

Analysis of the Actual Water Discharge Requirements for Existing Agricultural Land in D.I Cipari Makmur

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Abstrak:

Irrigation systems play a crucial role in supporting agricultural productivity, especially in regions dependent on water availability. The Cipari Makmur Irrigation Area (D.I. Cipari Makmur) is an agricultural region facing challenges related to the imbalance between water supply and demand due to changes in cropping patterns and hydrological conditions. This study aims to analyze the actual water discharge requirements to ensure efficient and sustainable distribution. The research methodology includes a hydrological analysis based on rainfall data from 2014–2023 and an evaluation of the balance between water availability and demand using a water balance approach. The results indicate a rainfall pattern with two main peaks: March–June (175–245 mm) and September–December (160–230 mm), with a deficit period occurring in July–August (90–135 mm). The highest water availability is recorded in February (1.05–1.09 m³/sec) and October (1.10–1.09 m³/sec), whereas a critical deficit is observed from June to August, with availability approaching 0.00 m³/sec. This imbalance highlights the need for adaptive water resource management strategies, such as the construction of reservoirs or retention basins to store surplus water and the optimization of irrigation system efficiency. These findings can serve as a basis for decision-making to enhance agricultural water resilience in DI Cipari Makmur. Further research could explore the impact of climate change on water availability and develop more effective mitigation strategies.

Kata kunci: Water Availability, Water Demand, Water Balance, Cipari Makmur Irrigation Area.

Introduction

The Cipari Makmur Irrigation Area (DI Cipari Makmur) is one of the agricultural regions that relies on an irrigation system to meet the water needs of existing farmland (Ferreira et al., 2023). The availability of an optimal water discharge is a key factor in ensuring sustainable agricultural production and preventing drought risks that could disrupt harvest yields (Hassan et al., 2023). Therefore, a study on the actual water discharge requirements is necessary to ensure efficient and effective water distribution (Alcon et al., 2022).

In practice, imbalances between water supply and demand often occur due to changes in cropping patterns, hydrological conditions, and the efficiency of the irrigation system used (Chu et al., 2004). If the available water discharge does not match the actual needs of agricultural land, either excess or insufficient water supply can affect plant growth and production yields (Dang et al., 2024). Analyzing the actual water discharge requirements is a strategic step in determining whether the water supply in DI Cipari Makmur is sufficient or needs further optimization (Su et al., 2022).

This study aims to analyze the actual water discharge required to meet the irrigation needs of existing agricultural land in DI Cipari Makmur (Martínez-Paz et al., 2018). The findings of this research are

expected to provide insights into the alignment between water availability and demand while offering recommendations for the management of irrigation water resources (Neitsch et al., 2011). By conducting this analysis, it is anticipated that the irrigation system in DI Cipari Makmur can become more efficient, sustainable, and capable of optimally supporting agricultural productivity (Watson et al., 2021).

Literature Study

According to (Tukimun. et al., 2018) The need for food continues to increase in line and directly proportional to the number of people, in addition to the development activities in the area of new autonomy which became a magnet for newcomers to try their luck, which requires efforts to increase food production continually and sustainably. In RTRW Penajam Paser Utara has clearly emphasize one of its policy to develop the agricultural sector. The desk study and analysis in hydrology of the two alternatives would plan the body of the dam and do more overlay two locations on the Location Permit in Penajam Paser Utara then obtained as follows: (1) For the dam Tunan alternative one looks inundation alternative 1 is in the area of PT. Harum Mukti Lestari, while the second alternative dam body plan of the Sar-free area business licenses; (2) The nature of the business license of PT Harum Mukti Lestari to plan Tunan dam catchment area is clearcut there should be a review of the permits for the Mukti Lestari PT Harum time to harvest it will affect the sustainability of the dam Tunan conditions.

According to (Prima Jiwa Osly. et al., 2020) Analysis of Water Needs and Availability in Manokwari Regency Using the Mock Model Water is one of the sources of life, because water is an essential substance or element for human life and other living things. It can be said that no life on earth can survive without water. Without the availability of water that meets the needs of humans and other living things, conflict can occur. So this study aims to analyze how much potential water availability is based on the mainstay discharge and how much water is needed in Manokwari Regency. The availability of water in Manokwari Regency is expected to meet the needs of the region quantitatively. The analysis used in this study uses the FJ. Mock method. This method is carried out by applying the rainfall-runoff model approach using rainfall data, potential evapotranspiration, and hydrological characteristics to predict the amount of river discharge with monthly time intervals. The results of this study indicate that the annual mainstay discharge obtained with a 50% probability of being fulfilled is $Q = 178,352 \text{ (m}^3 / \text{sec)}$ and the 80% mainstay discharge is $Q = 152,405 \text{ (m}^3 / \text{sec)}$. The potential availability of water in Manokwari Regency in 2018 was 398,570,549 m^3 and the total water requirement for use was 66,629,639 m^3 , so that Manokwari Regency has a surplus of raw water that can be further utilized.

According to (Asnidar Mastam. et al., 2024) Lekopancing Dam is an infrastructure that has the function of providing water supply for irrigation demand. To prevent a water availability deficit, a water balance analysis is conducted. This analysis will compare the need and availability of water, especially for irrigation. The purpose of this study is to analyze and determine the level of water availability at Lekopancing Dam for agricultural purposes in Maros Regency. Analysis of water availability with the water balance method is based on effective rainfall data, actual evapotranspiration, potential evapotranspiration, mainstay discharge, NFR of rice fields and irrigation water needs in the range of 2013-2022. The results showed that water availability in the December to July period I, tended to be greater than water demand, with the highest water availability of $22.02 \text{ m}^3 / \text{s}$. The highest water demand occurs in the August-November range and a deficit of $11.35 \text{ m}^3 / \text{s}$. The potential availability of water for irrigation needs at Lekopancing Dam is quite large because the water deficit is small and occurs at the end of the growth period or entering the harvest period.

Based on references to several studies above, it is necessary to conduct a study on the Analysis of Actual Water Discharge Needs of Existing Agricultural Land in D.I. Cipari Makmur in an effort to support government programs in increasing and achieving regional food self-sufficiency in East Kalimantan in particular and nationally in general.

Research methods

In supporting national food security which is a government program in fulfilling the basic needs of the community, of course, innovation is needed in opening new agricultural lands, especially in Kutai Kartanegara Regency. Kutai Kartanegara Regency has great potential in developing rice fields considering the geographical conditions that are very supportive of its rice field irrigation system. One of them is in the Cipari Makmur Irrigation Area located in Muara Kaman District.

The research was conducted in the Cipari Makmur Irrigation Area (DI Cipari Makmur), located in Muara Kaman District, Kutai Kartanegara Regency, covering a total area of 211.93 hectares. This region has an irrigation system that supports agricultural activities, particularly in supplying water for fully utilized rice fields. Key infrastructure, such as reservoirs and irrigation channel networks, plays a crucial role in water distribution to enhance agricultural productivity in the area.

The research method used in this study is by collecting data in the field in the form of primary data and secondary data. Then the data is analyzed using quantitative formulas to produce values of water needs in the Cipari Makmur Irrigation Area (DI), Muara Kaman District, Kutai Kartanegara Regency.

Additionally, there is a functional and potential area outside the irrigation zone covering 192.86 hectares, which presents opportunities for further development. Integrating this area with a more efficient irrigation system is expected to optimize land use for agriculture. Geographically, the research location is situated at coordinates 116.935164° E and -0.139097° S, with hydrological and topographical conditions that support water availability for the agricultural sector in Muara Kaman District.

The location of the Cipari Makmur Irrigation Area (DI) can be seen on the map presented in Figure 1 below:

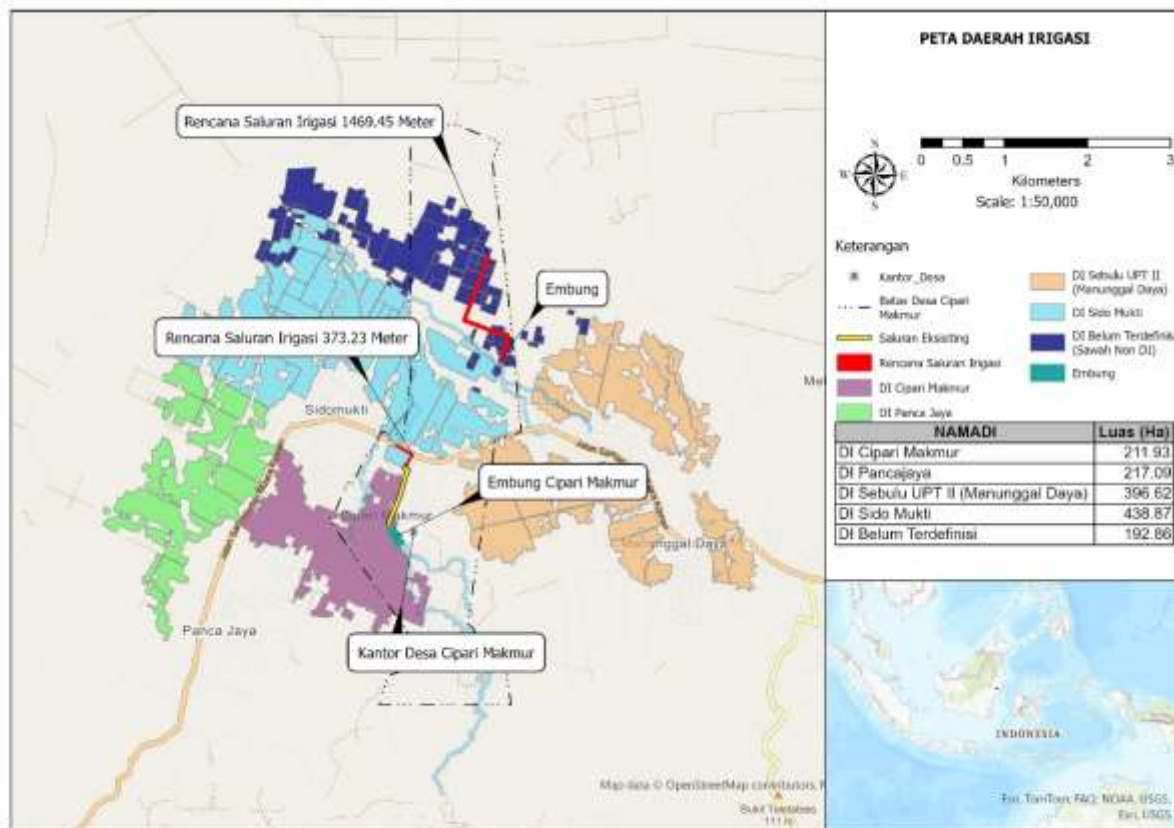


Figure 1. Research location

There are several research processes and methods that will be used in the research of the Analysis of Actual Water Discharge Needs of Existing Agricultural Land in D.I. Cipari Makmur which will certainly be useful in the research process and calculation analysis as follows:

A. Water Availability (Q_{avail})

According to Allen (1998), the formula used is:

$$Q_{avail} = \alpha \times Q_{inflow} \quad (1)$$

Where:

Q_{avail} is the available water supply (m^3/s or liters/second)

α is the availability factor (e.g., 80%)

Q_{inflow} is the inflow discharge into the irrigation system

B. Water Demand (Q_{demand})

According to Doorenbos (1977), water demand can be formulated as:

$$Q_{demand} = ETc - P \quad (2)$$

Where:

Q_{demand} is the water demand for agriculture

ETc is the crop evapotranspiration (mm/day)

P is the effective rainfall absorbed by the soil

C. Water Balance

$$S = Q_{avail} - Q_{demand} \quad (3)$$

Where:

S is the water balance surplus/deficit

If S is negative, a water deficit occurs; if positive, there is a surplus., This equation is derived from Chow (1988)

D. Koefisien Efisiensi Irigasi

According to Keller (1990), irrigation efficiency is calculated as:

$$E = \frac{Q_{efektif}}{Q_{masuk}} \quad (4)$$

Where:

$Q_{efektif}$ is the water effectively utilized by crops

Q_{masuk} is the total water supplied to the system

Results

Hydrological Analysis: Based on rainfall data from the Kalimantan IV River Basin Authority, obtained from the rainfall station in Muara Kaman Ilir Village, Kutai Kartanegara Regency, the graph illustrates the monthly rainfall variations from 2014 to 2023. The trend indicates a significant seasonal pattern, with two primary periods of increased rainfall: March–June and September–December. This increase is likely influenced by transitional seasons and the effects of monsoon wind patterns, which bring high moisture levels to the region. Conversely, lower rainfall periods are observed from July to August, which can be associated with the dry season in East Kalimantan.

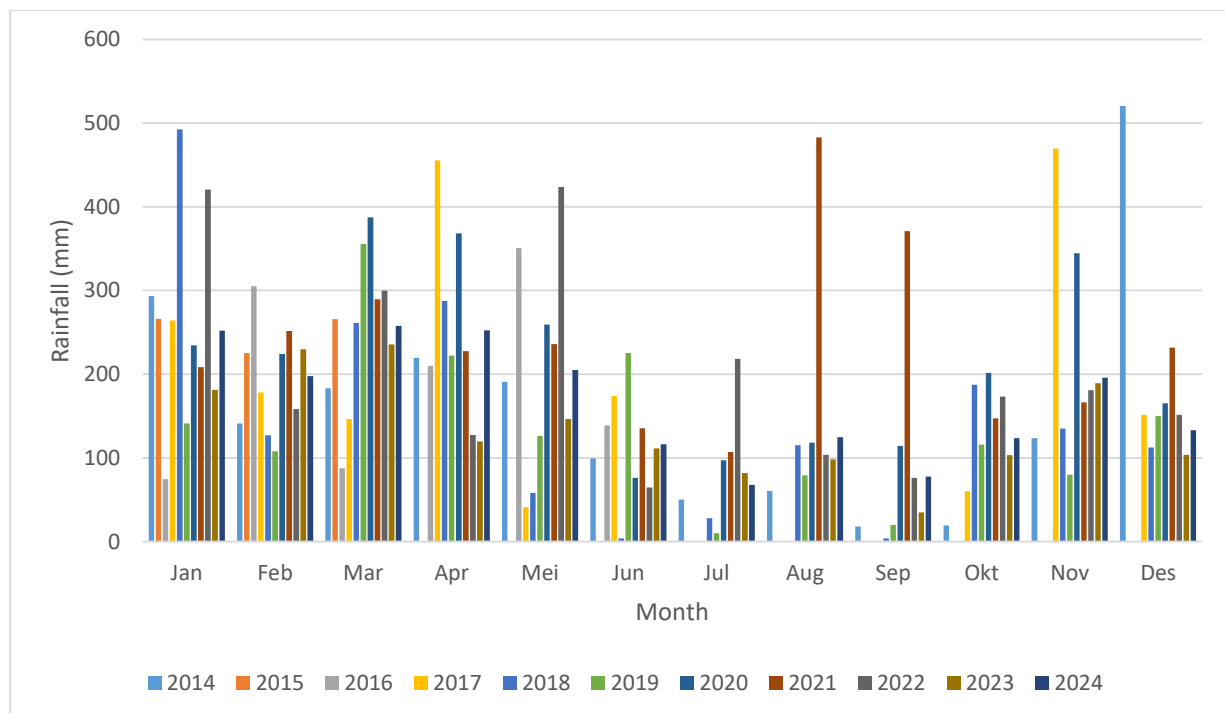


Figure 2. Research location

The average monthly rainfall trendline highlights two significant peak periods: March–June, with an average rainfall ranging from 175 mm to 245 mm, and September–December, ranging from 160 mm to 230 mm. The increase during these periods is likely due to seasonal transitions and monsoonal wind patterns

bringing high moisture to the area. Meanwhile, the lowest rainfall period occurs in July–August, with an average ranging from 90 mm to 135 mm, which corresponds to the dry season in East Kalimantan.

Discussion

Effective water resource management requires a comprehensive analysis of the balance between water availability and demand throughout the year. The figure below presents data on water discharge variations in the study area, comparing 80% water availability with annual water demand. Given the significant fluctuations in water discharge, this analysis is crucial for understanding water availability patterns, identifying critical water deficit periods, and developing optimal management strategies to ensure sustainable water supply.

Table 1. Annual Water Availability and Demand Analysis in the Study Area

Month	Growth Period	R	Et	Er	Fwr	Fwr-Er	Fwr-Er	Efp	A	Pwr	Pwr
		(mm/0.5 mth)	(mm/0.5 mth)	(mm/0.5 mth)	(mm/0.5 mth)	(mm/0.5 mth)	(l/sec/ha)	(%)	(Ha)	(L/Sec)	(M3/Sec)
OKT I	cultivation and seeding	48.75	86.77	34.33	254.21	219.89	1.70	0.65	200	522.04	0.52
OKT II	Vegetative growth	52.00	92.55	36.93	271.16	234.23	1.69	0.65	200	521.35	0.52
NOP I	Vegetative growth	84.46	85.84	57.22	253.19	195.97	1.51	0.65	200	466.27	0.47
NOP II	Generative growth	84.46	85.84	57.22	252.58	194.95	1.50	0.65	200	462.84	0.46
DES I	Generative growth	76.75	86.21	52.46	252.58	200.12	1.54	0.65	200	475.12	0.48
DES II	Generative growth	81.87	91.96	56.29	264.82	208.53	1.51	0.65	200	464.14	0.46
	Fertilization and										
JAN I	Maturation	124.68	83.04	80.51	233.56	153.05	1.18	0.65	200	363.36	0.36
JAN II	Harvest	133	88.58	85.95	-	-	-	0.65	200	-	-
FEB I	Bero	104.39	83.23	68.91	-	-	-	0.65	200	-	-
FEB II	cultivation and seeding	90.47	77.68	59.98	230.00	170.02	1.41	0.65	200	432.49	0.43
MAR I	Vegetative growth	121.52	84.16	78.9	248.48	169.58	1.31	0.65	200	402.61	0.40
MAR II	Vegetative growth	129.62	89.77	84.27	265.04	180.77	1.31	0.65	200	402.36	0.40
APR I	Generative growth	111.88	83.23	73.27	246.43	173.16	1.34	0.65	200	411.10	0.41
APR II	Generative growth	111.88	83.23	73.27	246.43	173.16	1.34	0.65	200	411.10	0.41
MEI I	Generative growth	88.65	84.72	59.67	243.83	184.16	1.42	0.65	200	437.23	0.44
	Fertilization and										
MEI II	Maturation	94.56	90.37	63.94	252.80	188.86	1.37	0.65	200	420.35	0.42
JUN I	Harvest	51.46	84.16	35.94	-	-	-	0.65	200	-	-
JUN II	Bero	51.46	84.16	35.94	-	-	-	0.65	200	-	-
JUL I	cultivation	28.67	84.16	20.48	73.76	53.27	0.41	0.65	200	126.48	0.13
JUL II	Seedling growth	30.58	89.77	22.06	92.14	70.08	0.51	0.65	200	156.97	0.16
AUGT I	Vegetative growth	51.18	85.09	35.82	114.21	78.39	0.60	0.65	200	186.11	0.19
	Vegetative growth										
AUGT II	Vegetative growth	54.59	90.76	38.52	127.27	88.75	0.64	0.65	200	197.54	0.20
SEPT I	Flowering	31.91	86.02	22.82	115.98	93.16	0.72	0.65	200	221.18	0.22
SEPT II	Maturation	31.91	86.02	22.82	104.80	81.98	0.63	0.65	200	194.63	0.19

Source: Calculation Results, 2024

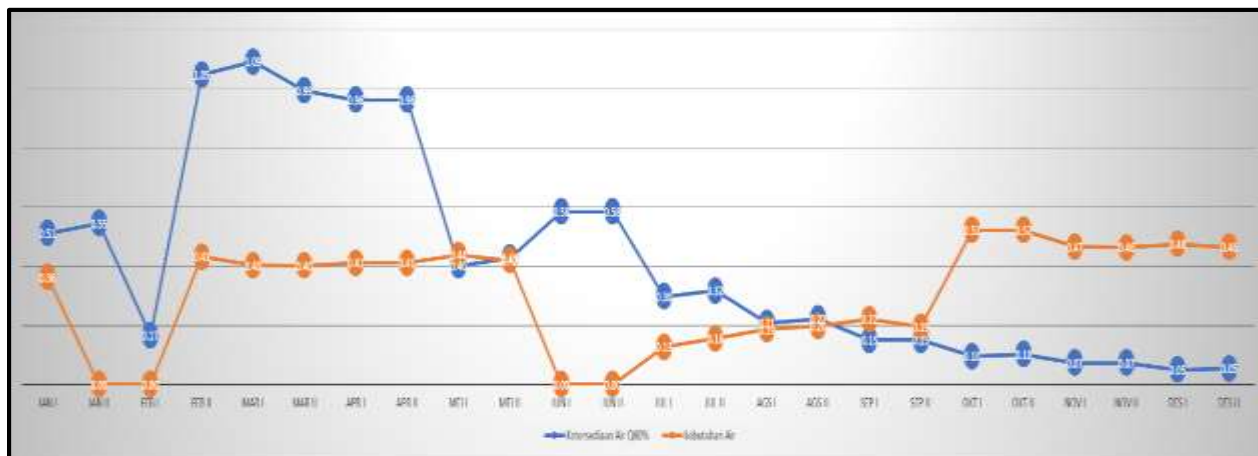


Figure 3. Chart of Annual Water Availability and Demand Analysis

Figure 3. illustrates the analysis of water availability and demand throughout the year in the study area. The lower section of the graph compares 80% water availability (blue line) with water demand (orange line) in cubic meters per second (m^3/s) over different time periods. The middle section presents a table displaying quantitative data on water availability and demand, categorized and highlighted in green.

The graph indicates significant fluctuations in water availability throughout the year, with peak availability occurring in February ($1.05\text{--}1.09 \text{ m}^3/\text{s}$) and October ($1.10\text{--}1.09 \text{ m}^3/\text{s}$). Meanwhile, a deficit period is observed from June to August, where water availability reaches $0.00 \text{ m}^3/\text{s}$ at certain points.

The supporting table provides specific numerical data on water discharge, which can be utilized to evaluate the balance between water supply and demand in the study area. This visualization offers a clear representation of water availability and demand patterns, serving as a basis for water resource planning and related infrastructure management.

Conclusion

Based on the hydrological analysis and evaluation of annual water availability and demand in the Cipari Makmur Irrigation Area (DI Cipari Makmur), the rainfall pattern exhibits two main peak periods: March–June ($175\text{--}245 \text{ mm}$) and September–December ($160\text{--}230 \text{ mm}$), while a deficit period occurs in July–August ($90\text{--}135 \text{ mm}$). Water availability analysis shows peak values in February ($1.05\text{--}1.09 \text{ m}^3/\text{s}$) and October ($1.10\text{--}1.09 \text{ m}^3/\text{s}$), whereas the critical water deficit period occurs from June to August, with availability nearing $0.00 \text{ m}^3/\text{s}$. These results highlight an imbalance between water supply and demand, necessitating more adaptive management strategies, such as the construction of reservoirs or water storage ponds to retain excess water and the optimization of irrigation systems for efficient water use. Future research could focus on the impact of climate change on water availability and mitigation strategies to ensure the sustainability of irrigation in this region.

Reference

- Alcon, F., Zabala, J. A., Martínez-García, V., Albaladejo, J. A., López-Becerra, E. I., de-Miguel, M. D., & Martínez-Paz, J. M. (2022). The social wellbeing of irrigation water: A demand-side integrated valuation in a Mediterranean agroecosystem. *Agricultural Water Management*, 262, 107400. <https://doi.org/10.1016/j.agwat.2021.107400>

- Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56. FAO.
- Brouwer, C., & Heibloem, M. (1989). Irrigation water management: Irrigation water needs. Rome.
- Chow, V. T., Maidment, D. R., & Mays, L. W. (1988). Applied Hydrology. McGraw-Hill.
- Chu, J., Chen, J., Wang, C., & Fu, P. (2004). Wastewater reuse potential analysis: Implications for China's water resources management. *Water Research*, 38(11), 2746–2756. <https://doi.org/10.1016/j.watres.2004.04.002>
- Doorenbos, J., & Pruitt, W. O. (1977). Guidelines for predicting crop water requirements (FAO Irrigation and Drainage Paper 24). FAO.
- Dang, C., Zhang, H., Yao, C., Mu, D., Lyu, F., Zhang, Y., & Zhang, S. (2024). IWRAM: A hybrid model for irrigation water demand forecasting to quantify the impacts of climate change. *Agricultural Water Management*, 291, 108643. <https://doi.org/10.1016/j.agwat.2023.108643>
- Drechsel, P., Qadir, M., & Wichelns, D. (Eds.). (2015). Wastewater economic asset in an urbanizing world. Springer, Netherlands, Dordrecht.
- Ferreira, T. R., Maguire, M. S., da Silva, B. B., Neale, C. M. U., Serrão, E. A. O., Ferreira, J. D., Moura, M. S. B., dos Santos, C. A. C., Silva, M. T., Rodrigues, L. N., & Carvalho, H. F. S. (2023). Assessment of water demands for irrigation using energy balance and satellite data fusion models in cloud computing: A study in the Brazilian semiarid region. *Agricultural Water Management*, 281, 108260. <https://doi.org/10.1016/j.agwat.2023.108260>
- Hassan, W., Manzoor, T., & Muhammad, A. (2023). Improving equity in demand-driven irrigation systems through a rights-preserving water allocation mechanism. *Agricultural Water Management*, 287, 108443. <https://doi.org/10.1016/j.agwat.2023.108443>
- Keller, J., & Bliesner, R. D. (1990). Sprinkle and trickle irrigation. Van Nostrand Reinhold.
- Martínez-Paz, J. M., Gomariz-Castillo, F., & Pellicer-Martínez, F. (2018). Appraisal of the water footprint of irrigated agriculture in a semi-arid area: The Segura River basin. *PLOS ONE*, 13(11), e0206852. <https://doi.org/10.1371/journal.pone.0206852>
- Neitsch, S., Arnold, J. G., Kiniry, J., & Williams, J. R. (2011). Soil and Water Assessment Tool—Theoretical Documentation. Technical Report TR-406. Texas A&M University.
- Oktaviani, V., & Tukimun, S. (2023). ANALISIS INVESTASI PEMBANGUNAN JARINGAN IRIGASI PADA DI. MANUNGGAL DAYA (DUSUN SIDOREJO), KECAMATAN SEBULU, KABUPATEN KUTAI KARTANEGARA. *Konsorsium UNTAG se-Indonesia*, 5(1), 59-66.
- Su, Q., Singh, V. P., & Karthikeyan, R. (2022). Improved reference evapotranspiration methods for regional irrigation water demand estimation. *Agricultural Water Management*, 274, 107979. <https://doi.org/10.1016/j.agwat.2022.107979>
- Watson, S. C. L., Newton, A. C., Ridding, L. E., Evans, P. M., Brand, S., McCracken, M., Gosal, A. S., & Bullock, J. M. (2021). Does agricultural intensification cause tipping points in ecosystem services? *Landscape Ecology*. <https://doi.org/10.1007/s10980-021-01321-8>

Tukimun, W. M., & Setiawan, M. I. (2018). Study And Analysis of Agriculture Spatial Planning In Penajam Paser Utara, East Kalimantan, Indonesia. https://www.researchgate.net/profile/Tukimun-Tukimun/publication/359939503_STUDY_AND_ANALYSIS_OF_AGRICULTURE_SPATIAL_PLANNING_IN_PENAJAM_PASER_UTARA_EAST_KALIMANTAN_INDONESIA/links/625807a49be52845a902caa8/STUDY-AND-ANALYSIS-OF-AGRICULTURE-SPATIAL-PLANNING-IN-PENAJAM-PASER-UTARA-EAST-KALIMANTAN-INDONESIA.pdf