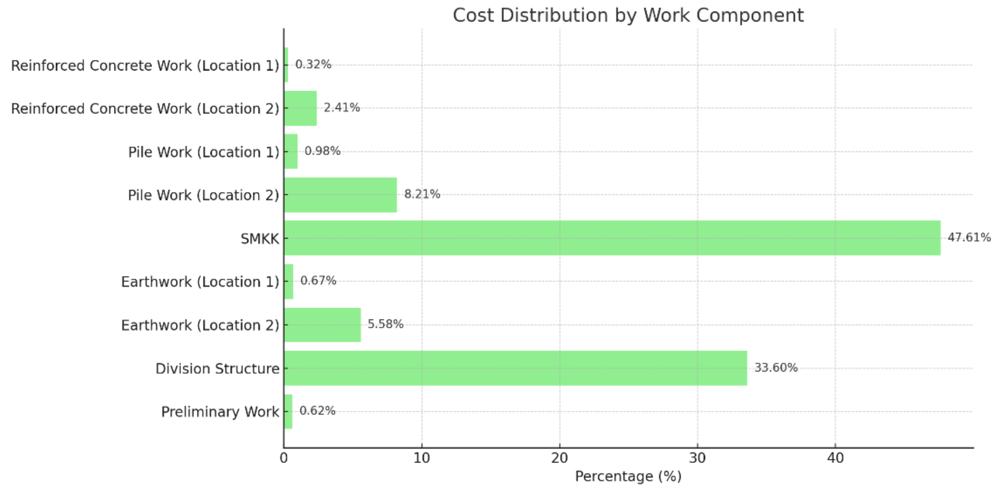

Figure 2. Percentage Distribution of Budget by Work Category

The budget distribution visualization in Figure 2 clearly illustrates the dominance of structural works, particularly reinforced concrete in Locations 1 and 2, which respectively absorb 47.61% and 33.60% of the total budget. Pile installation is also prominent, contributing 8.21% in Location 1 and 5.58% in Location 2. In contrast, other work categories such as earthworks, SMKK, preliminary works, and the division structure account for only a very small share, each below 3%. This chart highlights a significant imbalance in cost distribution, indicating that the project is highly concentrated on the structural components of the irrigation system. Such distribution underscores the importance of cost control on dominant components to maintain overall project efficiency.

3.3. Unit Cost Efficiency by Work Item

Cost efficiency was calculated by comparing the total cost of each work item with its corresponding work volume to determine the unit cost. This analysis aims to assess price fairness and budget utilization efficiency based on the types of work listed in the BoQ.

The results show that structural works have relatively high unit costs, such as concrete grade K-250 in Location 1, priced at IDR 2,380,000/m³, and lean concrete (K-100) at IDR 2,150,000/m³, with similar values found in Location 2 and the division structure. Timber pile installation shows a consistent unit price of IDR 150,000/m¹ at both locations, matching the unit rates stated in the documents. Meanwhile, reinforcement steel is priced at IDR 20,000/kg, and formwork is in the range of IDR 150,000/m².

For earthworks, the unit cost is IDR 60,000/m³ for mechanical excavation, IDR 50,000/m³ for compacted backfill, and IDR 160,000/m³ for soil transportation over a distance of ±3 km all considered reasonable within the context of infrastructure development in the region. These figures indicate that cost efficiency in this project is relatively well maintained and in line with general unit price standards in civil irrigation works. Nonetheless, the dominance of structural costs remains a critical concern, as their unit values significantly impact the overall budget.

This data may serve as a reference for evaluating the fairness of unit prices and the efficient use of resources (Ashour et al., 2024; Allam et al., 2023).

3.4. Cost Dominance and Cumulative Index

The calculation of the Job Dominance Ratio (JDR) shows that reinforced concrete work (combined from Locations 1 and 2) absorbs more than 81% of the total project budget. This confirms that the construction of the irrigation channel structure is the main investment focus of the project, while components such as SMKK, preliminary works, and earthworks contribute only a small share.

Meanwhile, the Cumulative Cost Efficiency Index (CCEI) indicates that the three largest work components reinforced concrete, piling, and earthworks account for approximately 95% of the total budget. This finding aligns with the Pareto principle, which suggests that a small number of activities typically consume the majority of project resources (Mwendwa et al., 2025; Eshete et al., 2020).

4. Discussion

ISSN : 2963-1637
(Online - Elektronik)

The analysis results indicate that the budget dominance in the Cipari Makmur irrigation network improvement project is heavily concentrated on structural works, particularly reinforced concrete, which accounts for more than 81% of the total project budget. This distribution implies that the success of the project implementation largely depends on the effectiveness of executing the irrigation channel structures. This finding aligns with studies by ElGamal et al. (2019) and Ashour et al. (2024), which emphasize that the quality of primary channel structures significantly influences water distribution efficiency and the resilience of the irrigation system.

In terms of cost efficiency, unit price calculations show that K-250 grade concrete is priced at approximately IDR 2,380,000/m³, and lean concrete (K-100) at around IDR 2,150,000/m³, with consistent values across both locations. Other unit costs, such as pile installation (IDR 150,000/m¹), formwork (IDR 150,000/m²), and reinforcement steel (IDR 20,000/kg), also reflect reasonable and competitive market standards. Earthwork items including excavation, backfill, and hauling fall within an efficient cost range of IDR 50,000–IDR 160,000/m³, indicating that budget allocation for basic works has been managed optimally.

Despite the acceptable unit cost values, the analysis of the Coefficient of Variation (KV) and the Cumulative Cost Efficiency Index (CCEI) continues to highlight the concentration of budget on dominant work components. This confirms that the greatest risk of budget deviation lies within structural works. Therefore, managerial attention must be focused on high-cost components to ensure overall project efficiency and to avoid budget overruns during implementation.

5. Conclusions

This study reveals that the Cipari Makmur irrigation network improvement project has a highly concentrated budget distribution, with structural works particularly reinforced concrete accounting for IDR 4,439,726,600 or approximately 81.21% of the total project budget of IDR 5,467,027,900. Pile installation ranks second with a total cost of IDR 753,900,000 or 13.79%, while earthworks in both locations contribute only IDR 90,108,700 or 1.65%. Other components, such as preliminary works and construction safety management (SMKK), contribute IDR 17,500,000 (0.32%) and IDR 131,670,000 (2.41%) respectively, while the division structure accounts for IDR 34,122,600 (0.62%).

The unit cost efficiency analysis indicates that the dominant work items are managed with fair and consistent unit prices. For instance, K-250 concrete is priced at IDR 2,380,000/m³, K-100 lean concrete at IDR 2,150,000/m³, timber piling at IDR 150,000/m¹, and formwork at IDR 150,000/m². Earthworks, such as excavation and backfill, are also within efficient ranges, at IDR 60,000/m³ and IDR 50,000/m³, respectively. These values suggest that despite the high concentration of budget allocation, the unit cost efficiency remains relatively well maintained.

Nevertheless, the high Coefficient of Variation (KV) and Cumulative Cost Efficiency Index (CCEI) which shows that over 95% of the budget is concentrated in just three work categories indicate a vulnerability to cost deviation. Therefore, cost control and implementation oversight should be focused on the dominant work components. The evaluation of the BoQ proves to be a strategic tool for identifying budget control priorities, supporting technical efficiency, and ensuring the success and sustainability of irrigation infrastructure development.

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