International Journal of Technology, Engineering and Computer
https://journal.globalacademic.id/index.php/ijtec
Volume 01 Number 02 October 2025

IJTEC

ISSN : XXXX XXXX

Analysis of Irrigation Water Needs and Availability Calculation in Loa Kulu with Construction Management Integration for Optimizing Water Management

Baharuddin Syafruddin [1], Alpian Nur [2] and Habir [3]

Faculty of Civil Engineering, 17 Agustus 1945 University of Samarinda, 75124, East Kalimantan, Indonesia
Email: baharuddinsyafruddin@gmail.com [1], alpiannursmd@gmail.com [2], habir_habir@yahoo.co.id

* Correspondence: baharuddinsyafruddin@gmail.com

Citations: Syafruddin, Baharuddin., Nur, Alpian., & Habir, Habir., (2025). Analysis of Irrigation Water Needs and Availability Calculation in Loa Kulu with Construction Management Integration for Optimizing Water Management. *International Journal of Technology, Engineering and Computer*, 01(02), 56-61.

Academic Editor:

Received: 19 September 2025 Accepted: 13 October 2025 Published: 31 October 2025

Abstract: This study aims to optimize cost planning for the rehabilitation of the Rempanga – Bukit Biru irrigation canal in Tenggarong, Kutai Kartanegara, East Kalimantan. The focus of this research encompasses accurate construction cost estimation, identification of key cost components, provision of a solid basis for project budget planning, and assurance of the project's economic feasibility. Data collection involved field surveys, technical documentation, and compilation of material price lists and labor costs. Detailed cost calculations were conducted using the standard analysis guidelines provided by the Ministry of Public Works and Housing, ensuring compliance with national best practices in cost estimation. The results indicate that concrete masonry work represents the largest portion of the total project budget, followed by stone masonry work and earthworks. Budget optimization was achieved through identification of dominant cost drivers and the application of value engineering principles to streamline resource utilization. The analysis emphasizes the importance of precise cost planning to enhance project efficiency and highlights potential risk control measures to minimize material waste and time delays. Moreover, the study addresses the implications of geographical and technical challenges specific to the region, proposing adaptive strategies for successful project implementation. The findings provide a valuable reference for similar irrigation infrastructure projects facing complex environmental conditions. Future research is recommended to incorporate digital technologies such as Building Information Modeling (BIM), which enables real-time cost simulation and facilitates integrated project management. The integration of BIM is expected to significantly enhance decision-making processes and operational efficiency in similar infrastructure projects.

Keywords: Cost Optimization; Economic Feasibility; Irrigation Canal Rehabilitation

1. Introduction

The availability of sufficient irrigation water is crucial for supporting agricultural productivity, particularly in Loa Kulu, Kutai Kartanegara Regency, which possesses vast potential for rice fields and secondary crops (Soewarno, 2000; Sinulingga, 1995). Effective irrigation water management requires precise calculations of water needs based on climatological data, including effective rainfall, potential evapotranspiration, and crop characteristics (Doorenbos & Pruitt, 1977; Hargreaves & Samani, 1985). The

IJTEC
ISSN : XXXX XXXX

calculation of evapotranspiration using the modified Penman-Monteith method has become one of the approaches that provides more accurate results (Allen et al., 1998; FAO, 2006). In this context, the climatological analysis in Loa Kulu relies on rainfall, temperature, humidity, solar radiation, and wind speed data collected during the 2013–2022 period (BMKG, 2022). The study results indicate that the irrigation water requirement for rice crops reaches 1.35 l/s/ha, while for secondary crops it is 0.48 l/s/ha (Suyono et al., 2017). These figures highlight the urgency of adopting adaptive water management strategies in response to climate change and dynamic cropping patterns (Rachman & Suripin, 2015).

Moreover, the calculation of water needs cannot be separated from the availability of water sourced from local resources such as rivers, reservoirs, and recharge wells (Effendi et al., 2020). Construction management plays a critical role in supporting the management of irrigation infrastructure, both in terms of planning and implementation (PMI, 2017; Hadisusanto, 2018). The construction and maintenance of canals, gates, and water control structures require the integration of technical and construction management based on climatological data (Prabowo et al., 2021). Therefore, this study is expected to serve as a foundation for designing sustainable irrigation water management policies and strategies in Loa Kulu, while also contributing to the improvement of local food security (Badan Pusat Statistik, 2023).

2. Materials and Methods

2.1. Location Study and Research Object

This study was conducted in the Loa Kulu area, Kutai Kartanegara Regency, East Kalimantan, Indonesia. Loa Kulu is recognized as one of the agricultural regions with potential for developing irrigated land for rice and secondary crops. Geographically, this region is located at approximately 0°28’0” N and 116°56’0” E, characterized by lowland topography and a tropical climate. The annual rainfall ranges from 2,000 to 2,500 mm, which significantly influences the availability of water for irrigation in the area. The irrigation infrastructure in this region includes a network of primary, secondary, and tertiary canals, with the main water sources originating from local rivers and reservoirs.

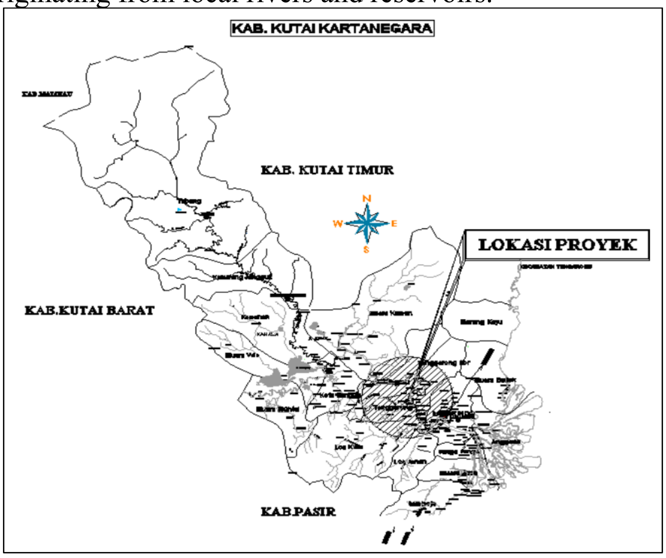

Figure 1. Study Location

2.2. Data

The data used in this study includes:

a. **Climatological Data**

Rainfall, air temperature, relative humidity, wind speed, and solar radiation. These data were obtained from the Meteorology, Climatology, and Geophysics Agency (BMKG) for the period 2013–2022.

b. **Agronomic Data**

Types of crops (rice, secondary crops), planted area, crop coefficient (Kc), and growth stages.

c. **Infrastructure Data**

Technical data of irrigation canals, hydraulic structures, and the current condition of existing infrastructure.

d. **Topographic Data**
Contour maps and the layout of the irrigation network.

2.3 Calculation Method

The methods used include:

a. **Calculation of Potential Evapotranspiration (ETo)** using the Penman-Monteith formula (FAO, 2006):

$$ETo = \frac{0\ 408\Delta(Rn - G) + \gamma\frac{900}{T + 273}u2(es - ea)}{\Delta + \gamma(1 + 0\ 34u2)}$$

Where :
ETo = Reference evapotranspiration (mm/day)
Rn = Net radiation at the crop surface (MJ/m²/day)
G = Soil heat flux density (MJ/m²/day)
T = Mean daily air temperature (°C)
$u\ 2$ = Wind speed at 2 m height (m/s)
$e\ s - e\ a$ = Saturation vapor pressure deficit (kPa)
Δ = Slope of vapor pressure curve (kPa/°C)
γ = Psychrometric constant (kPa/°C)

b. Calculation of Crop Water Requirement (ETc) :

$$ETc = Kc \times ETo$$

Where :
Kc = Crop coefficient
ETc = Reference evapotranspiration

c. Calculation of Effective Rainfall (Re) using the USDA or empirical method:

$$Re = P \times e$$

Where:
P = Total rainfall (mm)
e = Effective rainfall efficiency (percentage of rainfall utilized by crops)

d. Calculation of Net Irrigation Requirement (NFR) :

$$NFR = ETc - Re$$

Where :
NFR = Net irrigation requirement (mm/day)

e. Water Availability Analysis :
The discharge of water sources (rivers, reservoirs) is calculated based on actual discharge measurements or historical data. The supply capacity is then compared to the total irrigation water requirements.

2.4. Integration of Construction Management

A construction management approach is applied to evaluate the existing conditions and the needs for rehabilitation/improvement of irrigation infrastructure. The analysis includes:

IJTEC
ISSN : XXXX XXXX

a. Scheduling the construction and maintenance of irrigation canals;
b. Planning the material and labor requirements;
c. Evaluating construction risks and mitigation measures to ensure the sustainability of water management.

3. Results

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

The analysis of irrigation water requirements in the Loa Kulu area reveals significant variation in water volume throughout the year. Based on monthly rainfall data, the highest rainfall was recorded in January and December, with an average of approximately 240 mm and 250 mm, respectively. Conversely, July recorded the lowest rainfall, with only 50 mm. The results of the potential evapotranspiration (ETo) calculation, using the Penman-Monteith method, show an average monthly evapotranspiration ranging between 4.4 and 5.4 mm/day. The highest ETo value was recorded in July at 5.4 mm/day, coinciding with the dry season.

Table 1. Irrigation Water Requirement Analysis Results

Month	Total Rainfall (mm)	Potential Evapotranspiration (mm/day)	Crop Coefficient (Kc)	ETc (mm)	Effective Rainfall (mm)	Net Irrigation Requirement (NFR) (mm)
Jan	240	4.5	1.05	4.725	168	-163.2
Feb	200	4.7	1.05	4.935	140	-135.1
Mar	180	4.8	1.1	5.28	126	-120.7
Apr	120	5.1	1.1	5.61	84	-78.4
May	90	5.2	1.05	5.46	63	-57.5
June	60	5.3	1	5.3	42	-36.7
July	50	5.4	0.9	4.86	35	-30.1
Aug	70	5.3	0.9	4.77	49	-44.2
Sep	120	5.1	1	5.1	84	-78.9
Oct	180	4.8	1.05	5.04	126	-120.
Nov	220	4.6	1.1	5.06	154	-148.9
Dec	250	4.4	1.1	4.84	175	-170.1

The analysis of irrigation water requirements in the Loa Kulu area shows significant variation in water volumes throughout the year. Based on monthly rainfall data, the highest rainfall was recorded in January and December, with average rainfall reaching 240 mm and 250 mm, respectively. In contrast, July recorded the lowest rainfall of only 50 mm. According to the calculation of potential evapotranspiration (ETo) using the Penman-Monteith method, the average monthly evapotranspiration ranged from 4.4 to 5.4 mm/day. The highest ETo value was recorded in July at 5.4 mm/day, coinciding with the dry season.

The crop coefficient (Kc) used in the calculation ranged from 0.9 to 1.1, adjusted according to the growth stages of rice and secondary crops. The calculation of crop evapotranspiration (ETc) showed that March and November had the highest ETc values, at 5.3 mm and 5.1 mm, respectively. On the other hand, the effective rainfall, calculated with an assumed efficiency of 70%, showed that in peak rainy months such as January and December, effective rainfall could cover almost the entire water requirements of the crops. However, during the dry season, especially in July and August, there was a significant water deficit with the net irrigation requirement (NFR) reaching its highest value of 3.12 mm.

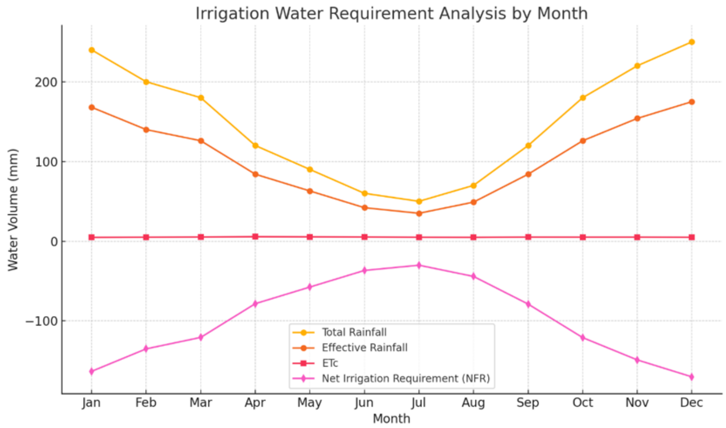

Figure 1. Irrigation Water Requirement Analysis Results

This graph illustrates the variation in irrigation water requirements and availability throughout the year in the Loa Kulu area. The total rainfall curve indicates the highest water volume in January and December (approximately 240–250 mm), with a significant drop in July (around 50 mm), depicting a seasonal pattern. Effective rainfall, with 70% efficiency, follows the same pattern but at a lower level. The crop evapotranspiration (ETc) curve, calculated using the Penman-Monteith method and crop coefficients (Kc), shows relatively stable crop water requirements ranging from 4.4–5.3 mm/day, with slight increases in March and November. Meanwhile, the net irrigation requirement (NFR) curve shows a surplus (negative values) in January and December, indicating that crop water needs are met by effective rainfall. However, in July and August, the NFR peaks at around 3.12 mm/day, reflecting a water deficit and the need for additional irrigation supply. This pattern highlights the importance of adaptive irrigation management based on climatological data to ensure the sustainability of the agricultural sector in the area.

4. Discussion

The analysis of irrigation water requirements and availability in the Loa Kulu area shows that climatological factors, such as rainfall, temperature, and evapotranspiration, play a significant role in determining the volume of water needed to support agricultural productivity. The substantial seasonal variation in rainfall, with peaks at the beginning and end of the year and a dry season in the middle, presents challenges for effective irrigation water management (Torres-Quezada et al., 2025). These conditions align with previous research findings emphasizing the importance of synchronizing water supply with crop growth stages (Doorenbos & Pruitt, 1977; Allen et al., 1998).

Adequate water availability during the rainy season allows for efficient water distribution by utilizing effective rainfall to meet crop needs (Yadav et al., 2024). However, during the dry season, irrigation water supply must be increased to maintain optimal production (You et al., 2022). This underscores the need for responsive construction management, including planning and maintaining irrigation infrastructure such as primary, secondary, and tertiary canals, as well as water control structures (Effendi et al., 2020; Hadisusanto, 2018). Rehabilitation of damaged irrigation networks and strengthening of water control structures are key measures to anticipate water deficits during the dry season (Prabowo et al., 2021).

Moreover, integrating historical climatological data into irrigation planning can improve the accuracy of water requirement projections and minimize the risk of water supply shortages in the future (FAO, 2006; BMKG, 2022). This approach should be complemented by increasing community participation in water management and utilizing digital monitoring technologies to support adaptive decision-making in response to climate change (Rachman & Suripin, 2015; PMI, 2017).

Based on these results and discussions, this study provides an important contribution to the development of efficient irrigation systems, both from technical and construction management aspects, to support food security and sustainability of the agricultural sector in the Loa Kulu area.

5. Conclusions

This study examines the irrigation water requirements and availability in the Loa Kulu area, Kutai Kartanegara Regency, by combining a climatological analysis approach and construction management. The

IJTEC
ISSN : XXXX XXXX

analysis results indicate that irrigation water requirements vary throughout the year, with the highest actual evapotranspiration (ETc) occurring in March, reaching 5.3 mm/day, and the lowest in December at 4.4 mm/day. The highest effective rainfall was recorded in December at 175 mm, while the lowest occurred in July at 35 mm. The highest net irrigation requirement (NFR) was recorded in July, reaching 3.12 mm/day, indicating a significant water deficit during the dry season. In contrast, in January and December, the irrigation water requirements could be almost entirely met by effective rainfall.

Water requirement calculations show that rice crops require 1.35 l/s/ha, while secondary crops require 0.48 l/s/ha. This highlights the importance of adaptive water management, particularly during critical crop growth phases and the dry season. The use of the modified Penman-Monteith method has proven to yield accurate calculations and can be utilized for efficient irrigation water distribution planning.

Construction management plays a crucial role in supporting the sustainability of the irrigation system through the construction, rehabilitation, and maintenance of irrigation canals and water control structures. Strengthening this infrastructure is essential to anticipate water shortages during the dry season and support food security in the Loa Kulu area. The discussion also underscores the importance of integrating climatological data into irrigation planning and enhancing community participation in water management.

References

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). *Crop Evapotranspiration – Guidelines for Computing Crop Water Requirements* (FAO Irrigation and Drainage Paper No. 56). Food and Agriculture Organization of The United Nations.

Badan Pusat Statistik. (2023). *Statistik Pertanian Indonesia*. Jakarta: BPS.

Badan Meteorologi, Klimatologi, dan Geofisika (BMKG). (2022). *Data Klimatologi Kalimantan Timur 2013–2022*. BMKG Stasiun Meteorologi APT Pranoto Samarinda.

Doorenbos, J., & Pruitt, W. O. (1977). *Crop Water Requirements* (FAO Irrigation and Drainage Paper No. 24). Food and Agriculture Organization of the United Nations.

Effendi, R. A., Hidayat, Y., & Nugroho, S. (2020). Analisis kebutuhan air irigasi dengan pendekatan data klimatologi dan pola tanam. *Jurnal Teknik Sipil Indonesia*, 27(3), 123–130.

FAO. (2006). *Guidelines for Computing Crop Water Requirements*. Rome: Food and Agriculture Organization of the United Nations.

Hadisusanto, S. (2018). *Manajemen Konstruksi Infrastruktur*. Yogyakarta: Pustaka Pelajar.

PMI. (2017). *Manajemen Konstruksi Proyek: Panduan Praktis*. Jakarta: PMI Indonesia.

Prabowo, A., Setiawan, B., & Siregar, P. (2021). Pengaruh Pengelolaan Infrastruktur Irigasi Terhadap Keberlanjutan Produksi Pertanian. *Jurnal Irigasi Indonesia*, 15(2), 45–57.

Rachman, A., & Suripin. (2015). Pengaruh Perubahan Iklim Terhadap Kebutuhan Air Irigasi di Daerah Pertanian. *Jurnal Teknik Pengairan*, 7(1), 35–42.

Sinulingga, S. (1995). *Hidrologi untuk Pengairan*. Jakarta: Erlangga.

Soewarno. (2000). *Hidrologi: Pengukuran dan Analisis Curah Hujan*. Bandung: Nova.

Torres-Quezada, E., Fuentes-Peñailillo, F., Gutter, K., Rondón, F., Marmolejos, J. M., Maurer, W., & Bisono, A. (2025). Remote Sensing and Soil Moisture Sensors for Irrigation Management in Avocado Orchards: A Practical Approach for Water Stress Assessment in Remote Agricultural Areas. *MDPI: Remote Sensing for Eco-Hydro-Environment*, *17*(4). https://doi.org/10.3390/rs17040708

Yadav, M., Vashisht, B. B., Jalota, S. K., Jyolsna, T., Singh, S. P., Kumar, A., Kumar, A., & Singh, G. (2024). Improving Water Efficiencies in Rural Agriculture for Sustainability of Water Resources: A Review. *Water Resources Management*, *38*, 3505–3526. https://doi.org/10.1007/s11269-024-03836-6

You, Y., Song, P., Yang, X., Zheng, Y., Dong, L., & Chen, J. (2022). Optimizing irrigation for Winter Wheat to Maximize Yield and Maintain High-Efficient Water Use in a Semi-Arid Environment. *Agricultural Water Management*, *273*(107901). https://doi.org/10.1016/j.agwat.2022.107901