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A Simple Method of Water Balance Analysis to Predict the Performance of Water Resource Management in the Unit of South Kalimantan Province Offices

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ABSTRACT

Banjarbaru city was legally established as the capital city of Kalimantan Selatan province, and it needed a new unit of government offices. In the new unit offices of 500 ha, the government built not only office facilities but also a small reservoir or Embung. This study aims to analyze the availability of water upstream of the Embung that can be provided to fulfill urban water demand in the service area with a simple method of water balance. The conclusions obtained from this research on a simple method of water balance analysis to predict the performance of water resource management in the unit of South Kalimantan province offices based on water available in upstream Embung in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after Embung construction is still quite adequate as much as 45,611,711.64 liter/day. Although until now, PDAM Intan Banjar still provides sufficient water to meet water needs in the service area. The construction of the reservoir is one of the methods applied by the South Kalimantan provincial government in managing water resources for conservation in the future. With the increase in the population in the future, it is necessary to think about other water sources to meet the water needs caused by population growth.

Keywords: water availability, water demand, water balance, water resources management, government official offices, South Kalimantan

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1. Introduction

Banjarbaru city was legally established as the capital city of Kalimantan Selatan province and started on March 16, 2022. It was lawfully validated with Undang-Undang Nomor 8 in 2022 on March 16, 2022 (Undang-Undang RI, 2022). The relocation of the provincial capital has begun with the transfer of government official offices. The South Kalimantan Provincial Government office area is an integrated office area where the spatial layout in it requires various supporting facilities, one of which is an area that can be used as a water catchment area to accommodate/reduce surface runoff leading to Banjarbaru City. The South Kalimantan Provincial Government office area built in 2011, which began with the transfer of the South Kalimantan Provincial Government Offices, which will be occupied by the governor and deputy governor, began to move from the City of Banjarmasin to the City of Banjarbaru in August 2011. Then gradually continued with other offices within the provincial government of South Kalimantan. The official

office area of South Kalimantan Province was built on a land area of about 500 hectares, with a total land prepared by the Banjarbaru City Government reaching 2,000 hectares. The office development program and regional arrangement in an area of 500 hectares will continue to be carried out in stages until 2025.

Changes in land use covering an area of 500 ha and increasing population growth in Banjarbaru City lead to an increase in the need for clean water and an increase in the need for water resource management. Water resources are predicted to experience a crisis threat in 2025 in the city of Banjarbaru, along with the development of tourism and population growth of 1.9% annually, which can be accelerated by industrial activities. Extensive industrial and tourism activities will significantly accelerate the depletion of water supply and increase water demand, based on the calculation results of large-scale companies, will accelerate the shortage of water supply for the next ten years (BPS, 2022c). Until now, Banjarbaru City has had a reasonably low intensity of land fires and floods at several points. This could

change significantly with the relocation of the provincial capital of South Kalimantan, which will increase the population and increase land use.

In the government official office construction, the government also builds small reservoirs (embung). The small reservoir, with an area of more than 6 hectares, is equipped with inlet and outlet buildings, outlet pumps, water pumps, reservoir towers, and jogging tracks (Gunawan, 2018).

This small reservoir is named The Embung Kampung Banjar. The Embung Kampung Banjar, which was built in the provincial government office area, in addition to functioning as a catchment, also functions as a water tourism area and is also used for watering plants. The Kampung Banjar Embung is also expected to work as a water conservation and preservation area and can be used as a source of water and for various purposes in office areas. The project will be carried out in multi-year 2019 – 2020. So it is necessary to evaluate the conservation of water resources with the projected city growth caused by the population increase. The purpose of this research is to evaluate the water balance that can be supplied by the reservoir to the planned service area (Gunawan, 2018).

2. Literature Review

2.1. Water Available

According to Bambang Triatmodjo (2008), the availability of water is the amount of water discharge which is estimated to be continuously in a location (water structure) in a certain amount of water and within a certain period of time (Bambang Triatmodjo, 2008). Evapotranspiration is a combination of evaporation and transpiration, which includes all evaporation of water that occurs on the earth's surface, including water bodies, soil, and plants. The evapotranspiration formula used is the Penman-Monteith FAO-56 reference evapotranspiration (Allen, 1998).

$$ET_o = \frac{0,408\Delta(Rn - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0,34u_2)}$$

Where:

- ET_o = reference evapotranspiration (mm/day)
- R_n = net radiation at the crop surface (MJ/m²/day)
- G = soil heat flux density (MJ/m²/day)
- T = mean daily temperature at 2 m height (°C)
- u_2 = wind speed at 2 m height (m/s)
- e_s = saturation vapor pressure (kPa)
- e_a = actual vapor pressure (kPa)
- $e_s - e_a$ = saturation vapor pressure deficit (kPa)
- Δ = slope vapor pressure curve (kPa/°C)
- γ = psychrometric constant (kPa/°C)

Water availability is calculated using the F.J. method (Nurrochmad, Sujono dan Damanjaya, 1998). The mock

with the output value is in the form of discharge data in the watershed at the research location.

$$R = \sqrt{\frac{Dt^2 - D^2}{Dt^2}}$$

Where:

$$Dt^2 = \sum_{i=1}^N (Q^{i_{obs}} - \bar{Q})^2$$

$$D^2 = \sum_{i=1}^N (Q^{i_{obs}} - Q^{i_{sim}})^2$$

$$\bar{Q} = \frac{\sum_{i=1}^N Q^{i_{obs}}}{N}$$

The formula can calculate volume Error (VE):

$$VE = \frac{\sum_{i=1}^N Q^{i_{obs}} - \sum_{i=1}^N Q^{i_{sim}}}{\sum_{i=1}^N Q^{i_{obs}}}$$

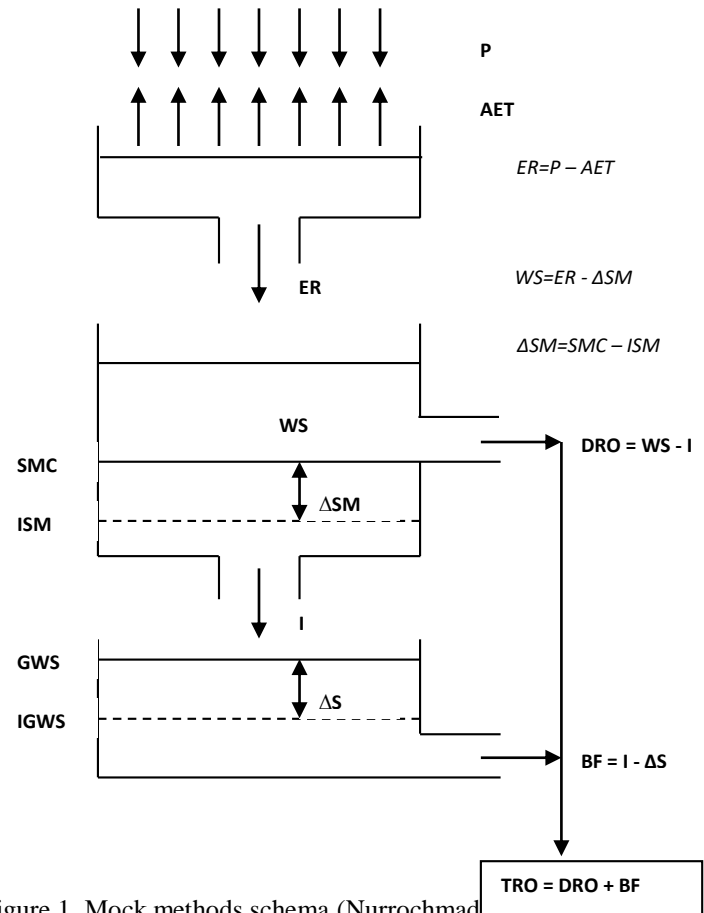


Figure 1. Mock methods schema (Nurrochmad, Sujono dan Damanjaya, 1998)

Where:

- Q_{sim} = simulation discharge of the i period (m^3/s)
 Q_{obs} = observation discharge of the i period (m^3/s)
 \bar{Q} = average observation discharge (m^3/s)
 N = the amount of data

2.2. Water Demand

First, as an analysis of water demand, The number of population needs that will be served in accordance with the portion can affect the quantity requirements of urban water demand, which generally people must obtain clean water and drinking water anytime for 24 hours to meet their needs. Water demand can be divided into household and household needs. According to the Directorate General of Cipta Karya (2000) there are 2 (two) standards for water demand, namely: domestic water demand has standards for use in private residences so that daily needs can be met, such as drinking water, cooking, washing, and other household needs and non-domestic water needs are clean water needs that are not household needs. The use in question is commercial, industrial, and general. Household and urban water needs are essential always to be met so that there is no failure to meet water needs which can lead to various kinds of disease outbreaks and unrest in the community. The need for water is correlated with population growth. Population projection is the calculation of the total population with the aim of obtaining past and future information in the context of long-term development planning. Population data is obtained from the census conducted by the Central Statistics Agency of Banjarbaru City and other government departments or institutions. In this study, the population projection calculation used is the geometric method (BPS, 2022b).

$$r = \left(\frac{p_t}{p_0}\right)^{1/t} - 1$$

Where:

- r = Population growth rate
 p_t = population of year t
 p_0 = amount of base population year
 t = time period between the base year and year t (in years)

2.3. Water Balance

A simple water balance analysis is based on a correlation between water availability and water demand in the location (Armstrong dan Johnson, 2018). The water balance calculations are used to meet irrigation water needs (Ariyani, Putuhena dan Wira, 2020) and urban water needs (Reed, Maidment dan Patoux, 1997).

2.4. Water Quality Measurement

Water quality analysis is needed to get the water quality that suits its needs. There are two regulations used in this study. Government Regulation (PP) No 82 dated December

14, 2001 on Water Quality Management and Water Pollution Control (Pemerintah Republik Indonesia, 2001) dan Minister of Health Regulation enacted on May 31 2017 about Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene, Swimming Pools, Solus Per Aqua, and Public Baths (Menteri Kesehatan Republik Indonesia, 2017).

2.5. Small Reservoir (Embung)

Embung, or what is usually also called a small reservoir, is a construction that is built to withstand the flow of water. This retained water will collect in Embung that can be used as the needs of irrigation water, household water, industrial water, hydroelectric power plants, and others (Arsyad, 2017a). Based on the opinion of one expert, a reservoir is an artificial building that functions to accommodate and store water with a certain small volume capacity, smaller than the capacity of the reservoir/dam (Kodoatie dan Roestam Syarief, 2010). Types of reservoirs are grouped into four types, namely as follows: 1. based on the purpose of construction with reservoirs for residential purposes and multipurpose reservoirs, 2. based on their use as water reservoirs, deflectors, and retainers, 3. Based on their location to the flow of water, reservoirs on watercourses, and reservoirs outside the watercourse, and 4. based on the constituent material, embankment reservoirs and reservoirs of concrete (Soedibyo, 1993; Arsyad, 2017b).

The planning of a water reservoir in Embung is based on the estimation of water availability to ensure water supply every year in both rainy and dry seasons. This includes not only the capacity of the reservoir and the height of the dam in accordance with the availability of water, but also the entire utilization system must be designed based on the needs and benefits, for example, the installed capacity of hydropower, irrigation water distribution systems and so on (Arsyad, 2017c).

3. Research Methodology

3.1. Data

Rainfall analysis is calculated by adding up the daily rainfall per month in one period. The rainfall data used is derived from the Banjarbaru Climatology Station for a period of 20 years (2001 to 2020) (BMKG, 2012). The method used to calculate evapotranspiration is the Penman-Monteith FAO-56 method, with climatological data downloaded on the BMKG Online (BMKG, 2012).

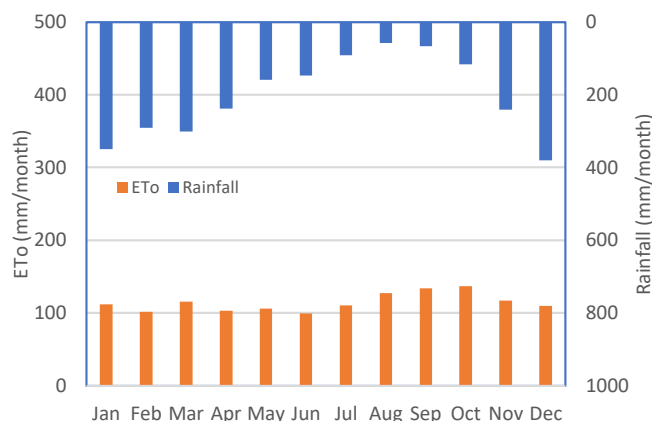


Figure 1. Rainfall and ETo Analysis

From rainfall data from the year 2000 to the year 2020, the average annual rain is 2439.99 mm/year. The yearly average evapotranspiration is 1374.13 mm/year. The lowest rainfall intensity occurred in August at 57.88 mm/month and the highest in December at 379.73 mm/month. The average monthly rainfall data is 203.33 mm/month. The monthly evapotranspiration data from the year 2000 to the year 2020, the highest data in October was 136.72 mm/month, and the lowest evapotranspiration data in June was 99.54 mm/month. The average monthly evapotranspiration data is 114.51 mm/month. Based on rain data and evapotranspiration data, it is determined the availability of water upstream of the reservoir.

Banjarbaru city, with a total area of 305.242 km² divided into five districts, Landasan Ulin, with an area of 74.054 km², Liang Anggang of 74.773 km²; Cempaka of 114.543 km²; North Banjarbaru 26.855 km², and South Banjarbaru 15.027 km² (BPS, 2022b). BPS (Central Bureau of Statistics) Banjarbaru City recorded data from 2013 – 2020. The highest population data is in the Landasan Ulin sub-district as many as 75,385 residents, and the lowest data is in the Cempaka sub-district as many as 35,584 residents (BPS, 2022a). Population growth is one of the effects of moving offices and government centers to Banjarbaru City.

In the South Banjarbaru sub-district, in the year 2013, the population of as many as 46,872 residents. It increases until years 2019, with as many as 67,542 residents but decreases in years 2020 to as many as 45,273 people, as shown in Figure 6. The Population in South Banjarbaru District in 2020 decreased by 32% because, in 2020, there was a Covid-19 pandemic (BPS, 2022b). The population growth rate reached 1.7.

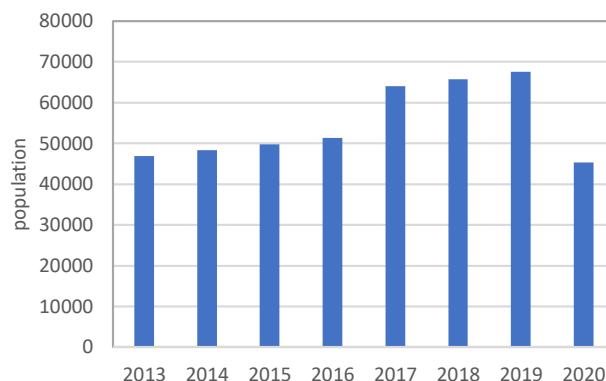


Figure 2. The Population in South Banjarbaru District

3.2. Research Area

The Banjarbaru City area is located at an altitude of 500 m above sea level, with an altitude of 0 – 7 m (33.49%), 7 – 25 m (48.46%), 25 – 100 m (15.15%), 100 – 250 m (2.55%) and 250 – 500 m (0.35%). The slope classification of Banjarbaru City is a slope of 0 – 2% covering 59.35% of the area, a slope of 2 – 8% covering 25.78% of the area, a slope of 8 – 15% covering 12.08% of the area. The rock classification in Banjarbaru City consists of Alluvium 48.44%. In the city of Banjarbaru, there are 3 (three) groups of soil types, namely Podzol soil (63.82%), Lathosol (6.36%), and Organosol (29.82%) (RPIJM, 2015). The South Kalimantan provincial government office building covering an area of 500 hectares in Banjarbaru city can be seen on the map below and is located in the Cempaka sub-district.



Figure 3. Research Study

Embung Kampung Banjar was built in the area of the South Kalimantan provincial government office building in Kampung Banjar village. It is geographically 3°28'27,9" south latitude and 114°49'39" north latitude.

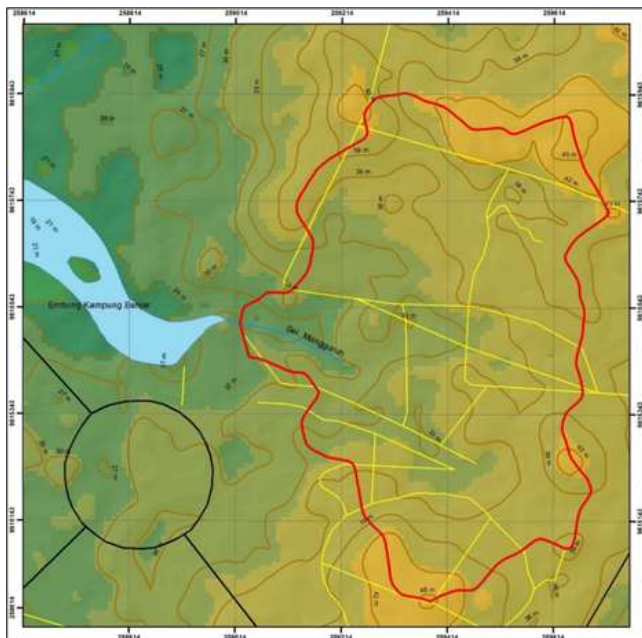


Figure 4. Embung Kampung Banjar

Embung Kampung Banjar has a service area in the part of the sub-district of South Banjarbaru and other sub districts with an area of 21.96 km². Facilities located at the Embung Kampung Banjar service location include water catchment areas, water tourism areas, reservoirs to reduce runoff to Banjarbaru city, watering plants, and water preservation and conservation areas. The need for water increases with the increase in population.

4. Result

4.1. Water Available Analysis

Water available analysis calculates from the river discharge data of the Riam Kiwa River. The calibration was conducted in 2001 with an area of 382 km² (Novitasari *et al.*, 2021). Based on discharge data observed in 2001, water discharge in other years can be calculated using mock parameters from the Riam Kiwa River. The wet infiltration coefficient is 0.3, the dry infiltration coefficient is 0.4, the initial soil moisture (ISM) is 110 mm, the soil moisture capacity (SMC) is 220 mm, the initial ground water storage (IGWS) is 1000 mm, and groundwater recession Constant (*k*) as 0.810.

The average monthly discharge data for 20 years is presented in Figure 5. The average annual discharge data is presented in Figure 6. The effectiveness of using Riam Kiwa discharge data to determine the calculated discharge with the measured discharge data obtained at the research location is shown in Table 1.

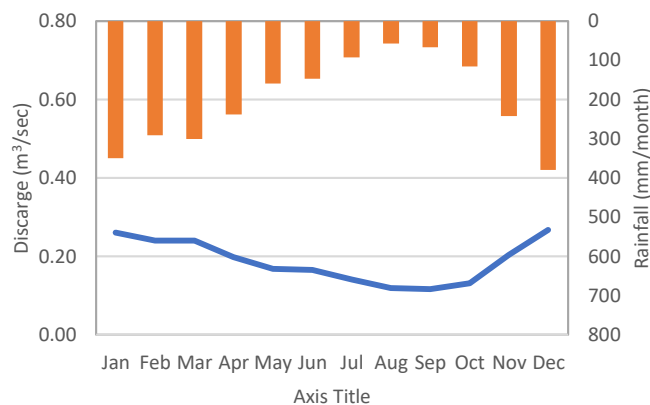


Figure 5. The average monthly discharge data for 20 years

The highest monthly average discharge for 20 years occurred in December at 0.27 m³/second, while the lowest discharge occurred in August and September at 0.12 m³/second. Debit rata-rata bulanan sebesar 0.19 m³/detik.

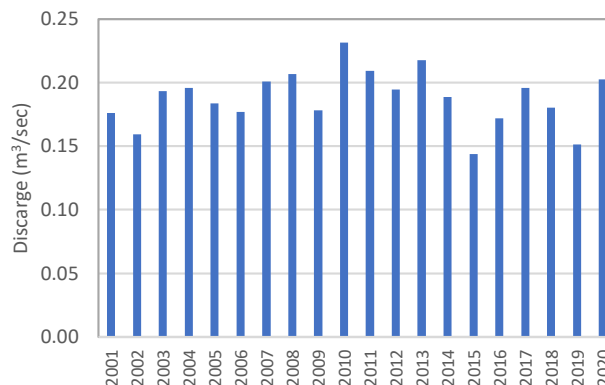


Figure 6. The average annual discharge data

Analysis of annual discharge from 2001 to 2020 found that the highest average annual discharge occurred in 2010 at 0.23 m³/second, and the lowest average annual discharge occurred in 2015 at 0.14 m³/second. The limitations of the discharge measurement data for analysis using the mock model need to be eliminated by measuring the instantaneous discharge at the research site. Measured discharge in upstream Embung (Paring River), Embung Inlet, and Embung outlet in April and May 2021.

Table 1. Data for Measured Discharge of Embung Kampung Banjar

Location	Qobs (2021) (m ³ /s)		Qcal (2021) (m ³ /s)		Qcal mean (m ³ /s)	
	Apr	May	Apr	May	Apr	May
Upstream	0.04	0.04	0.08	0.09	0.19	0.15
Inlet	0.02	0.08				

Outlet	0.02	0.002				
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The effectiveness is analyzed against the calculated discharge in 2021 and the average annual discharge in April and May. The value of the effectiveness of using the Riam Kiwa River discharge data for the calibration process at the Kampung Banjar Embung is 25% in April 2021 and 88% in May 2021. In April 2021, the effectiveness value was very small because, at the time of measurement, it was a day that rarely rains, starting from the middle of April, causing the measured discharge to be very low.

The mainstay discharge is calculated by sorting the average discharge per year (2001-2020) from the largest value to the smallest value so that the average discharge value is obtained at a probability of 90% for domestic water purposes. The following are the steps for calculating the mainstay discharge.

- The monthly average discharge data is sorted from the largest to the smallest.
- Give a sequence of r from 1 to N where the value of N is 20.
- The probability of the Weibull method, let's say that r is 1
- $$P = \frac{r}{(N+1)} \times 100\% = \frac{1}{(20+1)} \times 100\% = 4,76\% \approx 5\%$$
- Then look for the required mainstay discharge; because the function of the reservoir is of them to meet the needs of r water in the neighborhood of the location, the mainstay discharge used is Q90, specifically for domestic water demand.

The results of the monthly Q90 calculation can be seen in the table below.

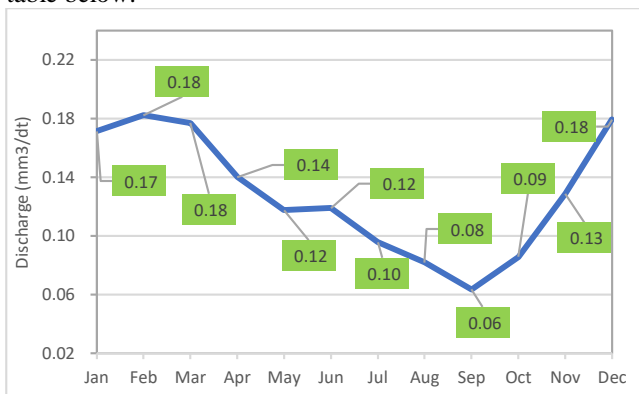


Figure 7. Month Average Water Discharge in 2001-2020

The most reliable discharge for water needs was obtained in February, March, and December with a discharge value of 0.18 m³/s and the smallest occurred in with a discharge value of 0.06 m³/s. The availability of water in the Embung Kampung Banjar will be used to fulfill the water demand of the local population, the need for watering plants,

and also the drinking water needs of livestock, especially during the dry season, when very little rain occurs. The reservoir is expected to be fully filled at the end of each rainy season so that it can be used during the dry season.

4.2. Water Demand

The amount of urban water demand according to the density criteria (people per hectare) is taken at 25-35. This is because the Population of Banjarbaru City is 506,884 people with an area of 37,130 Ha, so a population density of > 100 people/ha is obtained. The standard of household water needs is based on the type of city and population. Banjarbaru City is a type of big city whose accuracy criteria are more than 100, and the number of urban water needs taken is 25-35. The standard amount of non-domestic water needed according to the Population of Banjarbaru City is 40.

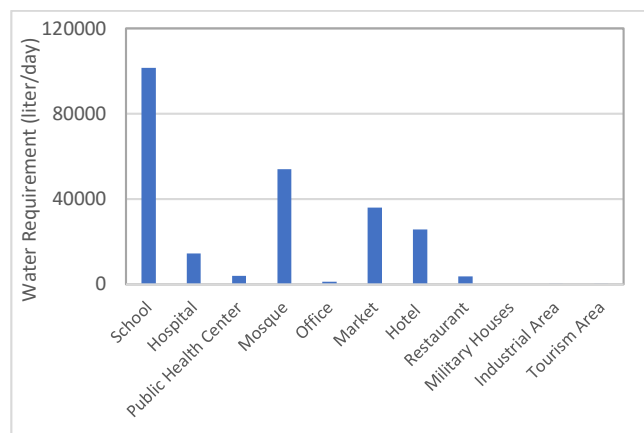


Figure 8. Non-Domestic Water Requirement

In Banjarbaru city, non-domestic water demands include water for public facilities such as schools from kindergarten to college, public and private hospitals, public health centers, mosques, government and non-government offices, traditional markets, hotels, restaurants, military houses, and some tourism area.

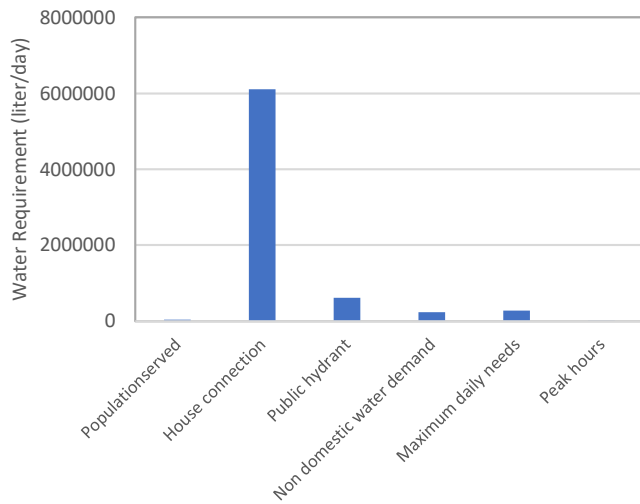


Figure 9. Domestic and Urban Water Requirements

The population served is 45,273 people with a house connection (SR) of 90% times The population served multiplied by 150 liters. The water requirement for a public hydrant (KU) is 90% times the house connection (SR). All water requirement includes domestic and non-domestic water demands, and maximum daily needs in peak hours.

The results of the analysis of water needs, the City of Banjarbaru is included in the category of a large city type with a population of 506,884 people. It can be concluded that the total number of non-domestic water needs in 2020 after the Embung was built was 240,593.4 Liters/day, and the total number of household and urban water needs was 7,289,740 Liters/day. The population reduction that occurred in 2020 in South Banjarbaru District impacts the amount of water demand in the service area.

Long-term development planning by taking into account the population for the next five years, ten years, 15 years, 20 years, and 25 years using the Geometric Method as shown in Figure 7.

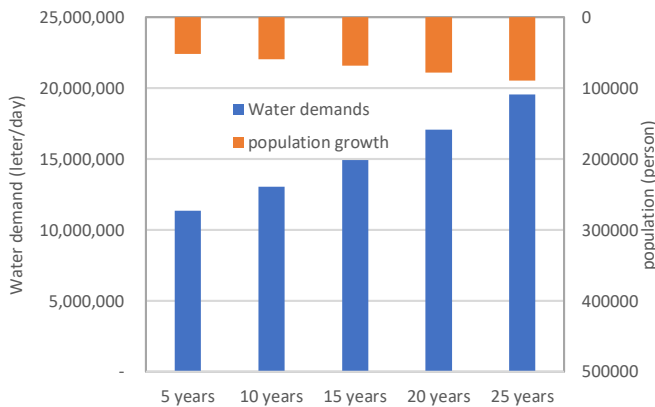


Figure 10. Projection of water demand and population growth after the construction of the Embung

The increase in population is used to calculate population projections for five years, ten years, 15 years, 20 years, and 25 years after 2020. Based on population projection, residents served as many as 88,987 people in the next 25 years. This population projection will be used to calculate the need for domestic and non-domestic water in Banjarbaru city.

The projected total domestic water demand after the construction of the Embung is 7,807,526 liters/day in 5 years, 8,937,414,318 liters/day in 10 years, 10,230,759.48 liters/day for 20 years, 1,1621,681,5 liters/day, and at 25 years as many as 1,3406,046.2 liters/day.

The projection of total household and urban water needs after the construction of the Embung is 11,366.893 liters/day; in 10 years, it is 13,045,123.53 liters/day; in 15 years, it is 14,932,900.78 liters/day; in 20 years as many as 17,093,784.53 liters/day, and at 25 years as many as 19,567,575.3 liters/day.

4.3. Water Balance

Analysis of the water balance that is planned to meet domestic and non-domestic raw water needs is carried out on population data in 2020, at the time of the start of office relocation in Banjarbaru city. The population growth area is taken in South Banjarbaru District. The analysis of water available to fulfill water demand in the service area of embung in 2020 as shown in Figure 11.

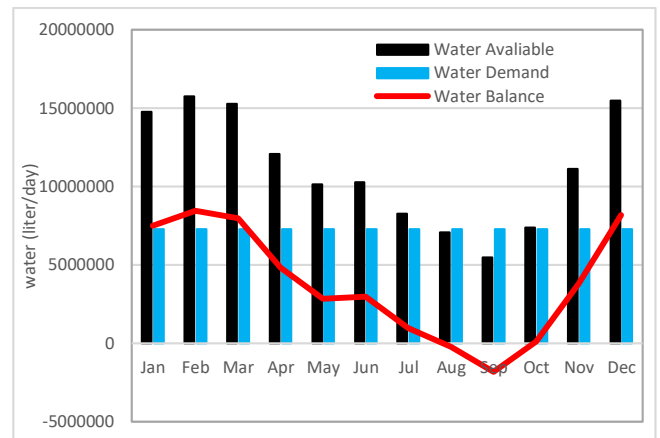


Figure 11. Water Balance Analysis

The water balance obtained by the construction of the Embung Kampung Banjar and the water needs to be obtained a surplus water balance for most of the year, except for August and September. In August has a deficit of water as much as 220,829.51 liter/day, and in September, the deficit as 1,815,842.40 liter/day. The highest deficit value occurred in September. It is necessary to regulate the water resource system to cope with these conditions, given the increase in population after 2020 with the movement of office complexes accompanied by the movement of the provincial capital in 2022. Analysis of water demand is carried out on

population growth of 5 years, 10 years, 15 years, 20 years, and 25 years as shown in Figure 12.

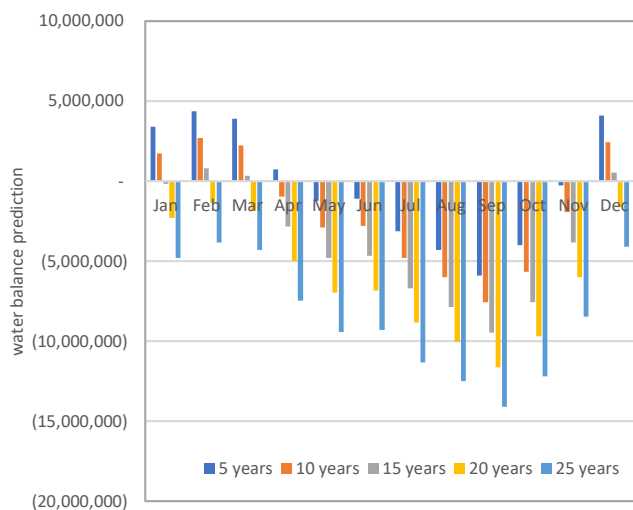


Figure 12. Water Balance for projected to meet water demand

Based on the current water availability data, it is projected to meet water demand for the 5 years, 10 years, 15 years, and 20 years to 25 years projections. It can be seen that

No .	Parameter	Unit	Max rate allowed	Inlet	Outlet	Em-bung	Parin g River
A. Physical							
1	Turbidity	Scala NTU	25	0.73	0.93	1.03	0
2	Water temperature	°C	air temperature ± 3 °C	30.51	30.34	30.22	29.46
B. chemical							
1	Ph	Mg/L	6,5-9,0	6.77	7.16	7.06	6.4
2	Total Dissolved Solid (TDS)	Mg/L	1500	0.007	0.002	0.002	0.007

water available only can fulfill the water needs in five years projections in January, February, March, April, and December. The deficit of water from May to November. The water deficit occurs throughout the year to meet water needs for population projections for 20 years and 25 years.

4.4. Water Quality Analysis

Water quality testing at the Embung Kampung Banjar took four samples in the Embung service area, namely Inlet, Outlet, and Paring River. The tool used in this test is U-50 HORIBA (multi-water quality checker). This test is to determine the parameters contained in the water sample. The test is carried out by dipping the U-50 HORIBA (multi-water

quality checker) tool into a water sample from which water quality data will be taken.

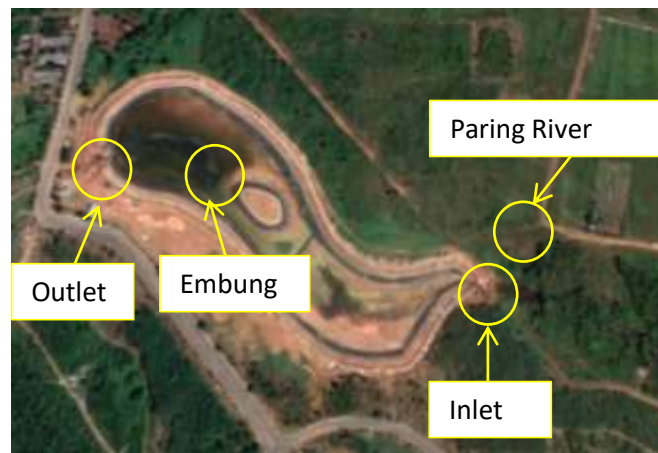


Figure 14. Location of Water Quality Sampling Data

Water quality testing consists of physical, chemical, and biological tests. Based on the tools available at the Hydraulic Laboratory, Faculty of Engineering, Lambung Mangkurat University, the only tests that can be done are physical and chemical tests. The measured water quality includes physical and chemical quality, which consists of water turbidity measurement, water temperature, degree of acidity of the water (pH), and total Dissolved Solid (TDS).

Table 2. Water Quality Sampling Data

In the physical test, the results obtained from the U-50 HORIBA (multi-water quality checker) tool get turbidity and temperature parameters, while for chemical testing, the results obtained are Ph and Total Dissolved Solid (TDS). From the physical and chemical tests, the parameters of the four samples met the maximum allowable levels. Based on direct observation, it was also found that the water entering and leaving the reservoir was tasteless, odorless, and colorless.

Water sampling for 4 locations consisted of an inlet for the first sample, an outlet for the second sample, an Embung for the third location, and the paring river for the fourth sample. Based on the test at the 4 locations, it can be taken from the data that the water quality in the service area of the Embung Kampung Banjar meets the class D water standard. Water turbidity less than 25 NTU. Water temperature based on air temperature ± 3 °C. the average maximum air temperature for the last 5 years is 32.27°C. The degree of acidity of the water (pH) is around 7. TSD less than 1500 Mg/l. It can be used for agriculture, urban businesses, industry, and hydroelectric power plants that can be used by the community around Banjarbaru District.

5. Discussion

5.1. Water balance as water resource management

Water balance in the unit of South Kalimantan Province Offices based on water available in upstream Embung in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after Embung construction is still quite adequate as much as 45,611,711.64 liter/day. The construction of the Embung Kampung Banjar is a good solution to overcoming the current problems of water resource management in Banjarbaru City as the new capital city of South Kalimantan province.

A well-managed reservoir can be used as a water provider to cover water needs in the dry season from water stored in the rainy season. The average annual rain that occurs based on observations at the Banjarbaru climatology station is around 2439.99 mm/year for 20 years, so it has the potential to be captured and utilized. Embung Kampung Banjar is the solution for current water needs. However, in the future, with the increase in population, it is necessary to build other reservoirs or other water source supplies in the South Kalimantan government office.

5.2. Water resources management as water conservation and tourism

The Banjarbaru City Government's planning during the construction of the Embung Kampung Banjar was to function as water conservation as an Embung for groundwater storage, watering plants, and water tourism. Embung also uses to reduce water runoff to Banjarbaru city and water plants. The Banjarbaru city government's planning was in accordance with the conditions when direct observations were made in the field.

Until now, water available needed to fulfill the need for clean water in the service area, namely South Banjarbaru District; it is still served by PDAM Intan Banjar. So the building of Embung still functions more as water conservation for groundwater storage and tourism with the jogging tracks around Embung. In addition to the need for rainwater storage during the rainy season, there is also a need for infiltration areas that are used to replace lands that have changed functions into office areas that are massively closed, and covering an area of 500 ha, it is necessary to take into account how much water runs over the surface considering that Banjarbaru city is a city with a clay soil structure, so it is an area that really needs good groundwater infiltration, considering that the groundwater level in Banjarbaru City is quite deep.

6. Conclusion and Implication

6.1. Conclusion

The conclusions obtained from this research on a simple method of water balance analysis to predict the performance of water resource management in the unit of

South Kalimantan province offices based on water available in upstream Embung in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after Embung construction is still quite adequate as much as 45,611,711.64 liter/day. Although until now, PDAM Intan Banjar still provides sufficient water to meet water needs in the service area.

The construction of the reservoir is one of the methods applied by the South Kalimantan provincial government in managing water resources for conservation in the future. In order to increase the population in the future, it is necessary to think about other water sources to meet the water needs caused by population growth.

6.2. Future Research

This research had a small scope of the area of water resources management in the new unit of government offices, with an area of 500 ha. Changes in land use covering an area of 500 ha also need to be considered regarding groundwater storage in the future and the effect of land erosion that can occur, considering that Banjarbaru City is a city with varying land heights.

In general, the relocation of the provincial capital will also cause the transfer of public facilities and other activities. It means needed more water resources management in the future on a larger scale.

Acknowledgments

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A Simple Method of Water Balance Analysis to Predict the Performance of Water Resource Management in the Unit of South Kalimantan Province Offices

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[tljes] Editor Decision

2022-11-21 12:30 AM

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Our decision is to: Resubmit for Review

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Reviewer A:

Recommendation: Revisions Required

Does the title of the article short, clear, and reflect the overall content?

The article is sufficient and reflect the overall content

Does the abstract of the articles clearly summarise the overall content of the research?

The Abstract is clearly. Need to correction some phrase

Does the article provide scientific and practical justification of the research?

The article is provide scientific and practical justification

Notifications



[tljes] Editor Decision

2022-11-21 12:30 AM

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[tljes] Editor Decision

2022-11-29 11:58 PM

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Our decision is to: Resubmit for Review

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Reviewer A:
Recommendation: Revisions Required

Does the title of the article short, clear, and reflect the overall content?

The article is clear

Does the abstract of the articles clearly summarise the overall content of the research?

Yes it does

Does the article provide scientific and practical justification of the research?

Yes it Does

Does the article formulate clear problem statement and objectives of the research?

Notifications



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2022-11-29 11:58 PM

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Edio da Costa
ediocosta@tljes.org

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Yes it does

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Does the article formulate clear problem statement and objectives of the research?

Notifications



[tljes] Editor Decision

2023-05-02 01:30 AM

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A Simple Method of Water Balance Analysis to Predict the Performance of Water Resource Management in the Unit of South Kalimantan Province Offices

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ABSTRACT

Banjarbaru city was legally established as the capital city of Kalimantan Selatan province, and it needed a new unit of government offices. In the new unit offices of 500 ha, the government built not only office facilities but also a small reservoir or Embung. This study aims to analyze the availability of water upstream of the Embung that can be provided to fulfill urban water demand in the service area with a simple method of water balance. The conclusions obtained from this research on a simple method of water balance analysis to predict the performance of water resource management in the unit of South Kalimantan province offices based on water available in upstream Embung in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after Embung construction is still quite adequate as much as 45,611,711.64 liter/day. Although until now, PDAM Intan Banjar still provides sufficient water to meet water needs in the service area. The construction of the reservoir is one of the methods applied by the South Kalimantan provincial government in managing water resources for conservation in the future. With the increase in the population in the future, it is necessary to think about other water sources to meet the water needs caused by population growth.

Keywords: water availability, water demand, water balance, water resources management, government official offices, South Kalimantan

Received November 02, 2022; Revised; Accepted

1. Introduction

Banjarbaru city was legally established as the capital city of Kalimantan Selatan province and started on March 16, 2022. It was lawfully validated with Undang-Undang Nomor 8 in 2022 on March 16, 2022 (Undang-Undang RI, 2022). The relocation of the provincial capital has begun with the transfer of government official offices. The South Kalimantan Provincial Government office area is an integrated office area where the spatial layout in it requires various supporting facilities, one of which is an area that can be used as a water catchment area to accommodate/reduce surface runoff leading to Banjarbaru City. The South Kalimantan Provincial Government office area built in 2011, which began with the transfer of the South Kalimantan Provincial Government Offices, which will be occupied by the governor and deputy governor, began to move from the City of Banjarmasin to the City of Banjarbaru in August 2011. Then gradually continued with other offices within the provincial government of South Kalimantan. The official

office area of South Kalimantan Province was built on a land area of about 500 hectares, with a total land prepared by the Banjarbaru City Government reaching 2,000 hectares. The office development program and regional arrangement in an area of 500 hectares will continue to be carried out in stages until 2025.

Changes in land use covering an area of 500 ha and increasing population growth in Banjarbaru City lead to an increase in the need for clean water and an increase in the need for water resource management. Water resources are predicted to experience a crisis threat in 2025 in the city of Banjarbaru, along with the development of tourism and population growth of 1.9% annually, which can be accelerated by industrial activities. Extensive industrial and tourism activities will significantly accelerate the depletion of water supply and increase water demand, based on the calculation results of large-scale companies, will accelerate the shortage of water supply for the next ten years (BPS, 2022c). Until now, Banjarbaru City has had a reasonably low intensity of land fires and floods at several points. This could

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change significantly with the relocation of the provincial capital of South Kalimantan, which will increase the population and increase land use.

In the government official office construction, the government also builds small reservoirs (embung). The small reservoir, with an area of more than 6 hectares, is equipped with inlet and outlet buildings, outlet pumps, water pumps, reservoir towers, and jogging tracks (Gunawan, 2018).

This small reservoir is named The Embung Kampung Banjar. The Embung Kampung Banjar, which was built in the provincial government office area, in addition to functioning as a catchment, also functions as a water tourism area and is also used for watering plants. The Kampung Banjar Embung is also expected to work as a water conservation and preservation area and can be used as a source of water and for various purposes in office areas. The project will be carried out in multi-year 2019 – 2020. So it is necessary to evaluate the conservation of water resources with the projected city growth caused by the population increase. The purpose of this research is to evaluate the water balance that can be supplied by the reservoir to the planned service area (Gunawan, 2018).

2. Literature Review

2.1. Water Available

According to Bambang Triatmodjo (2008), the availability of water is the amount of water discharge which is estimated to be continuously in a location (water structure) in a certain amount of water and within a certain period of time (Bambang Triatmodjo, 2008). Evapotranspiration is a combination of evaporation and transpiration, which includes all evaporation of water that occurs on the earth's surface, including water bodies, soil, and plants. The evapotranspiration formula used is the Penman-Monteith FAO-56 reference evapotranspiration (Allen, 1998).

$$ET_o = \frac{0,408\Delta(Rn - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0,34u_2)}$$

Where:

- ET_o = reference evapotranspiration (mm/day)
- R_n = net radiation at the crop surface (MJ/m²/day)
- G = soil heat flux density (MJ/m²/day)
- T = mean daily temperature at 2 m height (°C)
- u₂ = wind speed at 2 m height (m/s)
- e_s = saturation vapor pressure (kPa)
- e_a = actual vapor pressure (kPa)
- e_s - e_a = saturation vapor pressure deficit (kPa)
- Δ = slope vapor pressure curve (kPa/°C)
- γ = psychrometric constant (kPa/°C)

Water availability is calculated using the F.J. method (Nurrochmad, Sujono dan Damanjaya, 1998). The mock

with the output value is in the form of discharge data in the watershed at the research location.

$$R = \sqrt{\frac{Dt^2 - D^2}{Dt^2}}$$

Where:

$$Dt^2 = \sum_{i=1}^N (Q_{obs}^i - \bar{Q})^2$$

$$D^2 = \sum_{i=1}^N (Q_{obs}^i - Q_{sim}^i)^2$$

$$\bar{Q} = \frac{\sum_{i=1}^N Q_{obs}^i}{N}$$

The formula can calculate volume Error (VE):

$$VE = \frac{\sum_{i=1}^N Q_{obs}^i - \sum_{i=1}^N Q_{sim}^i}{\sum_{i=1}^N Q_{obs}^i}$$

Where:

- Q_{sim} = simulation discharge of the i period (m³/s)
- Q_{obs} = observation discharge of the i period (m³/s)
- Q̄ = average observation discharge (m³/s)
- N = the amount of data

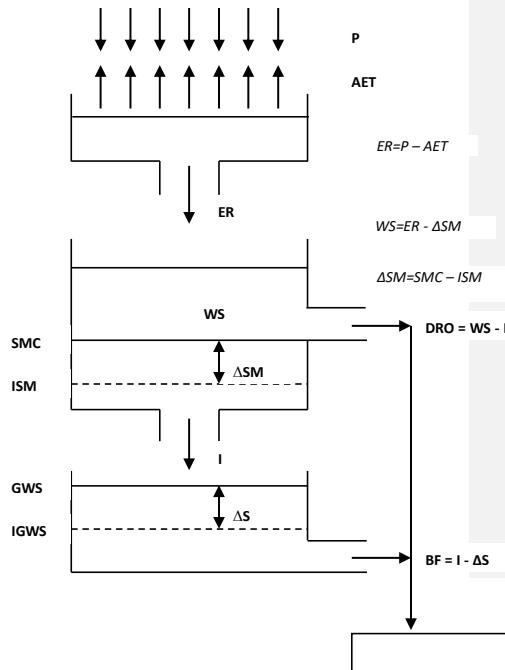
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balance calculations are used to meet irrigation water needs (Ariyani, Putuhena dan Wira, 2020) and urban water needs (Reed, Maidment dan Patoux, 1997).

2.4. Water Quality Measurement

Water quality analysis is needed to get the water quality that suits its needs. There are two regulations used in this study. Government Regulation (PP) No 82 dated December 14, 2001 on Water Quality Management and Water Pollution Control (Pemerintah Republik Indonesia, 2001) dan Minister of Health Regulation enacted on May 31 2017 about Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene, Swimming Pools, Solus Per Aqua, and Public Baths (Menteri Kesehatan Republik Indonesia, 2017).

2.5. Small Reservoir (Embung)

Embung, or what is usually also called a small reservoir, is a construction that is built to withstand the flow of water. This retained water will collect in Embung that can be used as the needs of irrigation water, household water, industrial water, hydroelectric power plants, and others (Arsyad, 2017a). Based on the opinion of one expert, a reservoir is an artificial building that functions to accommodate and store water with a certain small volume capacity, smaller than the capacity of the reservoir/dam (Kodoatie dan Roestam Syarief, 2010). Types of reservoirs are grouped into four types, namely as follows: 1. based on the purpose of construction with reservoirs for residential purposes and multipurpose reservoirs, 2. based on their use as water reservoirs, deflectors, and retainers, 3. Based on their location to the flow of water, reservoirs on watercourses, and reservoirs outside the watercourse, and 4. based on the constituent material, embankment reservoirs and reservoirs of concrete (Soedibyo, 1993; Arsyad, 2017b).

The planning of a water reservoir in Embung is based on the estimation of water availability to ensure water supply every year in both rainy and dry seasons. This includes not only the capacity of the reservoir and the height of the dam in accordance with the availability of water, but also the entire utilization system must be designed based on the needs and benefits, for example, the installed capacity of hydropower, irrigation water distribution systems and so on (Arsyad, 2017c).

3. Research Methodology

3.1. Data

Rainfall analysis is calculated by adding up the daily rainfall per month in one period. The rainfall data used is derived from the Banjarbaru Climatology Station for a period of 20 years (2001 to 2020) (BMKG, 2012). The method used to calculate evapotranspiration is the Penman-Monteith

Figure 1. Mock methods schema (Nurrochmad, Sujono dan Damanjaya, 1998)

2.2. Water Demand

First, as an analysis of water demand, The number of population needs that will be served in accordance with the portion can affect the quantity requirements of urban water demand, which generally people must obtain clean water and drinking water anytime for 24 hours to meet their needs. Water demand can be divided into household and household needs. According to the Directorate General of Cipta Karya (2000) there are 2 (two) standards for water demand, namely: domestic water demand has standards for use in private residences so that daily needs can be met, such as drinking water, cooking, washing, and other household needs and non-domestic water needs are clean water needs that are not household needs. The use in question is commercial, industrial, and general. Household and urban water needs are essential always to be met so that there is no failure to meet water needs which can lead to various kinds of disease outbreaks and unrest in the community. The need for water is correlated with population growth. Population projection is the calculation of the total population with the aim of obtaining past and future information in the context of long-term development planning. Population data is obtained from the census conducted by the Central Statistics Agency of Banjarbaru City and other government departments or institutions. In this study, the population projection calculation used is the geometric method (BPS, 2022b).

$$r = \left(\frac{P_t}{P_0}\right)^{1/t} - 1$$

Where:

- r = Population growth rate
- P_t = population of year t
- P_0 = amount of base population year
- t = time period between the base year and year t (in years)

2.3. Water Balance

A simple water balance analysis is based on a correlation between water availability and water demand in the location (Armstrong dan Johnson, 2018). The water

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- Commented [a17]:** Change with conserve
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FAO-56 method, with climatological data downloaded on the BMKG Online (BMKG, 2012).

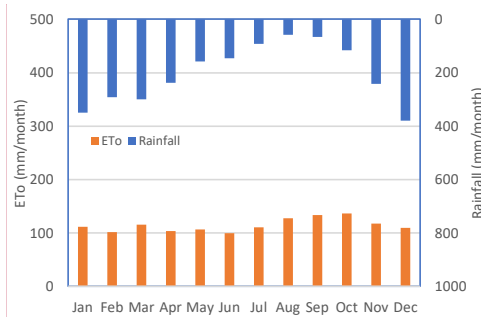


Figure 1. Rainfall and ETo Analysis

From rainfall data from the year 2000 to the year 2020, the average annual rain is 2439.99 mm/year. The yearly average evapotranspiration is 1374.13 mm/year. The lowest rainfall intensity occurred in August at 57.88 mm/month and the highest in December at 379.73 mm/month. The average monthly rainfall data is 203.33 mm/month. The monthly evapotranspiration data from the year 2000 to the year 2020, the highest data in October was 136.72 mm/month, and the lowest evapotranspiration data in June was 99.54 mm/month. The average monthly evapotranspiration data is 114.51 mm/month. Based on rain data and evapotranspiration data, it is determined the availability of water upstream of the reservoir.

Banjarbaru city, with a total area of 305.242 km² divided into five districts, Landasan Ulin, with an area of 74.054 km², Liang Anggang of 74.773 km²; Cempaka of 114.543 km²; North Banjarbaru 26.855 km², and South Banjarbaru 15.027 km² (BPS, 2022b). BPS (Central Bureau of Statistics) Banjarbaru City recorded data from 2013 – 2020. The highest population data is in the Landasan Ulin sub-district as many as 75,385 residents, and the lowest data is in the Cempaka sub-district as many as 35,584 residents (BPS, 2022a). Population growth is one of the effects of moving offices and government centers to Banjarbaru City.

In the South Banjarbaru sub-district, in the year 2013, the population of as many as 46,872 residents. It increases until years 2019, with as many as 67,542 residents but decreases in years 2020 to as many as 45,273 people, as shown in Figure 6. The Population in South Banjarbaru District in 2020 decreased by 32% because, in 2020, there was a Covid-19 pandemic (BPS, 2022b). The population growth rate reached 1.7.

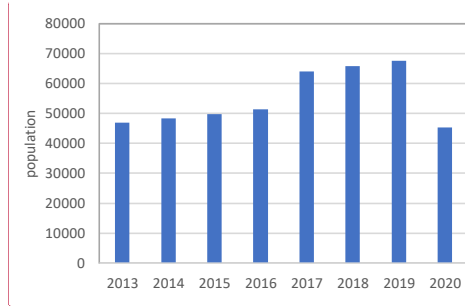


Figure 2. The Population in South Banjarbaru District

3.2. Research Area

The Banjarbaru City area is located at an altitude of 500 m above sea level, with an altitude of 0 – 7 m (33.49%), 7 – 25 m (48.46%), 25 – 100 m (15.15%), 100 – 250 m (2.55%) and 250 – 500 m (0.35%). The slope classification of Banjarbaru City is a slope of 0 – 2% covering 59.35% of the area, a slope of 2 – 8% covering 25.78% of the area, a slope of 8 – 15% covering 12.08% of the area. The rock classification in Banjarbaru City consists of Alluvium 48.44%. In the city of Banjarbaru, there are 3 (three) groups of soil types, namely Podzol soil (63.82%), Lathosol (6.36%), and Organosol (29.82%) (RPIJM, 2015). The South Kalimantan provincial government office building covering an area of 500 hectares in Banjarbaru city can be seen on the map below and is located in the Cempaka sub-district.



Figure 3. Research Study

Embung Kampung Banjar was built in the area of the South Kalimantan provincial government office building in Kampung Banjar village. It is geographically 3°28'27,9" south latitude and 114°49'39" north latitude.

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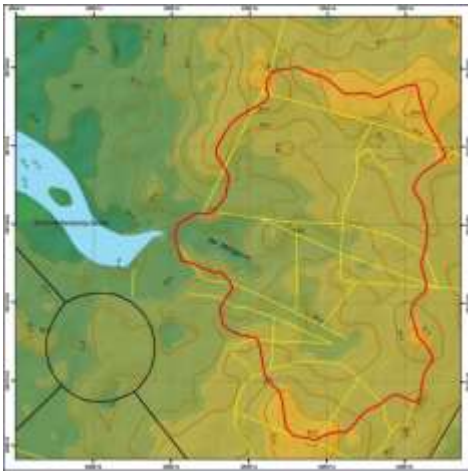


Figure 4. Embung Kampung Banjar

Embung Kampung Banjar has a service area in the part of the sub-district of South Banjarbaru and other sub districts with an area of 21.96 km². Facilities located at the Embung Kampung Banjar service location include water catchment areas, water tourism areas, reservoirs to reduce runoff to Banjarbaru city, watering plants, and water preservation and conservation areas. [The need for water increases with the increase in population.

4. Result

4.1. Water Available Analysis

Water available analysis calculates from the river discharge data of the Riam Kiwa River. The calibration was conducted in 2001 with an area of 382 km² (Novitasari *et al.*, 2021). Based on discharge data observed in 2001, water discharge in other years can be calculated using mock parameters from the Riam Kiwa River. The wet infiltration coefficient is 0.3, the dry infiltration coefficient is 0.4, the initial soil moisture (ISM) is 110 mm, the soil moisture capacity (SMC) is 220 mm, the initial ground water storage (IGWS) is 1000 mm, and groundwater recession Constant (*k*) as 0.810.

The average monthly discharge data for 20 years is presented in Figure 5. The average annual discharge data is presented in Figure 6. The effectiveness of using Riam Kiwa discharge data to determine the calculated discharge with the measured discharge data obtained at the research location is shown in Table 1.

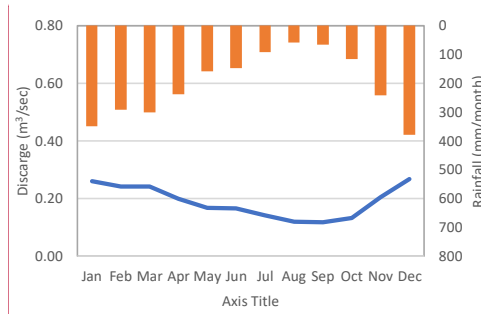


Figure 5. The average monthly discharge data for 20 years

The highest monthly average discharge for 20 years occurred in December at 0.27 m³/second, while the lowest discharge occurred in August and September at 0.12 m³/second. Debit rata-rata bulanan sebesar 0.19 m³/detik.

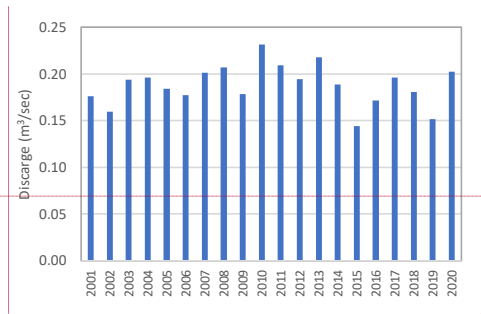


Figure 6. The average annual discharge data

Analysis of annual discharge from 2001 to 2020 found that the highest average annual discharge occurred in 2010 at 0.23 m³/second, and the lowest average annual discharge occurred in 2015 at 0.14 m³/second. The limitations of the discharge measurement data for analysis using the mock model need to be eliminated by measuring the instantaneous discharge at the research site. Measured discharge in upstream Embung (Paring River), Embung Inlet, and Embung outlet in April and May 2021.

Table 1. Data for Measured Discharge of Embung Kampung Banjar

Location	Qobs (2021) (m ³ /s)		Qcal (2021) (m ³ /s)		Qcal mean (m ³ /s)	
	Apr	May	Apr	May	Apr	May
Upstream	0.04	0.04				
Inlet	0.02	0.08	0.08	0.09	0.19	0.15

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Outlet	0.02	0.002				
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The effectiveness is analyzed against the calculated discharge in 2021 and the average annual discharge in April and May. The value of the effectiveness of using the Riam Kiwa River discharge data for the calibration process at the Kampung Banjar Embung is 25% in April 2021 and 88% in May 2021. In April 2021, the effectiveness value was very small because, at the time of measurement, it was a day that rarely rains, starting from the middle of April, causing the measured discharge to be very low.

The mainstay discharge is calculated by sorting the average discharge per year (2001-2020) from the largest value to the smallest value so that the average discharge value is obtained at a probability of 90% for domestic water purposes. The following are the steps for calculating the mainstay discharge.

- The monthly average discharge data is sorted from the largest to the smallest.
- Give a sequence of r from 1 to N where the value of N is 20.
- The probability of the Weibull method, let's say that r is 1
- $$P = \frac{r}{(N+1)} \times 100\% = \frac{1}{(20+1)} \times 100\% = 4,76\% \approx 5\%$$
- Then look for the required mainstay discharge; because the function of the reservoir is of them to meet the needs of r water in the neighborhood of the location, the mainstay discharge used is Q_{90} , specifically for domestic water demand.

The results of the monthly Q_{90} calculation can be seen in the table below.

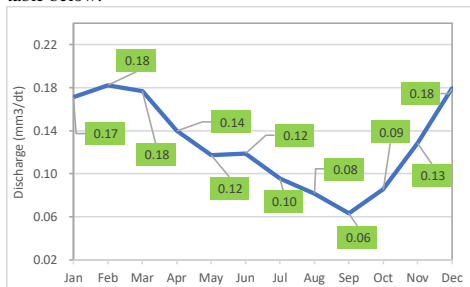


Figure 7. Month Average Water Discharge in 2001-2020

The most reliable discharge for water needs was obtained in February, March, and December with a discharge value of $0.18 \text{ m}^3/\text{s}$ and the smallest occurred in with a discharge value of $0.06 \text{ m}^3/\text{s}$. The availability of water in the Embung Kampung Banjar will be used to fulfill the water demand of the local population, the need for watering plants,

and also the drinking water needs of livestock, especially during the dry season, when very little rain occurs. The reservoir is expected to be fully filled at the end of each rainy season so that it can be used during the dry season.

4.2. Water Demand

The amount of urban water demand according to the density criteria (people per hectare) is taken at 25-35. This is because the Population of Banjarbaru City is 506,884 people with an area of 37,130 Ha, so a population density of > 100 people/ha is obtained. The standard of household water needs is based on the type of city and population. Banjarbaru City is a type of big city whose accuracy criteria are more than 100, and the number of urban water needs taken is 25-35. The standard amount of non-domestic water needed according to the Population of Banjarbaru City is 40.

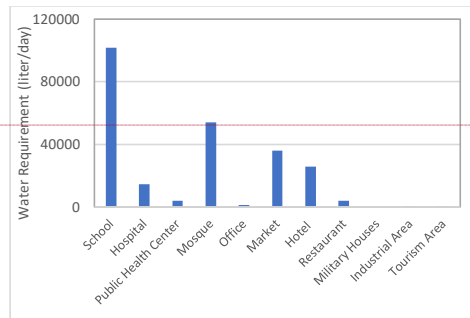


Figure 8. Non-Domestic Water Requirement

In Banjarbaru city, non-domestic water demands include water for public facilities such as schools from kindergarten to college, public and private hospitals, public health centers, mosques, government and non-government offices, traditional markets, hotels, restaurants, military houses, and some tourism area.

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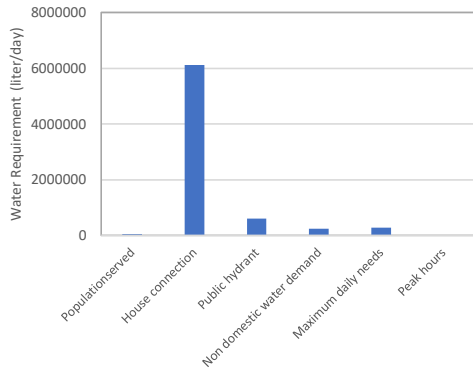


Figure 9. Domestic and Urban Water Requirements

The population served is 45,273 people with a house connection (SR) of 90% times The population served multiplied by 150 liters. The water requirement for a public hydrant (KU) is 90% times the house connection (SR). All water requirement includes domestic and non-domestic water demands, and maximum daily needs in peak hours.

The results of the analysis of water needs, the City of Banjarbaru is included in the category of a large city type with a population of 506,884 people. It can be concluded that the total number of non-domestic water needs in 2020 after the Embung was built was 240,593.4 Liters/day, and the total number of household and urban water needs was 7,289,740 Liters/day. The population reduction that occurred in 2020 in South Banjarbaru District impacts the amount of water demand in the service area.

Long-term development planning by taking into account the population for the next five years, ten years, 15 years, 20 years, and 25 years using the Geometric Method as shown in Figure 7.

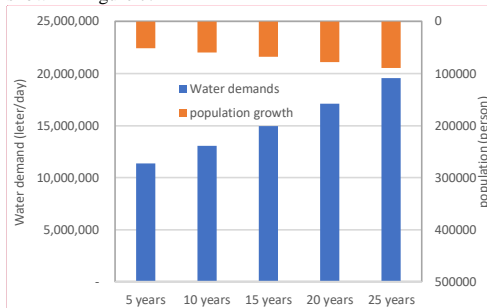


Figure 10. Projection of water demand and population growth after the construction of the Embung

The increase in population is used to calculate population projections for five years, ten years, 15 years, 20 years, and 25 years after 2020. Based on population projection, residents served as many as 88,987 people in the next 25 years. This population projection will be used to calculate the need for domestic and non-domestic water in Banjarbaru city.

The projected total domestic water demand after the construction of the Embung is 7,807,526 liters/day in 5 years, 8,937,414,318 liters/day in 10 years, 10,230,759.48 liters/day for 20 years, 1,1621,681,5 liters/day, and at 25 years as many as 1,3406,046.2 liters/day.

The projection of total household and urban water needs after the construction of the Embung is 11,366.893 liters/day; in 10 years, it is 13,045,123.53 liters/day; in 15 years, it is 14,932,900.78 liters/day; in 20 years as many as 17,093,784.53 liters/day, and at 25 years as many as 19,567,575.3 liters/day.

4.3. Water Balance

Analysis of the water balance that is planned to meet domestic and non-domestic raw water needs is carried out on population data in 2020, at the time of the start of office relocation in Banjarbaru city. The population growth area is taken in South Banjarbaru District. The analysis of water available to fulfill water demand in the service area of embung in 2020 as shown in Figure 11.

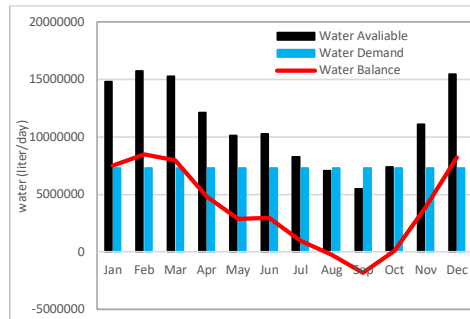


Figure 11. Water Balance Analysis

The water balance obtained by the construction of the Embung Kampung Banjar and the water needs to be obtained a surplus water balance for most of the year, except for August and September. In August has a deficit of water as much as 220,829.51 liter/day, and in September, the deficit as 1,815,842.40 liter/day. The highest deficit value occurred in September. It is necessary to regulate the water resource system to cope with these conditions, given the increase in population after 2020 with the movement of office complexes accompanied by the movement of the provincial capital in 2022. Analysis of water demand is carried out on

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population growth of 5 years, 10 years, 15 years, 20 years, and 25 years as shown in Figure 12.

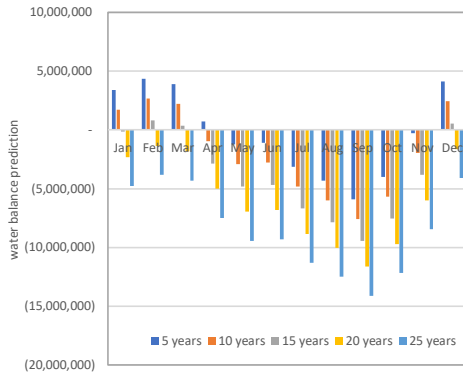


Figure 12. Water Balance for projected to meet water demand

Based on the current water availability data, it is projected to meet water demand for the 5 years, 10 years, 15 years, and 20 years to 25 years projections. It can be seen that

No.	Parameter	Unit	Max rate allowed	Inlet	Outlet	Embung	Paring River
A. Physical							
1	Turbidity	Scal a NTU	25	0.73	0.93	1.03	0
2	Water temperature	-C	air temperature ± 3 °C	30.51	30.34	30.22	29.46
B. chemical							
1	Ph	Mg/L	6,5-9,0	6.77	7.16	7.06	6.4
2	Total Dissolved Solid (TDS)	Mg/L	1500	0.007	0.002	0.002	0.007

water available only can fulfill the water needs in five years projections in January, February, March, April, and December. The deficit of water from May to November. The water deficit occurs throughout the year to meet water needs for population projections for 20 years and 25 years.

4.4. Water Quality Analysis

Water quality testing at the Embung Kampung Banjar took four samples in the Embung service area, namely Inlet, Outlet, and Paring River. The tool used in this test is U-50 HORIBA (multi-water quality checker). This test is to

determine the parameters contained in the water sample. The test is carried out by dipping the U-50 HORIBA (multi-water quality checker) tool into a water sample from which water quality data will be taken.

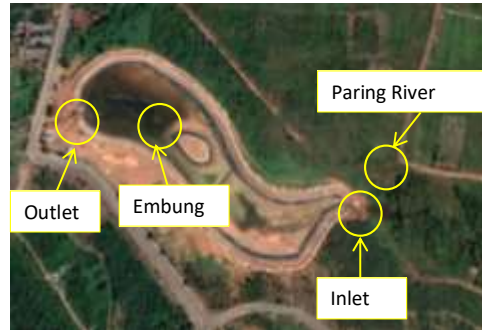


Figure 14. Location of Water Quality Sampling Data

Water quality testing consists of physical, chemical, and biological tests. Based on the tools available at the Hydraulic Laboratory, Faculty of Engineering, Lambung Mangkurat University, the only tests that can be done are physical and chemical tests. The measured water quality includes physical and chemical quality, which consists of water turbidity measurement, water temperature, degree of acidity of the water (pH), and total Dissolved Solid (TDS).

Table 2. Water Quality Sampling Data

In the physical test, the results obtained from the U-50 HORIBA (multi-water quality checker) tool get turbidity and temperature parameters, while for chemical testing, the results obtained are Ph and Total Dissolved Solid (TDS). From the physical and chemical tests, the parameters of the four samples met the maximum allowable levels. Based on direct observation, it was also found that the water entering and leaving the reservoir was tasteless, odorless, and colorless.

Water sampling for 4 locations consisted of an inlet for the first sample, an outlet for the second sample, an Embung for the third location, and the paring river for the fourth sample. Based on the test at the 4 locations, it can be taken from the data that the water quality in the service area of the Embung Kampung Banjar meets the class D water standard. Water turbidity less than 25 NTU. Water temperature based on air temperature ± 3 °C, the average maximum air temperature for the last 5 years is 32.27°C. The degree of acidity of the water (pH) is around 7. TSD less than 1500 Mg/l. It can be used for agriculture, urban businesses, industry, and hydroelectric power plants that can be used by the community around Banjarbaru District.

5. Discussion

5.1. Water balance as water resource management

Water balance in the unit of South Kalimantan Province Offices based on water available in upstream Embung in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after Embung construction is still quite adequate as much as 45,611,711.64 liter/day. The construction of the Embung Kampung Banjar is a good solution to overcoming the current problems of water resource management in Banjarbaru City as the new capital city of South Kalimantan province.

A well-managed reservoir can be used as a water provider to cover water needs in the dry season from water stored in the rainy season. The average annual rain that occurs based on observations at the Banjarbaru climatology station is around 2439.99 mm/year for 20 years, so it has the potential to be captured and utilized. Embung Kampung Banjar is the solution for current water needs. However, in the future, with the increase in population, it is necessary to build other reservoirs or other water source supplies in the South Kalimantan government office.

5.2. Water resources management as water conservation and tourism

The Banjarbaru City Government's planning during the construction of the Embung Kampung Banjar was to function as water conservation as an Embung for groundwater storage, watering plants, and water tourism. Embung also uses to reduce water runoff to Banjarbaru city and water plants. The Banjarbaru city government's planning was in accordance with the conditions when direct observations were made in the field.

Until now, water available needed to fulfill the need for clean water in the service area, namely South Banjarbaru District; it is still served by PDAM Intan Banjar. So the building of Embung still functions more as water conservation for groundwater storage and tourism with the jogging tracks around Embung. In addition to the need for rainwater storage during the rainy season, there is also a need for infiltration areas that are used to replace lands that have changed functions into office areas that are massively closed, and covering an area of 500 ha, it is necessary to take into account how much water runs over the surface considering that Banjarbaru city is a city with a clay soil structure, so it is an area that really needs good groundwater infiltration, considering that the groundwater level in Banjarbaru City is quite deep.

6. Conclusion and Implication

6.1. Conclusion

The conclusions obtained from this research on a simple method of water balance analysis to predict the performance of water resource management in the unit of South Kalimantan province offices based on water available in upstream Embung in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after Embung construction is still quite adequate as much as 45,611,711.64 liter/day. Although until now, PDAM Intan Banjar still provides sufficient water to meet water needs in the service area.

The construction of the reservoir is one of the methods applied by the South Kalimantan provincial government in managing water resources for conservation in the future. In order to increase the population in the future, it is necessary to think about other water sources to meet the water needs caused by population growth.

6.2. Future Research

This research had a small scope of the area of water resources management in the new unit of government offices, with an area of 500 ha. Changes in land use covering an area of 500 ha also need to be considered regarding groundwater storage in the future and the effect of land erosion that can occur, considering that Banjarbaru City is a city with varying land heights.

In general, the relocation of the provincial capital will also cause the transfer of public facilities and other activities. It means needed more water resources management in the future on a larger scale.

Acknowledgments

This present study was completed with partial funding from University Lambung Mangkurat through — Lecturer Compulsory Research Program with contract Number **024.64/UN8.2/PL/2022**. We also acknowledge the Hydraulic Laboratory, Faculty of Engineering, Lambung Mangkurat University.

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A Simple Method of Water Balance Analysis to Predict the Performance of Water Resource Management in the Unit of South Kalimantan Province Offices

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ABSTRACT

Banjarbaru city was legally established as the capital city of Kalimantan Selatan province, and it needed a new unit of government offices. In the new unit offices of 500 ha, the government built not only office facilities but also a small reservoir or *Embung*. This study aims to analyze the availability of water upstream of the *Embung* that can be provided to fulfill urban water demand in the service area with a simple method of water balance. The conclusions obtained from this research on a simple method of water balance analysis to predict the performance of water resource management in the unit of South Kalimantan province offices based on water available in upstream *Embung* in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after *Embung* construction is still quite adequate as much as 45,611,711.64 liter/day. Although until now, PDAM Intan Banjar still provides sufficient water to meet water needs in the service area. The construction of the reservoir is one of the methods applied by the South Kalimantan provincial government in managing water resources for conservation in the future. With the increase in the population in the future, it is necessary to think about other water sources to meet the water needs caused by due to population growth.

Keywords: water availability, water demand, water balance, water resources management, government official offices, South Kalimantan

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1. Introduction

Banjarbaru city was legally established as the capital city of Kalimantan Selatan province and started on March 16, 2022. It was lawfully validated with Undang-Undang Nomor 8 in 2022 on March 16, 2022 (Undang-Undang RI, 2022). The relocation of the provincial capital has begun with the transfer of government official offices. The South Kalimantan Provincial Government office area is an integrated office area where the spatial layout in it requires various supporting facilities, one of which is an area that can be used as a water catchment area to accommodate/reduce surface runoff leading to Banjarbaru City. The South Kalimantan Provincial Government office area built in 2011, which began with the transfer of the South Kalimantan Provincial Government Offices, which will be occupied by the governor and deputy governor, began to move from the City of Banjarmasin to the City of Banjarbaru in August 2011. Then gradually continued with other offices within the provincial government of South Kalimantan. The official

office area of South Kalimantan Province was built on a land area of about 500 hectares, with a total land prepared by the Banjarbaru City Government reaching 2,000 hectares (Gunawan, 2018). The office development program and regional arrangement in an area of 500 hectares will continue to be carried out in stages until 2025.

Changes in land use covering an area of 500 ha and increasing population growth as 2.43% (BPS, 2022b) in Banjarbaru City lead to an increase in the need for clean water and an increase in the need for water resource management. Water resources are predicted to experience a crisis threat in 2025 in the city of Banjarbaru, along with the development of tourism and population growth of 1.9% annually, which can be accelerated by industrial activities. Extensive industrial and tourism activities will significantly accelerate the depletion of water supply and increase water demand, based on the calculation results of large-scale companies, will accelerate the shortage of water supply for the next ten years (Jarwanto Jarwanto, 2022). Until now, Banjarbaru City has had a reasonably low intensity of land

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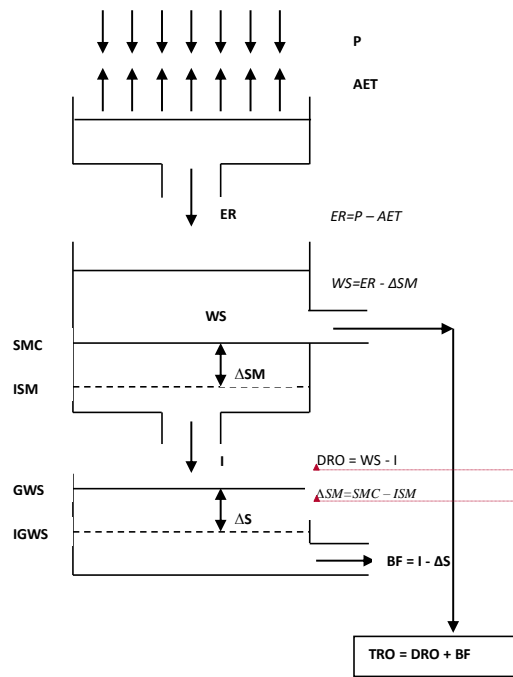


Figure 1. Mock methods schema (Nurrochmad, Sujono and Damanjaya, 1998)

2.2. Water Demand

First, as an analysis of water demand, The number of population needs that will be served in accordance with the portion can affect the quantity requirements of urban water demand, which generally people must obtain clean water and drinking water anytime for 24 hours to meet their needs. Water demand can be divided into household and household needs demand. According to the Directorate General of Cipta Karya (2000) there are 2 (two) standards for water demand, namely: 4 The domestic water demand has standards for use in private residences so that daily needs can be met, such as drinking water, cooking, washing. The and other household needs demand and non-domestic water needs demand are clean water needs demand that are not household

needs demand. The use in non-domestic question is commercial, industrial, and general. Household and urban water needs demands are essential always to be met so that there is no failure unsuccessful to meet fulfill water needs demand which can lead to various kinds of disease outbreaks and unrest in the community. The need for waterwater demand is correlated with population growth. Population projection is the calculation of the total population with the aim of obtaining past and future information in the context of long-term development planning. Population data is obtained from the census conducted by the Central Statistics Agency of Banjarbaru City and other government departments or institutions. In this study, the population projection calculation used is the geometric method (BPS, 2022b).

$$r = \left(\frac{P_t}{P_0} \right)^{1/t} - 1$$

Where:

- r = Population growth rate
- P_t = population of year t
- P_0 = amount of base population year
- t = time period between the base year and year t (in years)

2.3. Water Balance

A simple water balance analysis is based on a correlation between water availability and water demand in the location (Armstrong and Johnson, 2018). The water balance calculations are used to meet irrigation water needs demand (Ariyani, Putuhena and Wira, 2020) and urban water needs demand (Reed, Maidment and Patoux, 1997). The water balance is also used to calculate reservoir capacity (Brust et al., 2018).

2.4. Water Quality Measurement

Water quality analysis is needed to get the water quality that suits its needs. There are two regulations used in this study. Government Regulation (PP) No 82 dated December 14, 2001 on Water Quality Management and Water Pollution Control (Pemerintah Republik Indonesia, 2001) dan Minister of Health Regulation enacted on May 31 2017 about Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene, Swimming Pools, Solus Per Aqua, and Public Baths (Menteri Kesehatan Republik Indonesia, 2017).

2.5. Small Reservoir (Embung)

Embung, or what is usually also called a small reservoir, is a construction that is built to withstand conserve the flow of water. This retained water will collect in Embung that can be used as the needs demand for irrigation water, household water, industrial water, hydroelectric power plants, and others (Arsyad, 2017a). Based on the opinion of

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one expert, a reservoir is an artificial building that functions to accommodate and store water with a certain small volume capacity, smaller than the capacity of the reservoir/dam (Kodoatie and Roestam Syarief, 2010). Types of reservoirs are grouped into four types, namely as follows: 1. based on the purpose of construction with reservoirs for residential purposes and multipurpose reservoirs, 2. based on their use as water reservoirs, deflectors, and retainers, 3. Based on their location to the flow of water, reservoirs on watercourses, and reservoirs outside the watercourse, and 4. based on the constituent material, embankment reservoirs and reservoirs of concrete (Soedibyo, 1993; Arsyad, 2017b).

The planning of a water reservoir in *Embung* is based on the estimation of water availability to ensure water supply every year in both rainy and dry seasons. This includes not only the capacity of the reservoir and the height of the dam in accordance with the availability of water, but also the entire utilization system must be designed based on the needs and benefits, for example, the installed capacity of hydropower, irrigation water distribution systems and so on (Arsyad, 2017c).

3. Research Methodology

3.1. Data

Rainfall analysis is calculated by adding up the daily rainfall per month in one period. The rainfall data used is derived from the Banjarbaru Climatology Station for a period of 20 years (2001 to 2020) (BMKG, 2022). The method used to calculate evapotranspiration is the Penman-Monteith FAO-56 method, with climatological data downloaded on the BMKG Online (BMKG, 2022).

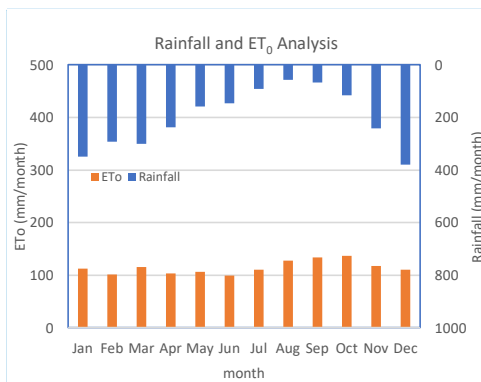


Figure 1. Rainfall and *ET₀* Analysis

From rainfall data from the year 2000 to the year 2020, the average annual rain is 2439.99 mm/year. The yearly average evapotranspiration is 1374.13 mm/year. The lowest rainfall intensity occurred in August at 57.88 mm/month and the highest in December at 379.73 mm/month. The average monthly rainfall data is 203.33 mm/month. The monthly evapotranspiration data from the year 2000 to the year 2020, the highest data in October was 136.72 mm/month, and the lowest evapotranspiration data in June was 99.54 mm/month. The average monthly evapotranspiration data is 114.51 mm/month. Based on rain data and evapotranspiration data, it is determined the availability of water upstream of the reservoir.

Banjarbaru city, with a total area of 305.242 km² divided into five districts, Landasan Ulin, with an area of 74.054 km², Liang Anggang of 74.773 km²; Cempaka of 114.543 km²; North Banjarbaru 26.855 km², and South Banjarbaru 15.027 km² (BPS, 2022b). BPS (Central Bureau of Statistics) Banjarbaru City recorded data from 2013 – 2020. The highest population data is in the Landasan Ulin sub-district as many as 75,385 residents, and the lowest data is in the Cempaka sub-district as many as 35,584 residents (BPS, 2022a). Population growth is one of the effects of moving offices and government centers to Banjarbaru City.

In the South Banjarbaru sub-district, in the year 2013, the population of as many as 46,872 residents. It increases until years 2019, with as many as 67,542 residents but decreases in years 2020 to as many as 45,273 people, as shown in Figure 6. The Population in South Banjarbaru District in 2020 decreased by 32% because, in 2020, there was a Covid-19 pandemic (BPS, 2022b). The population growth rate reached 1.7.

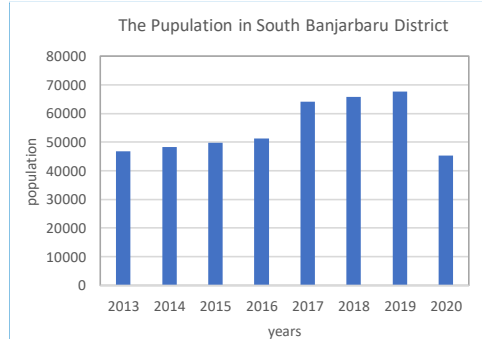


Figure 2. The Population in South Banjarbaru District

3.2. Research Area

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The Banjarbaru City area is located at an altitude of 500 m above sea level, with an altitude of 0 – 7 m (33.49%), 7 – 25 m (48.46%), 25 – 100 m (15.15%), 100 – 250 m (2.55%) and 250 – 500 m (0.35%) (BPS, 2022b). The slope classification of Banjarbaru City is a slope of 0 – 2% covering 59.35% of the area, a slope of 2 – 8% covering 25.78% of the area, a slope of 8 – 15% covering 12.08% of the area. The rock classification in Banjarbaru City consists of Alluvium 48.44%. In the city of Banjarbaru, there are 3 (three) groups of soil types, namely Podzol soil (63.82%), Lathosol (6.36%), and Organosol (29.82%) (RPIJM, 2015). The South Kalimantan provincial government office building covering an area of 500 hectares in Banjarbaru city can be seen on the map below and is located in the Cempaka sub-district.



Figure 3. Research Study

The *Embung Kampung Banjar* was built in the area of the South Kalimantan provincial government office building in Kampung Banjar village. It is geographically 3° 28'27,9" south latitude and 114°49'39" north latitude (Gunawan, 2018).

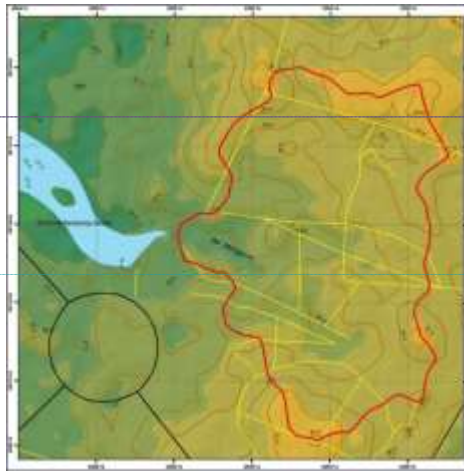


Figure 4. *The Embung Kampung Banjar*

The *Embung Kampung Banjar* has a service area in the part of the sub-district of South Banjarbaru and other sub districts with an area of 21.96 km². Facilities located at the *Embung Kampung Banjar* service location include water catchment areas, water tourism areas, reservoirs to reduce runoff to Banjarbaru city, watering plants, and water preservation and conservation areas. The need for water demand has increased increases with the increase in population.

4. Result

4.1. Water Available Analysis

Water available analysis calculates from the river discharge data of the Riam Kiwa River. The calibration was conducted in 2001 with an area of 382 km² (Novitasari *et al.*, 2021). Based on discharge data observed in 2001, water discharge in other years can be calculated using mock parameters from the Riam Kiwa River. The wet infiltration coefficient is 0.3, the dry infiltration coefficient is 0.4, the initial soil moisture (ISM) is 110 mm, the soil moisture capacity (SMC) is 220 mm, the initial ground water storage (IGWS) is 1000 mm, and groundwater recession Constant (*k*) as 0.810.

The average monthly discharge data for 20 years is presented in Figure 5. The average annual discharge data is presented in Figure 6. The effectiveness of using Riam Kiwa discharge data to determine the calculated discharge with the measured discharge data obtained at the research location is shown in Table 1.

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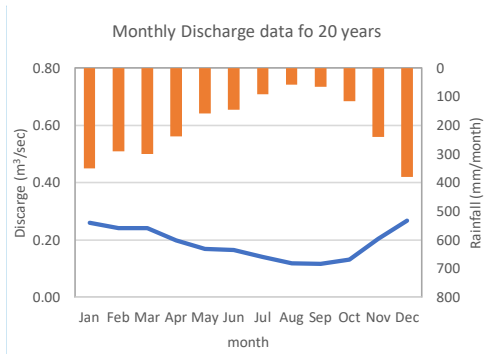


Figure 5. The average monthly discharge data for 20 years

The highest monthly average discharge for 20 years occurred in December at 0.27 m³/second, while the lowest discharge occurred in August and September at 0.12 m³/second. Debit rata-rata bulanan sebesar 0.19 m³/detik.

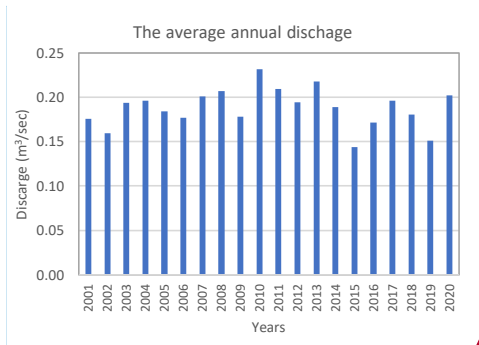


Figure 6. The average annual discharge data

Analysis of annual discharge from 2001 to 2020 found that the highest average annual discharge occurred in 2010 at 0.23 m³/second, and the lowest average annual discharge occurred in 2015 at 0.14 m³/second. The limitations of the discharge measurement data for analysis using the mock model need to be eliminated by measuring the instantaneous discharge at the research site. Measured discharge in upstream *Embung* (Paring River), *Embung* Inlet, and *Embung* outlet in April and May 2021.

Table 1. Data for Measured Discharge of *Embung* Kampung Banjar

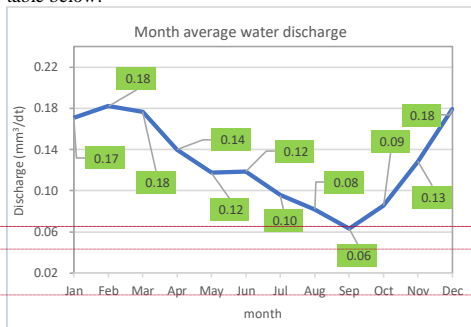
Location	Qobs (2021) (m ³ /s)		Qcal (2021) (m ³ /s)		Qcal mean (m ³ /s)	
	Apr	May	Apr	May	Apr	May
Upstream	0.04	0.04	0.08	0.09	0.19	0.15
Inlet	0.02	0.08				
Outlet	0.02	0.002				

The effectiveness is analyzed against the calculated discharge in 2021 and the average annual discharge in April and May. The value of the effectiveness of using the Riam Kiwa River discharge data for the calibration process at the *Embung Kampung Banjar* *Embung* is 25% in April 2021 and 88% in May 2021. In April 2021, the effectiveness value was very small because, at the time of measurement, it was a day that rarely rains, starting from the middle of April, causing the measured discharge to be very low.

The mainstay discharge is calculated by sorting the average discharge per year (2001-2020) from the largest value to the smallest value so that the average discharge value is obtained at a probability of 90% for domestic water purposes. The following are the steps for calculating the mainstay discharge.

- The monthly average discharge data is sorted from the largest to the smallest.
- Give a sequence of r from 1 to N where the value of N is 20.
- The probability of the Weibull method, let's say that r is 1
- $$P = \frac{r}{(N+1)} \times 100\% = \frac{1}{(20+1)} \times 100\% = 4,76\% \approx 5\%$$
- Then look for the required mainstay discharge; because the function of the reservoir is of them to meet the needs of r water in the neighborhood of the location, the mainstay discharge used is Q_{90} , specifically for domestic water demand.

The results of the monthly Q_{90} calculation can be seen in the table below.



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Figure 7. Month Average Water Discharge in 2001-2020

The most reliable discharge for water ~~needs-demand~~ was obtained in February, March, and December with a discharge value of 0.18 m³/s and the smallest occurred in with a discharge value of 0.06 m³/s. The availability of water in the *Embung Kampung Banjar* will be used to fulfill the water demand of the local population, the need for watering plants, and also the drinking water ~~needs-demand~~ of livestock, especially during the dry season, when very little rain occurs. The reservoir is expected to be fully filled at the end of each rainy season so that it can be used during the dry season.

4.2. Water Demand

The amount of urban water demand according to the density criteria (people per hectare) is taken at 25-35. This is because the Population of Banjarbaru City is 506,884 people with an area of 37,130 Ha, so a population density of > 100 people/ha is obtained. The standard of household water ~~needs-demand~~ is based on the type of city and population. Banjarbaru City is a type of big city whose accuracy criteria are more than 100, and the number of urban water ~~needs-demand~~ taken is 25-35. The standard amount of non-domestic water ~~needed-demand~~ according to the Population of Banjarbaru City is 40.

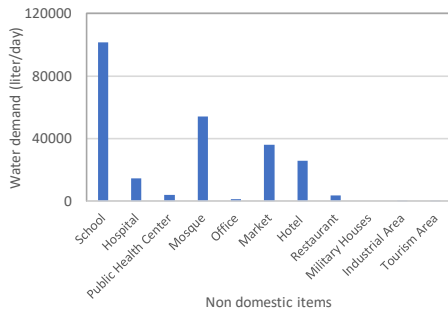


Figure 8. Non-Domestic Water ~~RequirementDemand~~

In Banjarbaru city, non-domestic water demands include water for public facilities such as schools from kindergarten to college, public and private hospitals, public health centers, mosques, government and non-government offices, traditional markets, hotels, restaurants, military houses, and some tourism area.

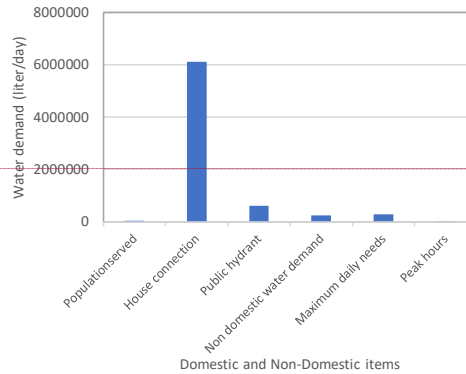


Figure 9. Domestic and Urban Water ~~RequirementsDemand~~

The population served is 45,273 people with a house connection (SR) of 90% times ~~The-the~~ population served multiplied by 150 liters. The water requirement for a public hydrant (KU) is 90% times the house connection (SR). All water requirement includes domestic and non-domestic water demands, and maximum daily needs in peak hours.

The results of the analysis of water ~~needsdemand~~, the City of Banjarbaru is included in the category of a large city type with a population of 506,884 people. It can be concluded that the total number of non-domestic water ~~needs-demand~~ in 2020 after the *Embung* was built was 240,593.4 Liters/day, and the total number of household and urban water ~~needs-demand~~ was 7,289,740 Liters/day. The population reduction that occurred in 2020 in South Banjarbaru District impacts the amount of water demand in the service area.

Long-term development planning by taking into account the population for the next five years, ten years, 15 years, 20 years, and 25 years using the Geometric Method as shown in Figure 7.

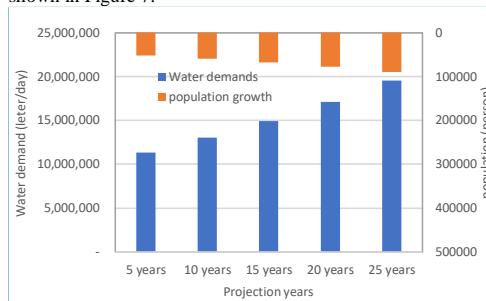


Figure 10. Projection of water demand and population growth after the construction of the *Embung*

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The increase in population is used to calculate population projections for five years, ten years, 15 years, 20 years, and 25 years after 2020. Based on population projection, residents served as many as 88,987 people in the next 25 years. This population projection will be used to calculate the need for domestic and non-domestic water in Banjarbaru city.

The projected total domestic water demand after the construction of the Embung is 7,807,526 liters/day in 5 years, 8,937,414,318 liters/day in 10 years, 10,230,759.48 liters/day for 20 years, 1,1621,681,5 liters/day, and at 25 years as many as 1,3406,046.2 liters/day.

The projection of total household and urban water needs-demand after the construction of the Embung is 11,366.893 liters/day; in 10 years, it is 13,045,123.53 liters/day; in 15 years, it is 14,932,900.78 liters/day; in 20 years as many as 17,093,784.53 liters/day, and at 25 years as many as 19,567,575.3 liters/day.

4.3. Water Balance

Analysis of the water balance that is planned to meet domestic and non-domestic raw water needs-demand is carried out on population data in 2020, at the time of the start of office relocation in Banjarbaru city. The population growth area is taken in South Banjarbaru District. The analysis of water available to fulfill water demand in the service area of embung-Embung in 2020 as shown in Figure 11.

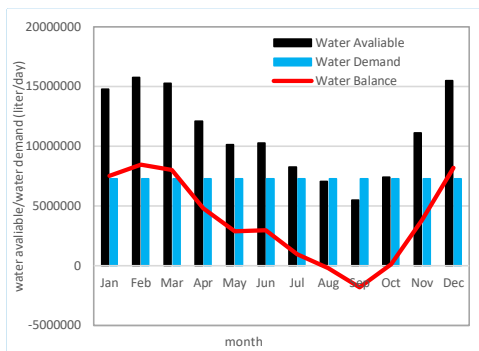


Figure 11. Water Balance Analysis

The water balance obtained by the construction of the Embung Kampung Banjar and the water needs-demand to be obtained a surplus water balance for most of the year, except for August and September. In August has a deficit of water as much as 220,829.51 liter/day, and in September, the deficit as 1,815,842.40 liter/day. The highest deficit value occurred in September. It is necessary to regulate the water

resource system to cope with these conditions, given the increase in population after 2020 with the movement of office complexes accompanied by the movement of the provincial capital in 2022. Analysis of water demand is carried out on population growth of 5 years, 10 years, 15 years, 20 years, and 25 years as shown in Figure 12.

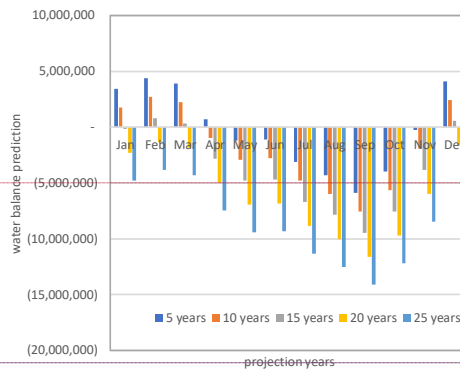


Figure 12. Water Balance for projected to meet water demand

Based on the current water availability data, it is projected to meet water demand for the 5 years, 10 years, 15 years, and 20 years to 25 years projections. It can be seen that water available only can fulfill the water needs-demand in five years projections in January, February, March, April, and December. The deficit of water from May to November. The water deficit occurs throughout the year to meet water needs-demand for population projections for 20 years and 25 years.

4.4. Water Quality Analysis

Water quality testing at the Embung Kampung Banjar took four samples in the Embung service area, namely Inlet, Outlet, and Paring River. The tool used in this test is U-50 HORIBA (multi-water quality checker). This test is to determine the parameters contained in the water sample. The test is carried out by dipping the U-50 HORIBA (multi-water quality checker) tool into a water sample from which water quality data will be taken.

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No	Parameter	Unit	Max rate allowed	Inlet	Outlet	Em-bung	Parin-g
-	Paring River						
1	Physical Turbidity	South NTU	25	0.73	0.93	1.03	0
-	Water Temperature	air ratur °C	-	30.5 1	30.24	30.2 2	29.46
-	chemical	-	-	-	-	-	-
1	Ph	Mg/ L	6.5-9.0	6.77	7.16	7.06	6.4
2	Total Dissolved Solid (TDS)	Mg/ L	1500	0.00 7	0.002	0.00 2	0.007



Figure 14. Location of Water Quality Sampling Data

Water quality testing consists of physical, chemical, and biological tests. Based on the tools available at the Hydraulic Laboratory, Faculty of Engineering, Lambung Mangkurat University, the only tests that can be done are physical and chemical tests. The measured water quality includes physical and chemical quality, which consists of water turbidity measurement, water temperature, degree of acidity of the water (pH), and total Dissolved Solid (TDS).

In the physical test, the results obtained from the U-50 HORIBA (multi-water quality checker) tool get turbidity and temperature parameters, while for chemical testing, the results obtained are Ph and Total Dissolved Solid (TDS). From the physical and chemical tests, the parameters of the four samples met the maximum allowable levels. Based on direct observation, it was also found that the water entering and leaving the reservoir was tasteless, odorless, and colorless.

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Water sampling for 4 locations consisted of an inlet for the first sample, an outlet for the second sample, an Embung for the third location, and the paring river for the fourth sample. Based on the test at the 4 locations, it can be taken from the data that the water quality in the service area of the Embung Kampung Banjar meets the class D water standard. Water turbidity less than 25 NTU. Water temperature based on air temperature ± 3 °C. the average maximum air temperature for the last 5 years is 32.27°C. The degree of acidity of the water (pH) is around 7. TSD less than 1500 Mg/l. It can be used for agriculture, urban businesses, industry, and hydroelectric power plants that can be used by the community around Banjarbaru District.

5. Discussion

5.1. Water balance as water resource management

Water balance in the unit of South Kalimantan Province Offices based on water available in upstream Embung in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after Embung construction is still quite adequate as much as 45,611,711.64 liter/day. The construction of the Embung Kampung Banjar is a good solution to overcoming the current problems of water resource management in Banjarbaru City as the new capital city of South Kalimantan province.

A well-managed reservoir can be used as a water provider to cover water needs-demand in the dry season from water stored in the rainy season. The average annual rain that occurs based on observations at the Banjarbaru climatology

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station is around 2439.99 mm/year for 20 years, so it has the potential to be captured and utilized. The *Embung Kampung Banjar* is the solution for current water ~~needs~~**demand**. However, in the future, with the increase in population, it is necessary to build other reservoirs or other water source supplies in the South Kalimantan government office.

5.2. Water resources management as water conservation and tourism

The Banjarbaru City Government's planning during the construction of the Embung Kampung Banjar was to function as water conservation as an Embung for groundwater storage, watering plants, and water tourism. Embung also uses to reduce water runoff to Banjarbaru city and water plants. The Banjarbaru city government's planning was in accordance with the conditions when direct observations were made in the field.

Until now, water available needed to fulfill the need for clean water in the service area, namely South Banjarbaru District; it is still served by PDAM Intan Banjar. So the building of Embung still functions more as water conservation for groundwater storage and tourism with the jogging tracks around Embung. In addition to the need for rainwater storage during the rainy season, there is also a need for infiltration areas that are used to replace lands that have changed functions into office areas that are massively closed, and covering an area of 500 ha, it is necessary to take into account how much water runs over the surface considering that Banjarbaru city is a city with a clay soil structure, so it is an area that really needs good groundwater infiltration, considering that the groundwater level in Banjarbaru City is quite deep.

6. Conclusion and Implication

6.1. Conclusion

The conclusions obtained from this research on a simple method of water balance analysis to predict the performance of water resource management in the unit of South Kalimantan province offices based on water available in upstream *Embung* in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after Embung construction is still quite adequate as much as 45,611,711.64 liter/day. Although until now, PDAM *Intan Banjar* still provides sufficient water to meet water ~~needs~~**demand** in the service area.

The construction of the reservoir is one of the methods applied by the South Kalimantan provincial government in managing water resources for conservation in the future. In order to increase the population in the future, it is necessary to think about other water sources to meet the water ~~needs~~**demand** caused by population growth.

6.2. Future Research

This research had a small scope of the area of water resources management in the new unit of government offices, with an area of 500 ha. Changes in land use covering an area of 500 ha also need to be considered regarding groundwater storage in the future and the effect of land erosion that can occur, considering that Banjarbaru City is a city with varying land heights.

In general, the relocation of the provincial capital will also cause the transfer of public facilities and other activities. It means needed more water resources management in the future on a larger scale.

Acknowledgments

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RPHM (2015) *RPIJM Kota Banjarbaru 2016-2021*.

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Waligórski, B. *et al.* (2020) "The water balance in a dam reservoir—a case study of the przebédowo reservoir," *Rocznik Ochrona Srodowiska*, 22(1), pp. 324–346.

Submissions

A Simple Method of Water Balance Analysis to Predict the Performance of Water Resource Management in the Unit of South Kalimantan Province Offices

Novitasari Novitasari, Holdani Kurd...

Submission

Review

Copyediting

Production

Round 1

Round 2

Round 2 Status


Submission accepted.

Notifications

[tljes] Editor Decision	2022-11-21 12:30 AM
[tljes] Editor Decision	2022-11-29 11:58 PM
[tljes] Editor Decision	2023-05-02 01:30 AM
[tljes] Editor Decision	2023-05-08 06:40 AM

Reviewer's Attachments

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 130-1 , 35-Article Text-129-1-4-20221122_Rev2.docx	November 29, 2022
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▶	 131-1	Article Text, A-35-Article Text-129-1-4-20221122_Rev2_Autor.docx	December 1, 2022	Article Text
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Review Discussions

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<i>No Items</i>				

Platform & workflow by
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novitasari ST.,MT. <novitasari.st.mt@gmail.com>

[tljes] Editor Decision

Edio da Costa <ediocosta@tljes.org>

21 November 2022 pukul 08.30

Kepada: Novitasari Novitasari <novitasari.st.mt@gmail.com>, Holdani Kurdi <holdani.kurdi@ulm.ac.id>

Dear Novitasari Novitasari, Holdani Kurdi:

We have reached a decision regarding your submission to Timor-Leste Journal of Engineering and Science, "A Simple Method of Water Balance Analysis to Predict the Performance of Water Resource Management in the Unit of South Kalimantan Province Offices : -".

Our decision is to: Resubmit for Review

Dr. Edio da Costa, BSc., MCs.

Managing Editor, Timor-Leste Journal of Business and Management (TLJBM)

E-mail: tljbm@gmail.com/ediocosta73@gmail.com

Mobile: +670 77990019

Reviewer A:Recommendation: Revisions Required

Does the title of the article short, clear, and reflect the overall content?

The article is sufficient and reflect the overall content

Does the abstract of the articles clearly summarise the overall content of the research?

The Abstract is clearly. Need to correction some phrase

Does the article provide scientific and practical justification of the research?

The article is provide scientific and practical justification

Does the article formulate clear problem statement and objectives of the research?

The article have clear problem statement

Does the article adequately and soundly provide and review relevant literatures, conceptual frameworks and hypothesis?

The article need to provide some last research/study to reinforced the Theory and concept. The literature review need to add some reference from other research in other nation yhan from Indonesia.

Does the article clearly outline research method, and data collection techniques?

Have clear outline research method and data collection techniques

Can You easily identify the manuscript statement?

Have clear manuscript statement

Does the article present results and discussions according to the objectives of the research?

The article has provided the result and discussion based on the objectives of research.

Does the article provide sound conclusions and implications of the research findings?

The article have the sufficient conclusion and provide the implication

Does the article state its research limitation?

There have a research limitation and give the opportunity for the future research

What is the greatest strength of this piece of writing?

The article provide the scientific information about the balance of water demand and water availability to solve the problem of water deficit. With some method and analysis, show the resut of water balance in the study area.

Does the distracting grammar, punctuation, spelling, or word usage problems?

The article have the limitation of grammar and word usage problem. Some phrase need to be change/revise to make it simple and easy to understand.


Does the article provide sound conclusions and implications of the research findings?

The article have a sufficient conclusion and implication in order to answer the research finding

Does the article provide good source of quotations and bibliography?

Majority of reference is from Indonesia. Need to revise and adding some reference from othe nation to increase the knowledge, novelty and reference.

[Timor-Leste Journal of Engineering and Science](#)

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novitasari ST.,MT. <novitasari.st.mt@gmail.com>

[tljes] Editor Decision

novitasari ST.,MT. <novitasari.st.mt@gmail.com>
Kepada: Edio da Costa <ediocosta@tljes.org>

22 November 2022 pukul 08.33

Dear Dr. Edio da Costa, BSc., MCs.

We are grateful for the review of the manuscript that we send, along with this we attach the revised manuscript of the viewer's improvement. We have also included it on the TLJES website.

Best regards,
Novitasari

[Kutipan teks disembunyikan]



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novitasari ST.,MT. <novitasari.st.mt@gmail.com>

[tljes] Editor Decision

Edio da Costa <ediocosta@tljes.org>

30 November 2022 pukul 07.58

Kepada: Novitasari Novitasari <novitasari.st.mt@gmail.com>, Holdani Kurdi <holdani.kurdi@ulm.ac.id>

Novitasari Novitasari, Holdani Kurdi:

We have reached a decision regarding your submission to Timor-Leste Journal of Engineering and Science, "A Simple Method of Water Balance Analysis to Predict the Performance of Water Resource Management in the Unit of South Kalimantan Province Offices : -".

Our decision is to: Resubmit for Review

Edio da Costa
ediocosta@tljes.org-----
Reviewer A:Recommendation: Revisions Required

Does the title of the article short, clear, and reflect the overall content?

The article is clear

Does the abstract of the articles clearly summarise the overall content of the research?

Yes it does

Does the article provide scientific and practical justification of the research?

Yes it Does

Does the article formulate clear problem statement and objectives of the research?

Yes it Does

Does the article adequately and soundly provide and review relevant literatures, conceptual frameworks and hypotesis?

Major of literatures is from Indonesia

Does the article clearly outline research method, and data collection techniques?

Yes it does

Can You easily identify the manuscript statement?

Yes I Can

Does the article present results and discussions according to the objectives of the research?

Yes, It does

Does the article provide sound conclusions and implications of the research findings?

Yes it Does

Does the article state its research limitation?

Yes, It Does

What is the greatest strength of this piece of writing?

The scientific of water balance has clear explore and it will be able to apply in the field (Located of study)

Does the distracting grammar, punctuation, spelling, or word usage problems?

No it does not

Does the article provide sound conclusions and implications of the research findings?

Yes it Does

Does the article provide good source of quotations and bibliography?

Major of bibliography is from Indonesia. Need to add some from outside Indonesia about water balance (the problem, the suitable method to resolve). Some of development country face this challenge in water balance therefore need to explore to get many information in their study.

[Timor-Leste Journal of Engineering and Science](#)



A-35-Article Text-129-1-4-20221122_Rev2.docx

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A Simple Method of Water Balance Analysis to Predict the Performance of Water Resource Management in the Unit of South Kalimantan Province Offices

Novitasari Novitasari^{1*}, Holdani Kurdi², Muhammad Azhar³, Elfrida Widyanti⁴, Ratri Handayanti⁵, Muhammad Hafizh Azhari⁶

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Email: novitasari@ulm.ac.id *Corresponding author, holdani.kurdi@ulm.ac.id, 1710811110033@mhs.ulm.ac.id, 1710811120012@mhs.ulm.ac.id, 1710811120043@mhs.ulm.ac.id, 1710811110035@mhs.ulm.ac.id

ABSTRACT

Banjarbaru city was legally established as the capital city of Kalimantan Selatan province, and it needed a new unit of government offices. In the new unit offices of 500 ha, the government built not only office facilities but also a small reservoir or *Embung*. This study aims to analyze the availability of water upstream of the *Embung* that can be provided to fulfill urban water demand in the service area with a simple method of water balance. The conclusions obtained from this research on a simple method of water balance analysis to predict the performance of water resource management in the unit of South Kalimantan province offices based on water available in upstream *Embung* in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after *Embung* construction is still quite adequate as much as 45,611,711.64 liter/day. Although until now, PDAM Intan Banjar still provides sufficient water to meet water needs in the service area. The construction of the reservoir is one of the methods applied by the South Kalimantan provincial government in managing water resources for conservation in the future. With the increase in the population in the future, it is necessary to think about other water sources to meet the water needs due to population growth.

Keywords: water availability, water demand, water balance, water resources management, government official offices, South Kalimantan

Received November 02, 2022; Revised; Accepted

1. Introduction

Banjarbaru city was legally established as the capital city of Kalimantan Selatan province and started on March 16, 2022. It was lawfully validated with Undang-Undang Nomor 8 in 2022 on March 16, 2022 (Undang-Undang RI, 2022). The relocation of the provincial capital has begun with the transfer of government official offices. The South Kalimantan Provincial Government office area is an integrated office area where the spatial layout in it requires various supporting facilities, one of which is an area that can be used as a water catchment area to accommodate/reduce surface runoff leading to Banjarbaru City. The South Kalimantan Provincial Government office area built in 2011, which began with the transfer of the South Kalimantan Provincial Government Offices, which will be occupied by the governor and deputy governor, began to move from the City of Banjarmasin to the City of Banjarbaru in August 2011. Then gradually continued with other offices within the provincial government of South Kalimantan. The official office area of South Kalimantan Province was built on a land area of about 500 hectares, with a total land prepared by the Banjarbaru City Government reaching 2,000 hectares (Gunawan, 2018). The office development program and regional arrangement in an area of 500 hectares will continue to be carried out in stages until 2025.

Changes in land use covering an area of 500 ha and increasing population growth as 2.43% (BPS, 2022b) in Banjarbaru City lead to an increase in the need for clean water and an increase in the need for water resource management. Water resources are predicted to experience a crisis threat in 2025 in the city of Banjarbaru, along with the development of tourism and population growth of 1.9% annually, which can be accelerated by industrial activities. Extensive industrial and tourism activities will significantly accelerate the depletion of water supply and increase water demand, based on the calculation results of large-scale companies, will accelerate the shortage of water supply for the next ten years (Jarwanto Jarwanto, 2022). Until now, Banjarbaru

City has had a reasonably low intensity of land fires and floods at several points. This could change significantly with the relocation of the provincial capital of South Kalimantan, which will increase the population and increase land use.

The government also builds mini reservoirs. It is called *Embung* in Indonesia. The small reservoir, with an area of more than 6 hectares, is equipped with inlet and outlet buildings, outlet pumps, water pumps, reservoir towers, and jogging tracks (Gunawan, 2018). Many studies of small reservoirs in other countries. In Georgia Piedmont, USA, mini reservoir influence headwater water quality (Ignatius and Rasmussen, 2016). Small reservoir rise the economic benefits of water management objectives in other countries (Ortiz-Partida, Lane and Sandoval-Solis, 2016). Reservoir ecosystems also support the sustainability of ecosystem services, and help address many of the global threats driving the decline in freshwater biodiversity (Hill *et al.*, 2021).

This small reservoir built in government office area is named The *Embung Kampung Banjar*. The *Embung Kampung Banjar*, which was built in the provincial government office area, in addition to functioning as a catchment, also functions as a water tourism area and is also used for watering plants (Gunawan, 2018). *Embung* are one of the most frequently constructed forms of water conservation in Indonesia (Agung, 2019). Some other benefit of *Embung* is to provide clean water (Prastika, Sundari and Dea, 2010). The *Embung Kampung Banjar* is also expected to work as a water conservation and preservation area and can be used as a source of water and for various purposes in office areas. The project will be carried out in multi-year 2019 – 2020. So it is necessary to evaluate the conservation of water resources with the projected city growth caused by the population increase. The relationship between water availability and water demand is referred to as the water balance (Waligórski *et al.*, 2020). The purpose of this research is to evaluate the water balance that can be supplied by the reservoir to the planned service area (Gunawan, 2018).

2. Literature Review

2.1. Water Available

According to Lias (2022), the availability of water is the amount of water discharge which is estimated to be continuously in a location (water structure) in a certain amount of water and within a certain period of time (Lias *et al.*, 2022). There are many methods that can be used to calculate evapotranspiration (Lu *et al.*, 2005). Evapotranspiration can also be calculated with limited climatological data using machine learning (Torres, Walker and McKee, 2011). Evapotranspiration is a combination of evaporation and transpiration, which includes all evaporation of water that occurs on the earth's surface, including water bodies, soil, and plants. The evapotranspiration formula used is the Penman-Monteith FAO-56 reference evapotranspiration (Allen, 1998).

$$ET_o = \frac{0,408\Delta(Rn - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0,34u_2)}$$

Where:

- ET_o = reference evapotranspiration (mm/day)
- R_n = net radiation at the crop surface (MJ/m²/day)
- G = soil heat flux density (MJ/m²/day)
- T = mean daily temperature at 2 m height (°C)
- u_2 = wind speed at 2 m height (m/s)
- e_s = saturation vapor pressure (kPa)
- e_a = actual vapor pressure (kPa)
- $e_s - e_a$ = saturation vapor pressure deficit (kPa)
- Δ = slope vapor pressure curve (kPa/°C)
- γ = psychrometric constant (kPa/°C)

So far, the availability of water is widely used to meet the irrigation water demand (Ariyani, Putuhena and Wira, 2020). The availability of water is not only used to meet irrigation water demand, but can also be used for water resource conservation, urban water demand and water disaster (Khalequzzaman K and Amirul, 2008)(Novitasari *et al.*, 2021). Water availability is calculated using the F.J. method (Nurrochmad, Sujono and Damanjaya, 1998). The mock with the output value is in the form of discharge data in the watershed at the research location.

$$R = \sqrt{\frac{Dt^2 - D^2}{Dt^2}}$$

Where:

$$Dt^2 = \sum_{i=1}^N (Q_{obs}^i - \bar{Q})^2$$

Commented [a1]: Major of reference is from Indonesia. It is better to have a literature review also from various nation so we can discover many new science or information

Commented [a2]: Major of reference is from Indonesia. It is better to have a literature review also from various nation so we can discover many new science or information

$$D^2 = \sum_{i=1}^N (Q_{obs}^i - Q_{sim}^i)^2$$

$$\bar{Q} = \frac{\sum_{i=1}^N Q_{obs}^i}{N}$$

The formula can calculate volume Error (VE):

$$VE = \frac{\sum_{i=1}^N Q_{obs}^i - \sum_{i=1}^N Q_{sim}^i}{\sum_{i=1}^N Q_{obs}^i}$$

Where:

- Q_{sim} = simulation discharge of the i period (m^3/s)
- Q_{obs} = observation discharge of the i period (m^3/s)
- \bar{Q} = average observation discharge (m^3/s)
- N = the amount of data

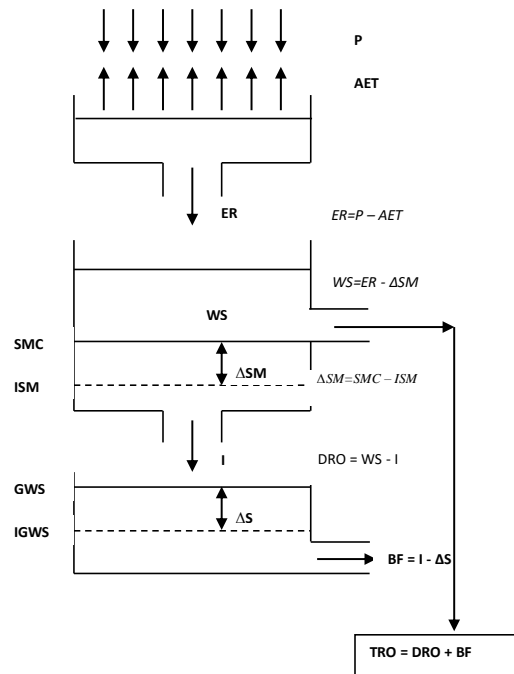


Figure 1. Mock methods schema (Nurrochmad, Sujono and Damanjaya, 1998)

2.2. Water Demand

The number of population needs that will be served in accordance with the portion can affect the quantity requirements of urban water demand, which generally people must obtain clean water and drinking water anytime for 24 hours to meet their needs. Water demand can be divided into household and household demand. According to the Directorate General of Cipta Karya (2000) there are 2 (two) standards for water demand. The domestic water demand has standards for use in private residences so that daily needs can be met, such as drinking water, cooking, washing. The other household demand and non-domestic water demand are clean water demand that are not household demand. The use in non-domestic is commercial, industrial, and general. Household and urban water demands are essential to be met so that there is no unsuccessful to fulfill water demand which can lead to various kinds of disease outbreaks and unrest in the community. The water demand is correlated with population growth. Population projection is the calculation of the total population with the aim of obtaining past and future information in the context of long-term development planning. Population data is obtained from the census conducted by the Central Statistics Agency of Banjarbaru City and other government departments or institutions. In this study, the population projection calculation used is the geometric method (BPS, 2022b).

$$r = \left(\frac{P_t}{P_0} \right)^{1/t} - 1$$

Where:

- r = Population growth rate
- P_t = population of year t
- P_0 = amount of base population year
- t = time period between the base year and year t (in years)

2.3. Water Balance

A simple water balance analysis is based on a correlation between water availability and water demand in the location (Armstrong and Johnson, 2018). The water balance calculations are used to meet irrigation water demand (Ariyani, Putuhena and Wira, 2020) and urban water demand (Reed, Maidment and Patoux, 1997). The water balance is also used to calculate reservoir capacity (Brust *et al.*, 2018).

2.4. Water Quality Measurement

Water quality analysis is needed to get the water quality that suits its needs. There are two regulations used in this study. Government Regulation (PP) No 82 dated December 14, 2001 on Water Quality Management and Water Pollution Control (Pemerintah Republik Indonesia, 2001) dan Minister of Health Regulation enacted on May 31 2017 about Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene, Swimming Pools, Solus Per Aqua, and Public Baths (Menteri Kesehatan Republik Indonesia, 2017).

2.5. Small Reservoir (*Embung*)

Embung, or what is usually also called a small reservoir, is a construction that is built to conserve the flow of water. This retained water will collect in *Embung* that can be used as the demand for irrigation, household, industrial water, hydroelectric power plants, and others (Arsyad, 2017a). Based on the opinion of one expert, a reservoir is an artificial building that functions to accommodate and store water with a certain small volume capacity, smaller than the capacity of the reservoir/dam (Kodoatie and Roestam Syarif, 2010). Types of reservoirs are grouped into four types, namely as follows: 1. based on the purpose of construction with reservoirs for residential purposes and multipurpose reservoirs, 2. based on their use as water reservoirs, deflectors, and retainers, 3. Based on their location to the flow of water, reservoirs on watercourses, and reservoirs outside the watercourse, and 4. based on the constituent material, embankment reservoirs and reservoirs of concrete (Soediby, 1993; Arsyad, 2017b).

The planning of a water reservoir in *Embung* is based on the estimation of water availability to ensure water supply every year in both rainy and dry seasons. This includes not only the capacity of the reservoir and the height of the dam in accordance with the availability of water, but also the entire utilization system must be designed based on the needs and benefits, for example, the installed capacity of hydropower, irrigation water distribution systems and so on (Arsyad, 2017c).

3. Research Methodology

3.1. Data

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Rainfall analysis is calculated by adding up the daily rainfall per month in one period. The rainfall data used is derived from the Banjarbaru Climatology Station for a period of 20 years (2001 to 2020) (BMKG, 2022). The method used to calculate evapotranspiration is the Penman-Monteith FAO-56 method, with climatological data downloaded on the BMKG Online (BMKG, 2022).

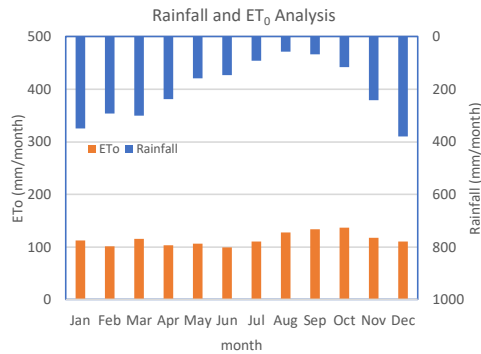


Figure 1. Rainfall and ET₀ Analysis

From rainfall data from the year 2000 to the year 2020, the average annual rain is 2439.99 mm/year. The yearly average evapotranspiration is 1374.13 mm/year. The lowest rainfall intensity occurred in August at 57.88 mm/month and the highest in December at 379.73 mm/month. The average monthly rainfall data is 203.33 mm/month. The monthly evapotranspiration data from the year 2000 to the year 2020, the highest data in October was 136.72 mm/month, and the lowest evapotranspiration data in June was 99.54 mm/month. The average monthly evapotranspiration data is 114.51 mm/month. Based on rain data and evapotranspiration data, it is determined the availability of water upstream of the reservoir.

Banjarbaru city, with a total area of 305.242 km² divided into five districts, Landasan Ulin, with an area of 74.054 km², Liang Anggang of 74.773 km²; Cempaka of 114.543 km²; North Banjarbaru 26.855 km², and South Banjarbaru 15.027 km² (BPS, 2022b). BPS (Central Bureau of Statistics) Banjarbaru City recorded data from 2013 – 2020. The highest population data is in the Landasan Ulin sub-district as many as 75,385 residents, and the lowest data is in the Cempaka sub-district as many as 35,584 residents (BPS, 2022a). Population growth is one of the effects of moving offices and government centers to Banjarbaru City.

In the South Banjarbaru sub-district, in the year 2013, the population of as many as 46,872 residents. It increases until years 2019, with as many as 67,542 residents but decreases in years 2020 to as many as 45,273 people, as shown in Figure 6. The Population in South Banjarbaru District in 2020 decreased by 32% because, in 2020, there was a Covid-19 pandemic (BPS, 2022b). The population growth rate reached 1.7.

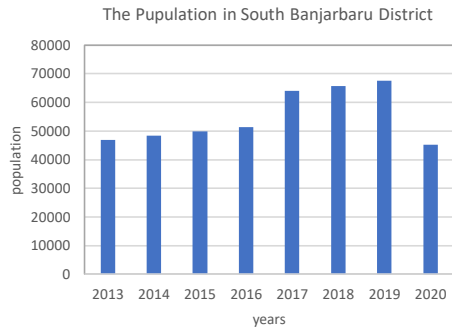


Figure 2. The Population in South Banjarbaru District

3.2. Research Area

The Banjarbaru City area is located at an altitude of 500 m above sea level, with an altitude of 0 – 7 m (33.49%), 7 – 25 m (48.46%), 25 – 100 m (15.15%), 100 – 250 m (2.55%) and 250 – 500 m (0.35%) (BPS, 2022b). The slope classification of Banjarbaru City is a slope of 0 – 2% covering 59.35% of the area, a slope of 2 – 8% covering 25.78% of the area, a slope of 8 – 15% covering 12.08% of the area. The rock classification in Banjarbaru City consists of Alluvium 48.44%. In the city of Banjarbaru, there are 3 (three) groups of soil types, namely Podzol soil (63.82%), Lathosol (6.36%), and Organosol (29.82%) (RPIJM, 2015). The South Kalimantan provincial government office building covering an area of 500 hectares in Banjarbaru city can be seen on the map below and is located in the Cempaka sub-district.



Figure 3. Research Study

The *Embung Kampung Banjar* was built in the area of the South Kalimantan provincial government office building in Kampung Banjar village. It is geographically $3^{\circ} 28' 27,9''$ south latitude and $114^{\circ} 49' 39''$ north latitude (Gunawan, 2018).

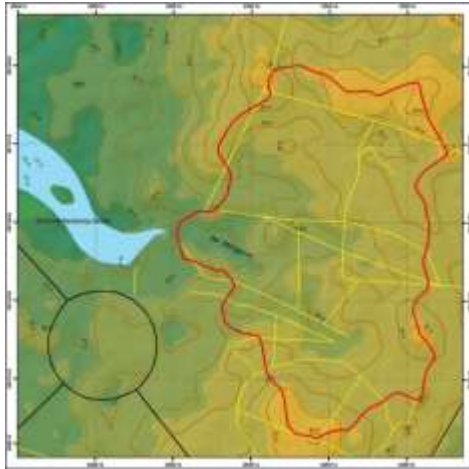


Figure 4. *The Embung Kampung Banjar*

The *Embung Kampung Banjar* has a service area in the part of the sub-district of South Banjarbaru and other sub districts with an area of 21.96 km². Facilities located at the *Embung Kampung Banjar* service location include water catchment areas, water tourism areas, reservoirs to reduce runoff to Banjarbaru city, watering plants, and water preservation and conservation areas. The water demand has increased with the increase in population.

4. Result

4.1. Water Available Analysis

Water available analysis calculates from the river discharge data of the Riam Kiwa River. The calibration was conducted in 2001 with an area of 382 km² (Novitasari *et al.*, 2021). Based on discharge data observed in 2001, water discharge in other years can be calculated using mock parameters from the Riam Kiwa River. The wet infiltration coefficient is 0.3, the dry infiltration coefficient is 0.4, the initial soil moisture (ISM) is 110 mm, the soil moisture capacity (SMC) is 220 mm, the initial ground water storage (IGWS) is 1000 mm, and groundwater recession Constant (k) as 0.810.

The average monthly discharge data for 20 years is presented in Figure 5. The average annual discharge data is presented in Figure 6. The effectiveness of using Riam Kiwa discharge data to determine the calculated discharge with the measured discharge data obtained at the research location is shown in Table 1.

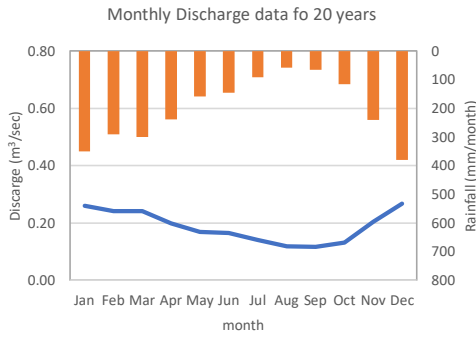


Figure 5. The average monthly discharge data for 20 years

The highest monthly average discharge for 20 years occurred in December at 0.27 m³/second, while the lowest discharge occurred in August and September at 0.12 m³/second. Debit rata-rata bulanan sebesar 0.19 m³/detik.

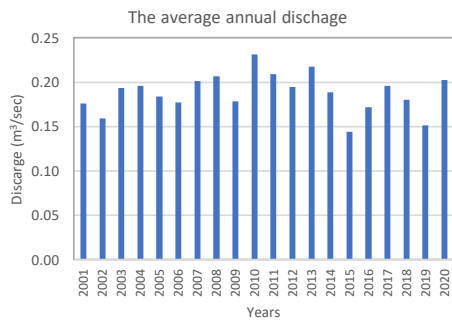


Figure 6. The average annual discharge data

Analysis of annual discharge from 2001 to 2020 found that the highest average annual discharge occurred in 2010 at 0.23 m³/second, and the lowest average annual discharge occurred in 2015 at 0.14 m³/second. The limitations of the discharge measurement data for analysis using the mock model need to be eliminated by measuring the instantaneous discharge at the research site. Measured discharge in upstream *Embung* (Paring River), *Embung* Inlet, and *Embung* outlet in April and May 2021.

Table 1. Data for Measured Discharge of *Embung* Kampung Banjar

Location	Qobs (2021) (m ³ /s)		Qcal (2021) (m ³ /s)		Qcal mean (m ³ /s)	
	Apr	May	Apr	May	Apr	May
Upstream	0.04	0.04	0.08	0.09	0.19	0.15
Inlet	0.02	0.08				
Outlet	0.02	0.002				

The effectiveness is analyzed against the calculated discharge in 2021 and the average annual discharge in April and May. The value of the effectiveness of using the Riam Kiwa River discharge data for the calibration process at the *Embung Kampung*

Banjar is 25% in April 2021 and 88% in May 2021. In April 2021, the effectiveness value was very small because, at the time of measurement, it was a day that rarely rains, starting from the middle of April, causing the measured discharge to be very low.

The mainstay discharge is calculated by sorting the average discharge per year (2001-2020) from the largest value to the smallest value so that the average discharge value is obtained at a probability of 90% for domestic water purposes. The following are the steps for calculating the mainstay discharge.

- The monthly average discharge data is sorted from the largest to the smallest.
- Give a sequence of r from 1 to N where the value of N is 20.
- The probability of the Weibull method that r is 1
- $$P = \frac{r}{(N+1)} \times 100\% = \frac{1}{(20+1)} \times 100\% = 4,76\% \approx 5\%$$
- Then look for the required mainstay discharge; because the function of the reservoir is of them to meet the needs of r water in the neighborhood of the location, the mainstay discharge used is Q_{90} , specifically for domestic water demand.

The results of the monthly Q_{90} calculation can be seen in the table below.

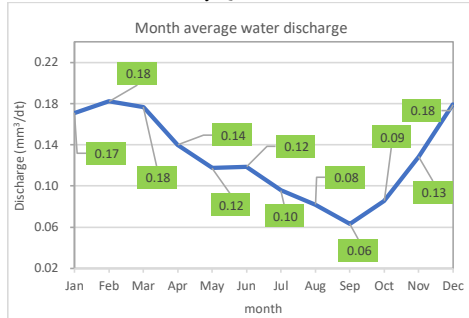


Figure 7. Month Average Water Discharge in 2001-2020

The most reliable discharge for water demand was obtained in February, March, and December with a discharge value of $0.18 \text{ m}^3/\text{s}$ and the smallest occurred in with a discharge value of $0.06 \text{ m}^3/\text{s}$. The availability of water in the *Embung Kampung Banjar* will be used to fulfill the water demand of the local population, the need for watering plants, and also the drinking water demand of livestock, especially during the dry season, when very little rain occurs. The reservoir is expected to be fully filled at the end of each rainy season so that it can be used during the dry season.

4.2. Water Demand

The amount of urban water demand according to the density criteria (people per hectare) is taken at 25-35. This is because the Population of Banjarbaru City is 506,884 people with an area of 37,130 Ha, so a population density of > 100 people/ha is obtained. The standard of household water demand is based on the type of city and population. Banjarbaru City is a type of big city whose accuracy criteria are more than 100, and the number of urban water demand taken is 25-35. The standard amount of non-domestic water demand according to the Population of Banjarbaru City is 40.

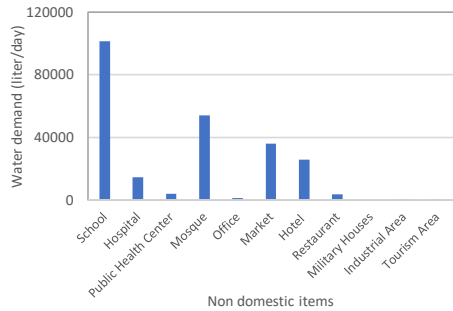


Figure 8. Non-Domestic Water Demand

In Banjarbaru city, non-domestic water demands include water for public facilities such as schools from kindergarten to college, public and private hospitals, public health centers, mosques, government and non-government offices, traditional markets, hotels, restaurants, military houses, and some tourism area.

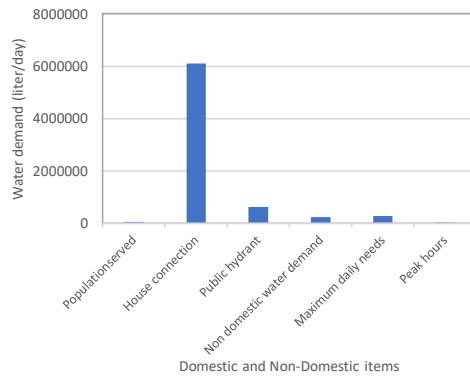


Figure 9. Domestic and Urban Water Demand

The population served is 45,273 people with a house connection (SR) of 90% times the population served multiplied by 150 liters. The water requirement for a public hydrant (KU) is 90% times the house connection (SR). All water requirement includes domestic and non-domestic water demands, and maximum daily needs in peak hours.

The results of the analysis of water demand, the City of Banjarbaru is included in the category of a large city type with a population of 506,884 people. It can be concluded that the total number of non-domestic water demand in 2020 after the *Embung* was built was 240,593.4 Liters/day, and the total number of household and urban water demand was 7,289,740 Liters/day. The population reduction that occurred in 2020 in South Banjarbaru District impacts the amount of water demand in the service area.

Long-term development planning by taking into account the population for the next five years, ten years, 15 years, 20 years, and 25 years using the Geometric Method as shown in Figure 7.

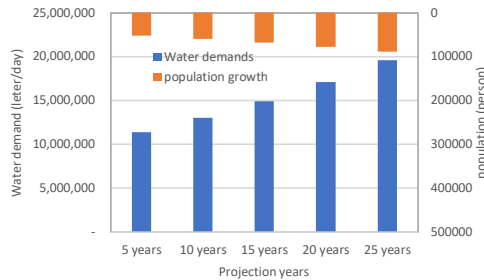


Figure 10. Projection of water demand and population growth after the construction of the *Embung*

The increase in population is used to calculate population projections for five years, ten years, 15 years, 20 years, and 25 years after 2020. Based on population projection, residents served as many as 88,987 people in the next 25 years. This population projection will be used to calculate the need for domestic and non-domestic water in Banjarbaru city.

The projected total domestic water demand after the construction of the *Embung* is 7,807,526 liters/day in 5 years, 8,937,414,318 liters/day in 10 years, 10,230,759.48 liters/day for 20 years, 1,1621,681,5 liters/day, and at 25 years as many as 1,3406,046.2 liters/day.

The projection of total household and urban water demand after the construction of the *Embung* is 11,366.893 liters/day; in 10 years, it is 13,045,123.53 liters/day; in 15 years, it is 14,932,900.78 liters/day; in 20 years as many as 17,093,784.53 liters/day, and at 25 years as many as 19,567,575.3 liters/day.

4.3. Water Balance

Analysis of the water balance that is planned to meet domestic and non-domestic water demand is carried out on population data in 2020, at the time of the start of office relocation in Banjarbaru city. The population growth area is taken in South Banjarbaru District. The analysis of water available to fulfill water demand in the service area of *Embung* in 2020 as shown in Figure 11.

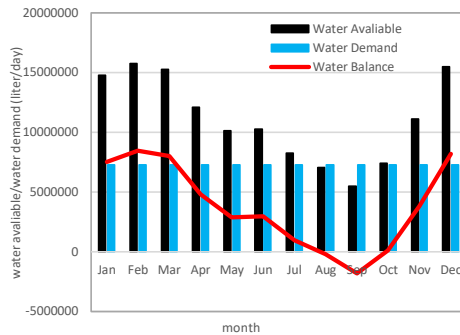


Figure 11. Water Balance Analysis

The water balance obtained by the construction of the *Embung Kampung Banjar* and the water demand to be obtained a surplus water balance for most of the year, except for August and September. In August has a deficit of water as much as 220,829.51 liter/day, and in September, the deficit as 1,815,842.40 liter/day. The highest deficit value occurred in September. It is necessary to regulate the water resource system to cope with these conditions, given the increase in population after 2020 with the movement of office complexes accompanied by the movement of the provincial capital in 2022. Analysis of water demand is carried out on population growth of 5 years, 10 years, 15 years, 20 years, and 25 years as shown in Figure 12.

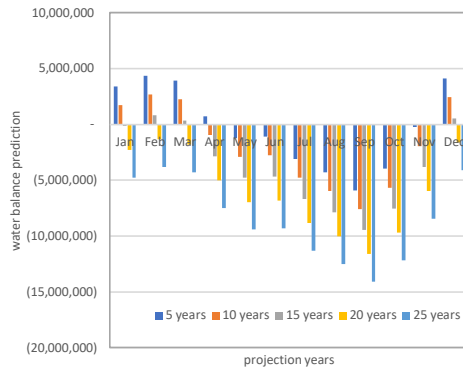


Figure 12. Water Balance for projected to meet water demand

Based on the current water availability data, it is projected to meet water demand for the 5 years, 10 years, 15 years, and 20 years to 25 years projections. It can be seen that water available only can fulfill the water demand in five years projections in January, February, March, April, and December. The deficit of water from May to November. The water deficit occurs from May to November. The water deficit occurs throughout the year to meet water demand for population projections for 20 years and 25 years.

4.4. Water Quality Analysis

Water quality testing at the Embung Kampung Banjar took four samples in the Embung service area, namely Inlet, Outlet, and Paring River. The tool used in this test is U-50 HORIBA (multi-water quality checker). This test is to determine the parameters contained in the water sample. The test is carried out by dipping the U-50 HORIBA (multi-water quality checker) tool into a water sample from which water quality data will be taken.



Figure 14. Location of Water Quality Sampling Data

Water quality testing consists of physical, chemical, and biological tests. Based on the tools available at the Hydraulic Laboratory, Faculty of Engineering, Lambung Mangkurat University, the only tests that can be done are physical and chemical tests. The measured water quality includes physical and chemical quality, which consists of water turbidity measurement, water temperature, degree of acidity of the water (pH), and total Dissolved Solid (TDS).

In the physical test, the results obtained from the U-50 HORIBA (multi-water quality checker) tool get turbidity and temperature parameters, while for chemical testing, the results obtained are Ph and Total Dissolved Solid (TDS). From the physical and chemical tests, the parameters of the four samples met the maximum allowable levels. Based on direct observation, it was also found that the water entering and leaving the reservoir was tasteless, odorless, and colorless.

Table 2. Water Quality Sampling Data

No.	Parameter	Unit	Max rate allowed	Inlet	Outlet	Em-bung	Paring River
A. Physical							
1	Turbidity	Scala NTU	25	0.73	0.93	1.03	0
2	Water temperature	°C	air temperature ± 3 °C	30.51	30.34	30.22	29.46
B. chemical							
1	Ph	Mg/L	6,5-9,0	6.77	7.16	7.06	6.4
2	Total Dissolved Solid (TDS)	Mg/L	1500	0.007	0.002	0.002	0.007

Water sampling for 4 locations consisted of an inlet for the first sample, an outlet for the second sample, an Embung for the third location, and the paring river for the fourth sample. Based on the test at the 4 locations, it can be taken from the data that the water quality in the service area of the Embung Kampung Banjar meets the class D water standard. Water turbidity less than 25 NTU. Water temperature based on air temperature ± 3 °C. the average maximum air temperature for the last 5 years is 32.27°C. The degree of acidity of the water (pH) is around 7. TSD less than 1500 Mg/l. It can be used for agriculture, urban businesses, industry, and hydroelectric power plants that can be used by the community around Banjarbaru District.

5. Discussion

5.1. Water balance as water resource management

Water balance in the unit of South Kalimantan Province Offices based on water available in upstream Embung in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after Embung construction is still quite adequate as much as 45,611,711.64 liter/day. The construction of the Embung Kampung Banjar is a good solution to overcoming the current problems of water resource management in Banjarbaru City as the new capital city of South Kalimantan province.

A well-managed reservoir can be used as a water provider to cover water demand in the dry season from water stored in the rainy season. The average annual rain that occurs based on observations at the Banjarbaru climatology station is around 2439.99 mm/year for 20 years, so it has the potential to be captured and utilized. The *Embung Kampung Banjar* is the solution for current water demand. However, in the future, with the increase in population, it is necessary to build other reservoirs or other water source supplies in the South Kalimantan government office.

5.2. Water resources management as water conservation and tourism

The Banjarbaru City Government's planning during the construction of the Embung Kampung Banjar was to function as water conservation as an Embung for groundwater storage, watering plants, and water tourism. Embung also uses to reduce water runoff to Banjarbaru city and water plants. The Banjarbaru city government's planning was in accordance with the conditions when direct observations were made in the field.

Until now, water available needed to fulfill the need for clean water in the service area, namely South Banjarbaru District; it is still served by PDAM Intan Banjar. So the building of Embung still functions more as water conservation for groundwater storage and tourism with the jogging tracks around Embung. In addition to the need for rainwater storage during the rainy season, there is also a need for infiltration areas that are used to replace lands that have changed functions into office areas that are massively closed, and covering an area of 500 ha, it is necessary to take into account how much water runs over the surface considering that Banjarbaru city is a city with a clay soil structure, so it is an area that really needs good groundwater infiltration, considering that the groundwater level in Banjarbaru City is quite deep.

6. Conclusion and Implication

6.1. Conclusion

The conclusions obtained from this research on a simple method of water balance analysis to predict the performance of water resource management in the unit of South Kalimantan province offices based on water available in upstream *Embung* in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after *Embung* construction is still quite adequate as much as 45,611,711.64 liter/day. Although until now, PDAM *Intan Banjar* still provides sufficient water to meet water demand in the service area.

The construction of the reservoir is one of the methods applied by the South Kalimantan provincial government in managing water resources for conservation in the future. In order to increase the population in the future, it is necessary to think about other water sources to meet the water demand caused by population growth.

6.2. Future Research

This research had a small scope of the area of water resources management in the new unit of government offices, with an area of 500 ha. Changes in land use covering an area of 500 ha also need to be considered regarding groundwater storage in the future and the effect of land erosion that can occur, considering that Banjarbaru City is a city with varying land heights.

In general, the relocation of the provincial capital will also cause the transfer of public facilities and other activities. It means needed more water resources management in the future on a larger scale.

Acknowledgments

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A Simple Method of Water Balance Analysis to Predict the Performance of Water Resource Management in the Unit of South Kalimantan Province Offices

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ABSTRACT

Banjarbaru city was legally established as the capital city of Kalimantan Selatan province, and it needed a new unit of government offices. In the new unit offices of 500 ha, the government built not only office facilities but also a small reservoir or *Embung*. This study aims to analyze the availability of water upstream of the *Embung* that can be provided to fulfill urban water demand in the service area with a simple method of water balance. The conclusions obtained from this research on a simple method of water balance analysis to predict the performance of water resource management in the unit of South Kalimantan province offices based on water available in upstream *Embung* in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after *Embung* construction is still quite adequate as much as 45,611,711.64 liter/day. Although until now, PDAM Intan Banjar still provides sufficient water to meet water needs in the service area. The construction of the reservoir is one of the methods applied by the South Kalimantan provincial government in managing water resources for conservation in the future. With the increase in the population in the future, it is necessary to think about other water sources to meet the water needs due to population growth.

Keywords: water availability, water demand, water balance, water resources management, government official offices, South Kalimantan

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1. Introduction

Banjarbaru city was legally established as the capital city of Kalimantan Selatan province and started on March 16, 2022. It was lawfully validated with Undang-Undang Nomor 8 in 2022 on March 16, 2022 (Undang-Undang RI, 2022). The relocation of the provincial capital has begun with the transfer of government official offices. The South Kalimantan Provincial Government office area is an integrated office area where the spatial layout in it requires various supporting facilities, one of which is an area that can be used as a water catchment area to accommodate/reduce surface runoff leading to Banjarbaru City. The South Kalimantan Provincial Government office area built in 2011, which began with the transfer of the South Kalimantan Provincial Government Offices, which will be occupied by the governor and deputy governor, began to move from the City of Banjarmasin to the City of Banjarbaru in August 2011. Then gradually continued with other offices within the provincial government of South Kalimantan. The official office area of South Kalimantan Province was built on a land area of about 500 hectares, with a total land prepared by the Banjarbaru City Government reaching 2,000 hectares (Gunawan, 2018). The office development program and regional arrangement in an area of 500 hectares will continue to be carried out in stages until 2025.

Changes in land use covering an area of 500 ha and increasing population growth as 2.43% (BPS, 2022b) in Banjarbaru City lead to an increase in the need for clean water and an increase in the need for water resource management. Water resources are predicted to experience a crisis threat in 2025 in the city of Banjarbaru, along with the development of tourism and population growth of 1.9% annually, which can be accelerated by industrial activities. Extensive industrial and tourism activities will significantly accelerate the depletion of water supply and increase water demand, based on the calculation results of large-scale companies, will accelerate the shortage of water supply for the next ten years (Jarwanto Jarwanto, 2022). Until now, Banjarbaru

City has had a reasonably low intensity of land fires and floods at several points. This could change significantly with the relocation of the provincial capital of South Kalimantan, which will increase the population and increase land use.

The government also builds mini reservoirs. It is called *Embung* in Indonesia. The small reservoir, with an area of more than 6 hectares, is equipped with inlet and outlet buildings, outlet pumps, water pumps, reservoir towers, and jogging tracks (Gunawan, 2018). Many studies of small reservoirs in other countries. In Georgia Piedmont, USA, mini reservoir influence headwater water quality (Ignatius and Rasmussen, 2016). Small reservoir rise the economic benefits of water management objectives in other countries (Ortiz-Partida, Lane and Sandoval-Solis, 2016). Reservoir ecosystems also support the sustainability of ecosystem services, and help address many of the global threats driving the decline in freshwater biodiversity (Hill *et al.*, 2021).

This small reservoir built in government office area is named The *Embung Kampung Banjar*. The *Embung Kampung Banjar*, which was built in the provincial government office area, in addition to functioning as a catchment, also functions as a water tourism area and is also used for watering plants (Gunawan, 2018). *Embung* are one of the most frequently constructed forms of water conservation in Indonesia (Agung, 2019). Some other benefit of *Embung* is to provide clean water (Prastika, Sundari and Dea, 2010). The *Embung Kampung Banjar* is also expected to work as a water conservation and preservation area and can be used as a source of water and for various purposes in office areas. The project will be carried out in multi-year 2019 – 2020. So it is necessary to evaluate the conservation of water resources with the projected city growth caused by the population increase. The relationship between water availability and water demand is referred to as the water balance (Waligórski *et al.*, 2020). The purpose of this research is to evaluate the water balance that can be supplied by the reservoir to the planned service area (Gunawan, 2018).

2. Literature Review

2.1. Water Available

According to [Lias Konapala \(20202\)](#), the availability of water is the amount of water discharge which is estimated to be continuously in a location (water structure) in a certain amount of water and within a certain period of time (Konapala *et al.*, 2020). There are many methods that can be used to calculate evapotranspiration (Lu *et al.*, 2005). Evapotranspiration can also be calculated with limited climatological data using machine learning (Torres, Walker and Mckee, 2011). Evapotranspiration is a combination of evaporation and transpiration, which includes all evaporation of water that occurs on the earth's surface, including water bodies, soil, and plants. The evapotranspiration formula used is the Penman-Monteith FAO-56 reference evapotranspiration (Allen, 1998).

$$ET_o = \frac{0,408\Delta(Rn - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0,34u_2)}$$

Where:

- ET_o = reference evapotranspiration (mm/day)
- R_n = net radiation at the crop surface (MJ/m²/day)
- G = soil heat flux density (MJ/m²/day)
- T = mean daily temperature at 2 m height (°C)
- u_2 = wind speed at 2 m height (m/s)
- e_s = saturation vapor pressure (kPa)
- e_a = actual vapor pressure (kPa)
- $e_s - e_a$ = saturation vapor pressure deficit (kPa)
- Δ = slope vapor pressure curve (kPa/°C)
- γ = psychrometric constant (kPa/°C)

So far, the availability of water is widely used to meet the irrigation water demand (Kylstra *et al.*, 2021) (Sun, Huang and Wang, 2017) (Allen *et al.*, 1998; Ariyani, Putehena and Wira, 2020). The availability of water is not only used to meet irrigation water demand, but can also be used for water resource conservation, urban water demand and water disaster (Khalequzzaman K and Amirul, 2008) (Novitasari *et al.*, 2021). Water availability is calculated using the F.J. [Mock method-model as the modification of Tank Model](#) (Nurrochmad, Sujono and Damanjaya, 1998; Lee, Chegal and Lee, 2020). The [F.J. Mock model](#) with the output value is in the form of discharge data in the watershed at the research location.

$$R = \sqrt{\frac{Dt^2 - D^2}{Dt^2}}$$

Where:

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Commented [a2]: Major of reference is from Indonesia. It is better to have a literature review also from various nation so we can discover many new science or information

$$Dt^2 = \sum_{i=1}^N (Q_{obs}^i - \bar{Q})^2$$

$$D^2 = \sum_{i=1}^N (Q_{obs}^i - Q_{sim}^i)^2$$

$$\bar{Q} = \frac{\sum_{i=1}^N Q_{obs}^i}{N}$$

The formula can calculate volume Error (VE):

$$VE = \frac{\sum_{i=1}^N Q_{obs}^i - \sum_{i=1}^N Q_{sim}^i}{\sum_{i=1}^N Q_{obs}^i}$$

Where:

- Q_{sim} = simulation discharge of the i period (m^3/s)
- Q_{obs} = observation discharge of the i period (m^3/s)
- \bar{Q} = average observation discharge (m^3/s)
- N = the amount of data

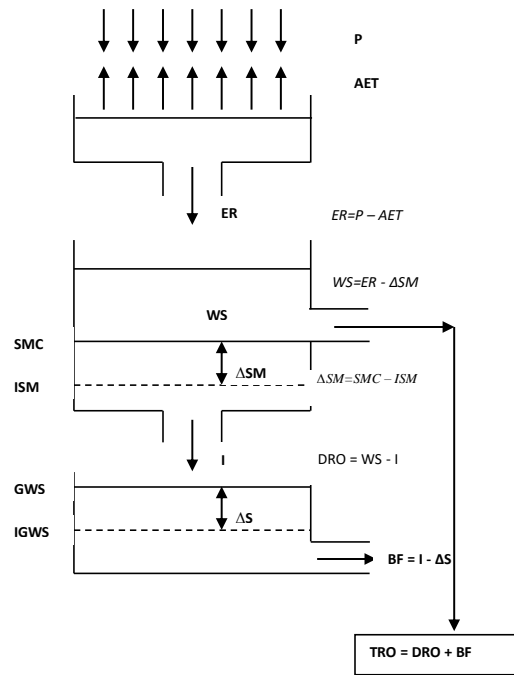


Figure 1. Mock methods schema (Nurrochmad, Sujono and Damanjaya, 1998)

2.2. Water Demand

The number of population **needs** that will be served in accordance with the portion can affect the quantity requirements of urban water demand, which generally people must obtain clean water and drinking water anytime for 24 hours to meet their needs. Water demand can be divided into household and household demand. According to the Directorate General of Cipta Karya (2000) there are 2 (two) standards for water demand. The domestic water demand has standards for use in private residences so that daily needs can be met, such as drinking water, cooking, washing. The other household demand and non-domestic water demand are clean water demand that are not household demand. The use in non-domestic is commercial, industrial, and general. Household and urban water demands are essential to be met so that there is no unsuccessful to fulfill water demand which can lead to various kinds of disease outbreaks and unrest in the community. The water demand is correlated with population growth. Population projection is the calculation of the total population with the aim of obtaining past and future information in the context of long-term development planning. Population data is obtained from the census conducted by the Central Statistics Agency of Banjarbaru City and other government departments or institutions. In this study, the population projection calculation used is the geometric method (BPS, 2022b).

$$r = \left(\frac{P_t}{P_0} \right)^{1/t} - 1$$

Where:

- r = Population growth rate
- P_t = population of year t
- P_0 = amount of base population year
- t = time period between the base year and year t (in years)

2.3. Water Balance

A simple water balance analysis is based on a correlation between water availability and water demand in the location (Armstrong and Johnson, 2018). The water balance calculations are used to meet irrigation water demand (Ariyani, Putuhena and Wira, 2020) and urban water demand (Reed, Maidment and Patoux, 1997). The water balance is also used to calculate reservoir capacity (Brust *et al.*, 2018).

2.4. Water Quality Measurement

Water quality analysis is needed to get the water quality that suits its needs. There are two regulations used in this study. Government Regulation (PP) No 82 dated December 14, 2001 on Water Quality Management and Water Pollution Control (Pemerintah Republik Indonesia, 2001) dan Minister of Health Regulation enacted on May 31 2017 about Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene, Swimming Pools, Solus Per Aqua, and Public Baths (Menteri Kesehatan Republik Indonesia, 2017).

2.5. Small Reservoir (*Embung*)

Embung, or what is usually also called a small reservoir, is a construction that is built to **conserve** the flow of water. This retained water will collect in *Embung* that can be used as the demand for irrigation, household, industrial water, hydroelectric power plants, and others (Arsyad, 2017a). Based on the opinion of one expert, a reservoir is an artificial building that functions to accommodate and store water with a certain small volume capacity, smaller than the capacity of the reservoir/dam (Kodoatie and Roestam Syarief, 2010). Types of reservoirs are grouped into four types, namely as follows: 1. based on the purpose of construction with reservoirs for residential purposes and multipurpose reservoirs, 2. based on their use as water reservoirs, deflectors, and retainers, 3. Based on their location to the flow of water, reservoirs on watercourses, and reservoirs outside the watercourse, and 4. based on the constituent material, embankment reservoirs and reservoirs of concrete (Soedibyo, 1993; Arsyad, 2017b).

The planning of a water reservoir in *Embung* is based on the estimation of water availability to ensure water supply every year in both rainy and dry seasons. This includes not only the capacity of the reservoir and the height of the dam in accordance with the availability of water, but also the entire utilization system must be designed based on the needs and benefits, for example, the installed capacity of hydropower, irrigation water distribution systems and so on (Arsyad, 2017c).

3. Research Methodology

3.1. Data

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Rainfall analysis is calculated by adding up the daily rainfall per month in one period. The rainfall data used is derived from the Banjarbaru Climatology Station for a period of 20 years (2001 to 2020) (BMKG, 2022). The method used to calculate evapotranspiration is the Penman-Monteith FAO-56 method, with climatological data downloaded on the BMKG Online (BMKG, 2022).

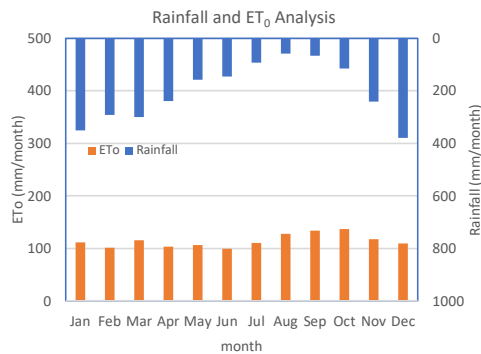


Figure 1. Rainfall and ET_0 Analysis

From rainfall data from the year 2000 to the year 2020, the average annual rain is 2439.99 mm/year. The yearly average evapotranspiration is 1374.13 mm/year. The lowest rainfall intensity occurred in August at 57.88 mm/month and the highest in December at 379.73 mm/month. The average monthly rainfall data is 203.33 mm/month. The monthly evapotranspiration data from the year 2000 to the year 2020, the highest data in October was 136.72 mm/month, and the lowest evapotranspiration data in June was 99.54 mm/month. The average monthly evapotranspiration data is 114.51 mm/month. Based on rain data and evapotranspiration data, it is determined the availability of water upstream of the reservoir.

Banjarbaru city, with a total area of 305.242 km² divided into five districts, Landasan Ulin, with an area of 74.054 km², Liang Anggang of 74.773 km², Cempaka of 114.543 km², North Banjarbaru 26.855 km², and South Banjarbaru 15.027 km² (BPS, 2022b). BPS (Central Bureau of Statistics) Banjarbaru City recorded data from 2013 – 2020. The highest population data is in the Landasan Ulin sub-district as many as 75,385 residents, and the lowest data is in the Cempaka sub-district as many as 35,584 residents (BPS, 2022a). Population growth is one of the effects of moving offices and government centers to Banjarbaru City.

In the South Banjarbaru sub-district, in the year 2013, the population of as many as 46,872 residents. It increases until years 2019, with as many as 67,542 residents but decreases in years 2020 to as many as 45,273 people, as shown in Figure 6. The Population in South Banjarbaru District in 2020 decreased by 32% because, in 2020, there was a Covid-19 pandemic (BPS, 2022b). The population growth rate reached 1.7.

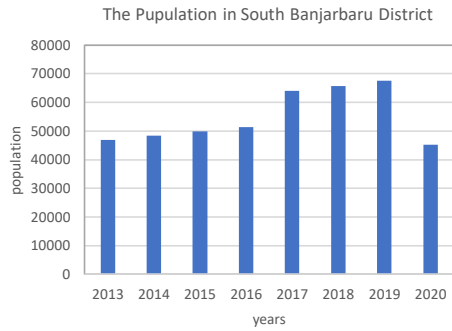


Figure 2. The Population in South Banjarbaru District

3.2. Research Area

The Banjarbaru City area is located at an altitude of 500 m above sea level, with an altitude of 0 – 7 m (33.49%), 7 – 25 m (48.46%), 25 – 100 m (15.15%), 100 – 250 m (2.55%) and 250 – 500 m (0.35%) (BPS, 2022b). The slope classification of Banjarbaru City is a slope of 0 – 2% covering 59.35% of the area, a slope of 2 – 8% covering 25.78% of the area, a slope of 8 – 15% covering 12.08% of the area. The rock classification in Banjarbaru City consists of Alluvium 48.44%. In the city of Banjarbaru, there are 3 (three) groups of soil types, namely Podzol soil (63.82%), Lathosol (6.36%), and Organosol (29.82%) (RPIJM, 2015). The South Kalimantan provincial government office building covering an area of 500 hectares in Banjarbaru city can be seen on the map below and is located in the Cempaka sub-district.



Figure 3. Research Study

The *Embung Kampung Banjar* was built in the area of the South Kalimantan provincial government office building in Kampung Banjar village. It is geographically 3° 28' 27,9" south latitude and 114° 49' 39" north latitude (Gunawan, 2018).

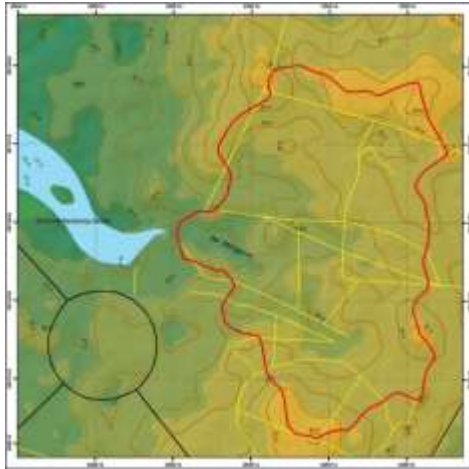


Figure 4. *The Embung Kampung Banjar*

The *Embung Kampung Banjar* has a service area in the part of the sub-district of South Banjarbaru and other sub districts with an area of 21.96 km². Facilities located at the *Embung Kampung Banjar* service location include water catchment areas, water tourism areas, reservoirs to reduce runoff to Banjarbaru city, watering plants, and water preservation and conservation areas. The water demand has increased with the increase in population.

4. Result

4.1. Water Available Analysis

Water available analysis calculates from the river discharge data of the Riam Kiwa River. The calibration was conducted in 2001 with an area of 382 km² (Novitasari *et al.*, 2021). Based on discharge data observed in 2001, water discharge in other years can be calculated using mock parameters from the Riam Kiwa River. The wet infiltration coefficient is 0.3, the dry infiltration coefficient is 0.4, the initial soil moisture (ISM) is 110 mm, the soil moisture capacity (SMC) is 220 mm, the initial ground water storage (IGWS) is 1000 mm, and groundwater recession Constant (k) as 0.810.

The average monthly discharge data for 20 years is presented in Figure 5. The average annual discharge data is presented in Figure 6. The effectiveness of using Riam Kiwa discharge data to determine the calculated discharge with the measured discharge data obtained at the research location is shown in Table 1.

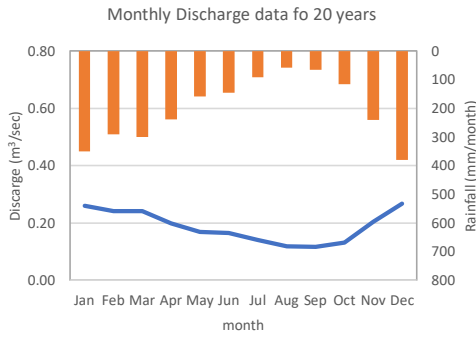


Figure 5. The average monthly discharge data for 20 years

The highest monthly average discharge for 20 years occurred in December at 0.27 m³/second, while the lowest discharge occurred in August and September at 0.12 m³/second. Debit rata-rata bulanan sebesar 0.19 m³/detik.

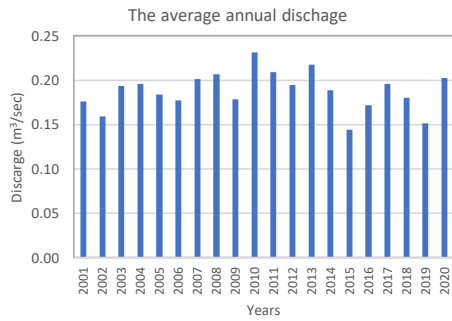


Figure 6. The average annual discharge data

Analysis of annual discharge from 2001 to 2020 found that the highest average annual discharge occurred in 2010 at 0.23 m³/second, and the lowest average annual discharge occurred in 2015 at 0.14 m³/second. The limitations of the discharge measurement data for analysis using the mock model need to be eliminated by measuring the instantaneous discharge at the research site. Measured discharge in upstream *Embung* (Paring River), *Embung* Inlet, and *Embung* outlet in April and May 2021.

Table 1. Data for Measured Discharge of *Embung* Kampung Banjar

Location	Qobs (2021) (m ³ /s)		Qcal (2021) (m ³ /s)		Qcal mean (m ³ /s)	
	Apr	May	Apr	May	Apr	May
Upstream	0.04	0.04	0.08	0.09	0.19	0.15
Inlet	0.02	0.08				
Outlet	0.02	0.002				

The effectiveness is analyzed against the calculated discharge in 2021 and the average annual discharge in April and May. The value of the effectiveness of using the Riam Kiwa River discharge data for the calibration process at the *Embung Kampung*

Banjar is 25% in April 2021 and 88% in May 2021. In April 2021, the effectiveness value was very small because, at the time of measurement, it was a day that rarely rains, starting from the middle of April, causing the measured discharge to be very low.

The mainstay discharge is calculated by sorting the average discharge per year (2001-2020) from the largest value to the smallest value so that the average discharge value is obtained at a probability of 90% for domestic water purposes. The following are the steps for calculating the mainstay discharge.

- a. The monthly average discharge data is sorted from the largest to the smallest.
- b. Give a sequence of r from 1 to N where the value of N is 20.
- c. The probability of the Weibull method that r is 1
- d. $P = \frac{r}{(N+1)} \times 100\% = \frac{1}{(20+1)} \times 100\% = 4,76\% \approx 5\%$
- e. Then look for the required mainstay discharge; because the function of the reservoir is of them to meet the needs of r water in the neighborhood of the location, the mainstay discharge used is Q90, specifically for domestic water demand.

The results of the monthly Q90 calculation can be seen in the table below.

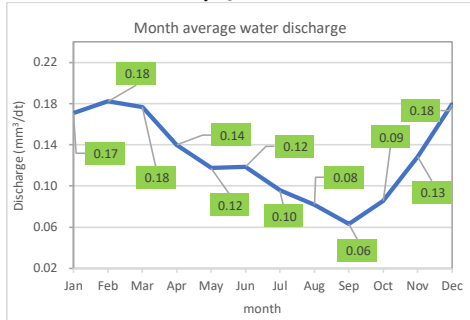


Figure 7. Month Average Water Discharge in 2001-2020

The most reliable discharge for water demand was obtained in February, March, and December with a discharge value of 0.18 m³/s and the smallest occurred in with a discharge value of 0.06 m³/s. The availability of water in the *Embung Kampung Banjar* will be used to fulfill the water demand of the local population, the need for watering plants, and also the drinking water demand of livestock, especially during the dry season, when very little rain occurs. The reservoir is expected to be fully filled at the end of each rainy season so that it can be used during the dry season.

4.2. Water Demand

The amount of urban water demand according to the density criteria (people per hectare) is taken at 25-35. This is because the Population of Banjarbaru City is 506,884 people with an area of 37,130 Ha, so a population density of > 100 people/ha is obtained. The standard of household water demand is based on the type of city and population. Banjarbaru City is a type of big city whose accuracy criteria are more than 100, and the number of urban water demand taken is 25-35. The standard amount of non-domestic water demand according to the Population of Banjarbaru City is 40.

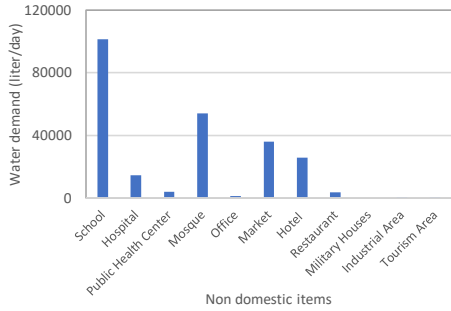


Figure 8. Non-Domestic Water Demand

In Banjarbaru city, non-domestic water demands include water for public facilities such as schools from kindergarten to college, public and private hospitals, public health centers, mosques, government and non-government offices, traditional markets, hotels, restaurants, military houses, and some tourism area.

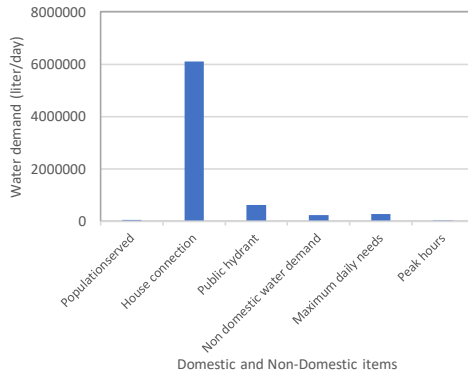


Figure 9. Domestic and Urban Water Demand

The population served is 45,273 people with a house connection (SR) of 90% times the population served multiplied by 150 liters. The water requirement for a public hydrant (KU) is 90% times the house connection (SR). All water requirement includes domestic and non-domestic water demands, and maximum daily needs in peak hours.

The results of the analysis of water demand, the City of Banjarbaru is included in the category of a large city type with a population of 506,884 people. It can be concluded that the total number of non-domestic water demand in 2020 after the *Embung* was built was 240,593.4 Liters/day, and the total number of household and urban water demand was 7,289,740 Liters/day. The population reduction that occurred in 2020 in South Banjarbaru District impacts the amount of water demand in the service area.

Long-term development planning by taking into account the population for the next five years, ten years, 15 years, 20 years, and 25 years using the Geometric Method as shown in Figure 7.

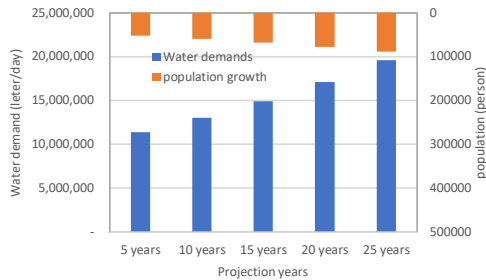


Figure 10. Projection of water demand and population growth after the construction of the *Embung*

The increase in population is used to calculate population projections for five years, ten years, 15 years, 20 years, and 25 years after 2020. Based on population projection, residents served as many as 88,987 people in the next 25 years. This population projection will be used to calculate the need for domestic and non-domestic water in Banjarbaru city.

The projected total domestic water demand after the construction of the *Embung* is 7,807,526 liters/day in 5 years, 8,937,414,318 liters/day in 10 years, 10,230,759.48 liters/day for 20 years, 1,1621,681,5 liters/day, and at 25 years as many as 1,3406,046.2 liters/day.

The projection of total household and urban water demand after the construction of the *Embung* is 11,366.893 liters/day; in 10 years, it is 13,045,123.53 liters/day; in 15 years, it is 14,932,900.78 liters/day; in 20 years as many as 17,093,784.53 liters/day, and at 25 years as many as 19,567,575.3 liters/day.

4.3. Water Balance

Analysis of the water balance that is planned to meet domestic and non-domestic water demand is carried out on population data in 2020, at the time of the start of office relocation in Banjarbaru city. The population growth area is taken in South Banjarbaru District. The analysis of water available to fulfill water demand in the service area of *Embung* in 2020 as shown in Figure 11.

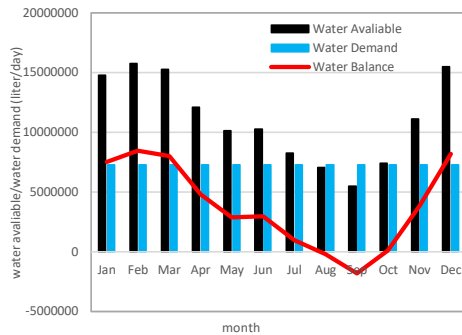


Figure 11. Water Balance Analysis

The water balance obtained by the construction of the *Embung Kampung Banjar* and the water demand to be obtained a surplus water balance for most of the year, except for August and September. In August has a deficit of water as much as 220,829.51 liter/day, and in September, the deficit as 1,815,842.40 liter/day. The highest deficit value occurred in September. It is necessary to regulate the water resource system to cope with these conditions, given the increase in population after 2020 with the movement of office complexes accompanied by the movement of the provincial capital in 2022. Analysis of water demand is carried out on population growth of 5 years, 10 years, 15 years, 20 years, and 25 years as shown in Figure 12.

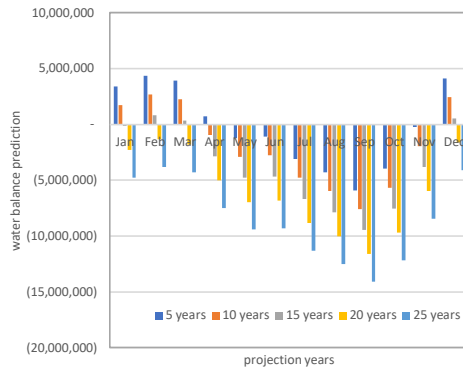


Figure 12. Water Balance for projected to meet water demand

Based on the current water availability data, it is projected to meet water demand for the 5 years, 10 years, 15 years, and 20 years to 25 years projections. It can be seen that water available only can fulfill the water demand in five years projections in January, February, March, April, and December. The deficit of water from May to November. The water deficit occurs from May to November. The water deficit occurs throughout the year to meet water demand for population projections for 20 years and 25 years.

4.4. Water Quality Analysis

Water quality testing at the Embung Kampung Banjar took four samples in the Embung service area, namely Inlet, Outlet, and Paring River. The tool used in this test is U-50 HORIBA (multi-water quality checker). This test is to determine the parameters contained in the water sample. The test is carried out by dipping the U-50 HORIBA (multi-water quality checker) tool into a water sample from which water quality data will be taken.

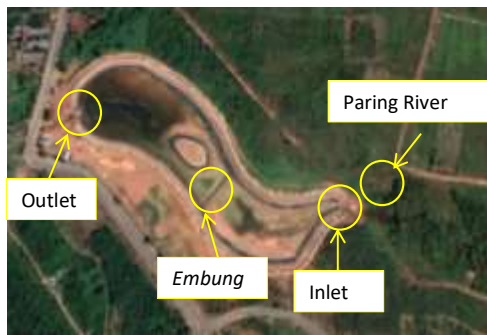


Figure 14. Location of Water Quality Sampling Data

Water quality testing consists of physical, chemical, and biological tests. Based on the tools available at the Hydraulic Laboratory, Faculty of Engineering, Lambung Mangkurat University, the only tests that can be done are physical and chemical tests. The measured water quality includes physical and chemical quality, which consists of water turbidity measurement, water temperature, degree of acidity of the water (pH), and total Dissolved Solid (TDS).

In the physical test, the results obtained from the U-50 HORIBA (multi-water quality checker) tool get turbidity and temperature parameters, while for chemical testing, the results obtained are Ph and Total Dissolved Solid (TDS). From the physical and chemical tests, the parameters of the four samples met the maximum allowable levels. Based on direct observation, it was also found that the water entering and leaving the reservoir was tasteless, odorless, and colorless.

Table 2. Water Quality Sampling Data

No.	Parameter	Unit	Max rate allowed	Inlet	Outlet	Em-bung	Paring River
A. Physical							
1	Turbidity	Scala NTU	25	0.73	0.93	1.03	0
2	Water temperature	°C	air temperature ± 3 °C	30.51	30.34	30.22	29.46
B. chemical							
1	Ph	Mg/L	6,5-9,0	6.77	7.16	7.06	6.4
2	Total Dissolved Solid (TDS)	Mg/L	1500	0.007	0.002	0.002	0.007

Water sampling for 4 locations consisted of an inlet for the first sample, an outlet for the second sample, an Embung for the third location, and the paring river for the fourth sample. Based on the test at the 4 locations, it can be taken from the data that the water quality in the service area of the Embung Kampung Banjar meets the class D water standard. Water turbidity less than 25 NTU. Water temperature based on air temperature ± 3 °C. the average maximum air temperature for the last 5 years is 32.27°C. The degree of acidity of the water (pH) is around 7. TSD less than 1500 Mg/l. It can be used for agriculture, urban businesses, industry, and hydroelectric power plants that can be used by the community around Banjarbaru District.

5. Discussion

5.1. Water balance as water resource management

Water balance in the unit of South Kalimantan Province Offices based on water available in upstream Embung in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after Embung construction is still quite adequate as much as 45,611,711.64 liter/day. The construction of the Embung Kampung Banjar is a good solution to overcoming the current problems of water resource management in Banjarbaru City as the new capital city of South Kalimantan province.

A well-managed reservoir can be used as a water provider to cover water demand in the dry season from water stored in the rainy season. The average annual rain that occurs based on observations at the Banjarbaru climatology station is around 2439.99 mm/year for 20 years, so it has the potential to be captured and utilized. The *Embung Kampung Banjar* is the solution for current water demand. However, in the future, with the increase in population, it is necessary to build other reservoirs or other water source supplies in the South Kalimantan government office.

5.2. Water resources management as water conservation and tourism

The Banjarbaru City Government's planning during the construction of the Embung Kampung Banjar was to function as water conservation as an Embung for groundwater storage, watering plants, and water tourism. Embung also uses to reduce water runoff to Banjarbaru city and water plants. The Banjarbaru city government's planning was in accordance with the conditions when direct observations were made in the field.

Until now, water available needed to fulfill the need for clean water in the service area, namely South Banjarbaru District; it is still served by PDAM Intan Banjar. So the building of Embung still functions more as water conservation for groundwater storage and tourism with the jogging tracks around Embung. In addition to the need for rainwater storage during the rainy season, there is also a need for infiltration areas that are used to replace lands that have changed functions into office areas that are massively closed, and covering an area of 500 ha, it is necessary to take into account how much water runs over the surface considering that Banjarbaru city is a city with a clay soil structure, so it is an area that really needs good groundwater infiltration, considering that the groundwater level in Banjarbaru City is quite deep.

6. Conclusion and Implication

6.1. Conclusion

The conclusions obtained from this research on a simple method of water balance analysis to predict the performance of water resource management in the unit of South Kalimantan province offices based on water available in upstream *Embung* in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after *Embung* construction is still quite adequate as much as 45,611,711.64 liter/day. Although until now, PDAM *Intan Banjar* still provides sufficient water to meet water demand in the service area.

The construction of the reservoir is one of the methods applied by the South Kalimantan provincial government in managing water resources for conservation in the future. In order to increase the population in the future, it is necessary to think about other water sources to meet the water demand caused by population growth.

6.2. Future Research

This research had a small scope of the area of water resources management in the new unit of government offices, with an area of 500 ha. Changes in land use covering an area of 500 ha also need to be considered regarding groundwater storage in the future and the effect of land erosion that can occur, considering that Banjarbaru City is a city with varying land heights.

In general, the relocation of the provincial capital will also cause the transfer of public facilities and other activities. It means needed more water resources management in the future on a larger scale.

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We are grateful for the review of the manuscript that we send, along with this we attach the second revised manuscript of the viewer's improvement. We have also included it on the TLJES website.

Best regards,
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Our decision is to: Accept Submission

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A Simple Method of Water Balance Analysis to Predict the Performance of Water Resource Management in the Unit of South Kalimantan Province Offices

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ABSTRACT

Banjarbaru city was legally established as the capital city of Kalimantan Selatan province, and it needed a new unit of government offices. In the new unit offices of 500 ha, the government built not only office facilities but also a small reservoir or *Embung*. This study aims to analyze the availability of water upstream of the *Embung* that can be provided to fulfill urban water demand in the service area with a simple method of water balance. The conclusions obtained from this research on a simple method of water balance analysis to predict the performance of water resource management in the unit of South Kalimantan province offices based on water available in upstream *Embung* in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after *Embung* construction is still quite adequate as much as 45,611,711.64 liter/day. Although until now, PDAM Intan Banjar still provides sufficient water to meet water needs in the service area. The construction of the reservoir is one of the methods applied by the South Kalimantan provincial government in managing water resources for conservation in the future. With the increase in the population in the future, it is necessary to think about other water sources to meet the water needs due to population growth.

Keywords: water availability, water demand, water balance, water resources management, government official offices, South Kalimantan

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1. Introduction

Banjarbaru city was legally established as the capital city of Kalimantan Selatan province and started on March 16, 2022. It was lawfully validated with Undang-Undang Nomor 8 in 2022 on March 16, 2022 (Undang-Undang RI, 2022). The relocation of the provincial capital has begun with the transfer of government official offices. The South Kalimantan Provincial Government office area is an integrated office area where the spatial layout in it requires various supporting facilities, one of which is an area that can be used as a water catchment area to accommodate/reduce surface runoff leading to Banjarbaru City. The South Kalimantan Provincial Government office area built in 2011, which began with the transfer of the South Kalimantan Provincial Government Offices, which will be occupied by the governor and deputy governor, began to move from the City of Banjarmasin to the City of Banjarbaru in August 2011. Then gradually continued with other offices within the provincial government of South Kalimantan. The official office area of South Kalimantan Province was built on a land area of about 500 hectares, with a total land prepared by the Banjarbaru City Government reaching 2,000 hectares (Gunawan, 2018). The office development program and

regional arrangement in an area of 500 hectares will continue to be carried out in stages until 2025.

Changes in land use covering an area of 500 ha and increasing population growth as 2.43% (BPS, 2022b) in Banjarbaru City lead to an increase in the need for clean water and an increase in the need for water resource management. Water resources are predicted to experience a crisis threat in 2025 in the city of Banjarbaru, along with the development of tourism and population growth of 1.9% annually, which can be accelerated by industrial activities. Extensive industrial and tourism activities will significantly accelerate the depletion of water supply and increase water demand, based on the calculation results of large-scale companies, will accelerate the shortage of water supply for the next ten years (Jarwanto Jarwanto, 2022).

Until now, Banjarbaru City has had a reasonably low intensity of land fires and floods at several points. This could change significantly with the relocation of the provincial capital of South Kalimantan, which will increase the population and increase land use.

The government also builds mini reservoirs. It is called *Embung* in Indonesia. The small reservoir, with an area of more than 6 hectares, is equipped with inlet and outlet buildings, outlet pumps, water pumps, reservoir towers, and jogging tracks (Gunawan, 2018). Many studies of small

reservoirs in other countries. In Georgia Piedmont, USA, mini reservoir influence headwater water quality (Ignatius and Rasmussen, 2016). Small reservoir rise the economic benefits of water management objectives in other countries (Ortiz-Partida, Lane and Sandoval-Solis, 2016). Reservoir ecosystems also support the sustainability of ecosystem services, and help address many of the global threats driving the decline in freshwater biodiversity (Hill *et al.*, 2021).

This small reservoir built in government office area is named The *Embung Kampung Banjar*. The *Embung Kampung Banjar*, which was built in the provincial government office area, in addition to functioning as a catchment, also functions as a water tourism area and is also used for watering plants (Gunawan, 2018). *Embung* are one of the most frequently constructed forms of water conservation in Indonesia (Agung, 2019). Some other benefit of *Embung* is to provide clean water (Prastika, Sundari and Dea, 2010). The *Embung Kampung Banjar* is also expected to work as a water conservation and preservation area and can be used as a source of water and for various purposes in office areas. The project will be carried out in multi-year 2019 – 2020. So it is necessary to evaluate the conservation of water resources with the projected city growth caused by the population increase. The relationship between water availability and water demand is referred to as the water balance (Waligórski *et al.*, 2020). The purpose of this research is to evaluate the water balance that can be supplied by the reservoir to the planned service area (Gunawan, 2018).

2. Literature Review

2.1. Water Available

According to Konapala (2020), the availability of water is the amount of water discharge which is estimated to be continuously in a location (water structure) in a certain amount of water and within a certain period of time (Konapala *et al.*, 2020). There are many methods that can be used to calculate evapotranspiration (Lu *et al.*, 2005). Evapotranspiration can also be calculated with limited climatological data using machine learning (Torres, Walker and Mckee, 2011). Evapotranspiration is a combination of evaporation and transpiration, which includes all evaporation of water that occurs on the earth's surface, including water bodies, soil, and plants. The evapotranspiration formula used is the Penman-Monteith FAO-56 reference evapotranspiration (Allen, 1998).

$$ET_o = \frac{0,408\Delta(Rn - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0,34u_2)}$$

Where:

ET_o = reference evapotranspiration (mm/day)

R_n	=	net radiation at the crop surface (MJ/m ² /day)
G	=	soil heat flux density (MJ/m ² /day)
T	=	mean daily temperature at 2 m height (°C)
u_2	=	wind speed at 2 m height (m/s)
e_s	=	saturation vapor pressure (kPa)
e_a	=	actual vapor pressure (kPa)
$e_s - e_a$	=	saturation vapor pressure deficit (kPa)
Δ	=	slope vapor pressure curve (kPa/°C)
γ	=	psychometric constant (kPa/°C)

So far, the availability of water is widely used to meet the irrigation water demand (Kylstra *et al.*, 2021) (Sun, Huang and Wang, 2017). The availability of water is not only used to meet irrigation water demand, but can also be used for water resource conservation, urban water demand and water disaster (Khalequzzaman K and Amirul, 2008)(Novitasari *et al.*, 2021). Water availability is calculated using the F.J. Mock model as the modification of Tank Model (Nurrochmad, Sujono and Damanjaya, 1998; Lee, Chegal and Lee, 2020). The F.J Mock model with the output value is in the form of discharge data in the watershed at the research location.

$$R = \sqrt{\frac{Dt^2 - D^2}{Dt^2}}$$

$$\text{Where: } Dt^2 = \sum_{i=1}^N (Q^i_{obs} - \bar{Q})^2$$

$$D^2 = \sum_{i=1}^N (Q^i_{obs} - Q^i_{sim})^2$$

$$\bar{Q} = \frac{\sum_{i=1}^N Q^i_{obs}}{N}$$

The formula can calculate volume Error (VE):

$$VE = \frac{\sum_{i=1}^N Q^i_{obs} - \sum_{i=1}^N Q^i_{sim}}{\sum_{i=1}^N Q^i_{obs}}$$

Where:

Q_{sim}	=	simulation discharge of the i period (m ³ /s)
Q_{obs}	=	observation discharge of the i period (m ³ /s)
\bar{Q}	=	average observation discharge (m ³ /s)
N	=	the amount of data

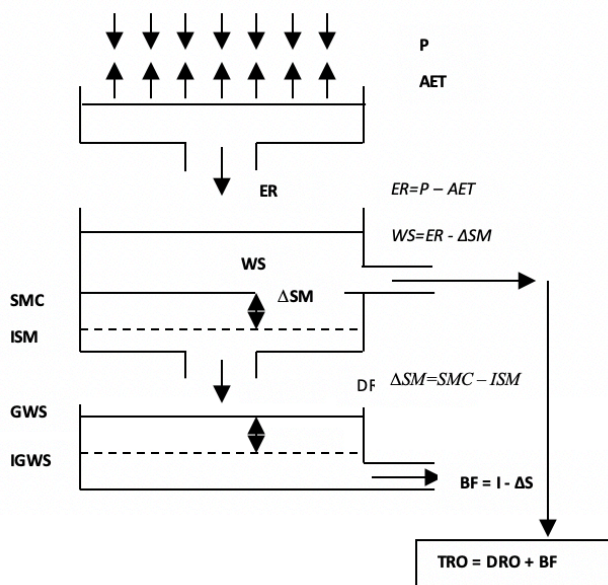


Figure 1. Mock methods schema (Nurrochmad, Sujono and Damanjaya, 1998).

2.2. Water Demand

The number of populations that will be served in accordance with the portion can affect the quantity requirements of urban water demand, which generally people must obtain clean water and drinking water anytime for 24 hours to meet their needs. Water demand can be divided into household and household demand. According to the Directorate General of Cipta Karya (2000) there are 2 (two) standards for water demand. The domestic water demand has standards for use in private residences so that daily needs can be met, such as drinking water, cooking, washing. The other household demand and non-domestic water demand are clean water demand that are not household demand. The use in non-domestic is commercial, industrial, and general. Household and urban water demands are essential to be met so that there is no unsuccessful to fulfill water demand which can lead to various kinds of disease outbreaks and unrest in the community. The water demand is correlated with population growth. Population projection is the calculation of the total population with the aim of obtaining past and future information in the context of long-term development planning. Population data is obtained from the census conducted by the Central Statistics Agency of Banjarbaru City and other government departments or institutions. In this study, the population projection calculation used is the geometric method (BPS, 2022b).

$$r = \left(\frac{P_t}{P_0} \right)^{1/t} - 1$$

Where:

r = Population growth rate

p_t = population of year t

p_0 = amount of base population year

t = time period between the base year and year t (in years)

2.3. Water Balance

A simple water balance analysis is based on a correlation between water availability and water demand in the location (Armstrong and Johnson, 2018). The water balance calculations are used to meet irrigation water demand (Ariyani, Putuhena and Wira, 2020) and urban water demand (Reed, Maidment and Patoux, 1997). The water balance is also used to calculate reservoir capacity (Brust *et al.*, 2018).

2.4. Water Quality Measurement

Water quality analysis is needed to get the water quality that suits its needs. There are two regulations used in this study. Government Regulation (PP) No 82 dated December 14, 2001 on Water Quality Management and Water Pollution Control (Pemerintah Republik Indonesia, 2001) dan Minister of Health Regulation enacted on May 31 2017 about Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene, Swimming Pools, Solus Per Aqua, and Public Baths (Menteri Kesehatan Republik Indonesia, 2017).

2.5. Small Reservoir (*Embung*)

Embung, or what is usually also called a small reservoir, is a construction that is built to conserve the flow of water. This retained water will collect in *Embung* that can be used as the demand for irrigation, household, industrial water, hydroelectric power plants, and others (Arsyad, 2017a). Based on the opinion of one expert, a reservoir is an artificial building that functions to accommodate and store water with a certain small volume capacity, smaller than the capacity of the reservoir/dam (Kodoatie and Roestam Syarief, 2010). Types of reservoirs are grouped into four types, namely as follows: 1. based on the purpose of construction with reservoirs for residential purposes and multipurpose reservoirs, 2. based on their use as water reservoirs, deflectors, and retainers, 3. Based on their location to the flow of water, reservoirs on watercourses, and reservoirs outside the watercourse, and 4. based on the constituent material, embankment reservoirs and reservoirs of concrete (Soedibyo, 1993; Arsyad, 2017b).

The planning of a water reservoir in *Embung* is based on the estimation of water availability to ensure water supply every year in both rainy and dry seasons. This includes not only the capacity of the reservoir and the height of the dam in accordance with the availability of water, but also the entire

utilization system must be designed based on the needs and benefits, for example, the installed capacity of hydropower, irrigation water distribution systems and so on (Arsyad, 2017c).

3. Research Methodology

3.1. Data

Rainfall analysis is calculated by adding up the daily rainfall per month in one period. The rainfall data used is derived from the Banjarbaru Climatology Station for a period of 20 years (2001 to 2020) (BMKG, 2022). The method used to calculate evapotranspiration is the Penman-Monteith FAO-56 method, with climatological data downloaded on the BMKG Online (BMKG, 2022).

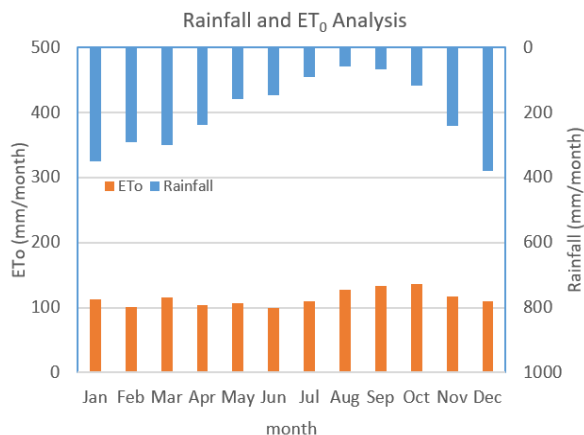


Figure 2. Rainfall and *ET₀* Analysis

From rainfall data from the year 2000 to the year 2020, the average annual rain is 2439.99 mm/year. The yearly average evapotranspiration is 1374.13 mm/year. The lowest rainfall intensity occurred in August at 57.88 mm/month and the highest in December at 379.73 mm/month. The average monthly rainfall data is 203.33 mm/month. The monthly evapotranspiration data from the year 2000 to the year 2020, the highest data in October was 136.72 mm/month, and the lowest evapotranspiration data in June was 99.54 mm/month. The average monthly evapotranspiration data is 114.51 mm/month. Based on rain data and evapotranspiration data, it is determined the availability of water upstream of the reservoir.

Banjarbaru city, with a total area of 305.242 km² divided into five districts, Landasan Ulin, with an area of 74.054 km², Liang Anggang of 74.773 km²; Cempaka of 114.543 km²; North Banjarbaru 26.855 km², and South Banjarbaru 15.027 km² (BPS, 2022b). BPS (Central Bureau of Statistics) Banjarbaru City recorded data from 2013 – 2020. The highest population data is in the Landasan Ulin sub-district as many as 75,385 residents, and the lowest data is in the Cempaka sub-district as many as 35,584 residents (BPS,

2022a). Population growth is one of the effects of moving offices and government centers to Banjarbaru City.

In the South Banjarbaru sub-district, in the year 2013, the population of as many as 46,872 residents. It increases until years 2019, with as many as 67,542 residents but decreases in years 2020 to as many as 45,273 people, as shown in Figure 6. The Population in South Banjarbaru District in 2020 decreased by 32% because, in 2020, there was a Covid-19 pandemic (BPS, 2022b). The population growth rate reached 1.7.

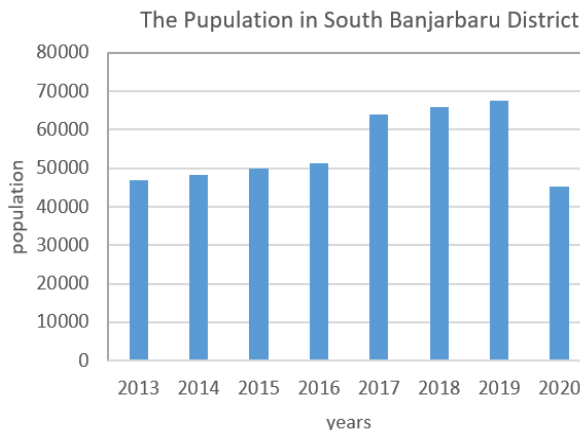


Figure 3. The Population in South Banjarbaru District

3.2. Research Area

The Banjarbaru City area is located at an altitude of 500 m above sea level, with an altitude of 0 – 7 m (33.49%), 7 – 25 m (48.46%), 25 – 100 m (15.15%), 100 – 250 m (2.55%) and 250 – 500 m (0.35%) (BPS, 2022b). The slope classification of Banjarbaru City is a slope of 0 – 2% covering 59.35% of the area, a slope of 2 – 8% covering 25.78% of the area, a slope of 8 – 15% covering 12.08% of the area. The rock classification in Banjarbaru City consists of Alluvium 48.44%. In the city of Banjarbaru, there are 3 (three) groups of soil types, namely Podzol soil (63.82%), Lathosol (6.36%), and Organosol (29.82%) (RPIJM, 2015). The South Kalimantan provincial government office building covering an area of 500 hectares in Banjarbaru city can be seen on the map below and is located in the Cempaka sub-district.

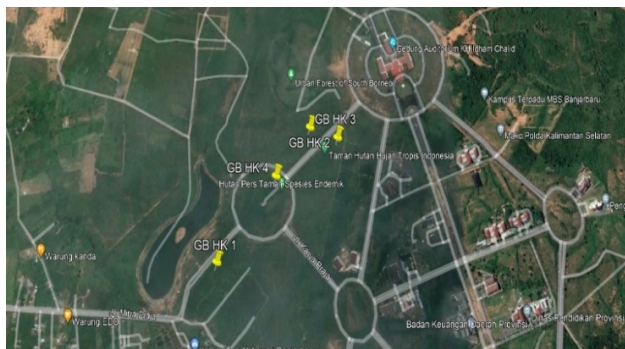


Figure 3. Research Study

The *Embung Kampung Banjar* was built in the area of the South Kalimantan provincial government office building in Kampung Banjar village. It is geographically 3°28'27,9" south latitude and 114°49'39" north latitude (Gunawan, 2018).

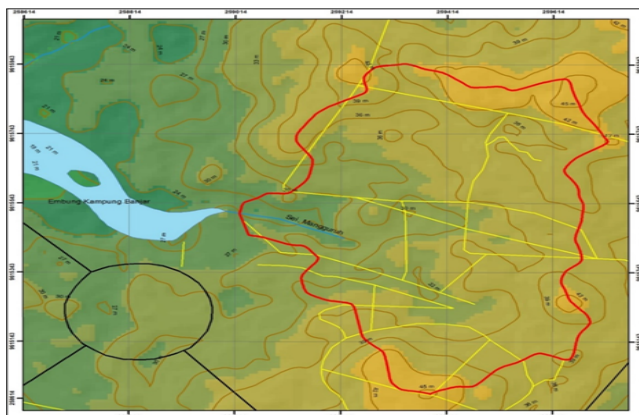


Figure 4. The *Embung Kampung Banjar*

The *Embung Kampung Banjar* has a service area in the part of the sub-district of South Banjarbaru and other sub districts with an area of 21.96 km². Facilities located at the *Embung Kampung Banjar* service location include water catchment areas, water tourism areas, reservoirs to reduce runoff to Banjarbaru city, watering plants, and water preservation and conservation areas. The water demand has increased with the increase in population.

4. Result

4.1. Water Available Analysis

Water available analysis calculates from the river discharge data of the Riam Kiwa River. The calibration was conducted in 2001 with an area of 382 km² (Novitasari *et al.*, 2021). Based on discharge data observed in 2001, water discharge in other years can be calculated using mock parameters from the Riam Kiwa River. The wet infiltration coefficient is 0.3, the dry infiltration coefficient is 0.4, the initial soil moisture (ISM) is 110 mm, the soil moisture

capacity (SMC) is 220 mm, the initial ground water storage (IGWS) is 1000 mm, and groundwater recession Constant (*k*) as 0.810.

The average monthly discharge data for 20 years is presented in Figure 5. The average annual discharge data is presented in Figure 6. The effectiveness of using Riam Kiwa discharge data to determine the calculated discharge with the measured discharge data obtained at the research location is shown in Table 1.

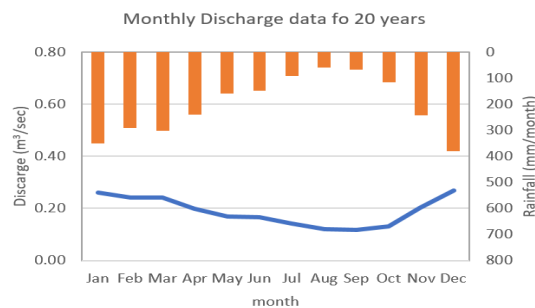


Figure 5. The average monthly discharge data for 20 years.

The highest monthly average discharge for 20 years occurred in December at 0.27 m³/second, while the lowest discharge occurred in August and September at 0.12 m³/second. Debit rata-rata bulanan sebesar 0.19 m³/detik.

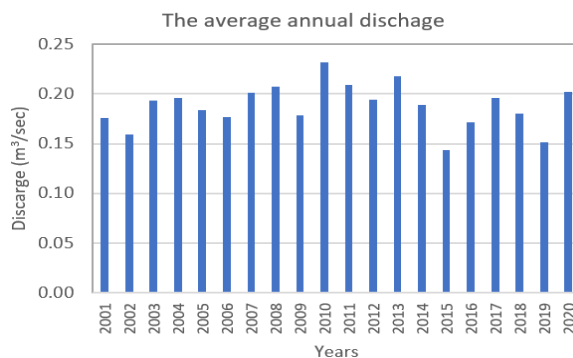


Figure 6. The average annual discharge data

Analysis of annual discharge from 2001 to 2020 found that the highest average annual discharge occurred in 2010 at 0.23 m³/second, and the lowest average annual discharge occurred in 2015 at 0.14 m³/second. The limitations of the discharge measurement data for analysis using the mock model need to be eliminated by measuring the instantaneous discharge at the research site. Measured discharge in upstream *Embung* (Paring River), *Embung Inlet*, and *Embung outlet* in April and May 2021.

Table 1. Data for Measured Discharge of *Embung Kampung Banjar*

Location	Qobs (2021) (m ³ /s)		Qcal (2021) (m ³ /s)		Qcal mean (m ³ /s)	
	Apr	May	Apr	May	Apr	May
Upstream	0.04	0.04				
Inlet	0.02	0.08	0.08	0.09	0.19	0.15
Outlet	0.02	0.002				

The effectiveness is analyzed against the calculated discharge in 2021 and the average annual discharge in April and May. The value of the effectiveness of using the Riam Kiwa River discharge data for the calibration process at the *Embung Kampung Banjar* is 25% in April 2021 and 88% in May 2021. In April 2021, the effectiveness value was very small because, at the time of measurement, it was a day that rarely rains, starting from the middle of April, causing the measured discharge to be very low.

The mainstay discharge is calculated by sorting the average discharge per year (2001-2020) from the largest value to the smallest value so that the average discharge value is obtained at a probability of 90% for domestic water purposes. The following are the steps for calculating the mainstay discharge.

- The monthly average discharge data is sorted from the largest to the smallest.
- Give a sequence of r from 1 to N where the value of N is 20.
- The probability of the Weibull method that r is 1
- $$P = \frac{r}{(N+1)} \times 100\% = \frac{1}{(20+1)} \times 100\% = 4,76\% \approx 5\%$$
- Then look for the required mainstay discharge; because the function of the reservoir is of them to meet the needs of r water in the neighborhood of the location, the mainstay discharge used is Q_{90} , specifically for domestic water demand.

The results of the monthly Q_{90} calculation can be seen in the table below.

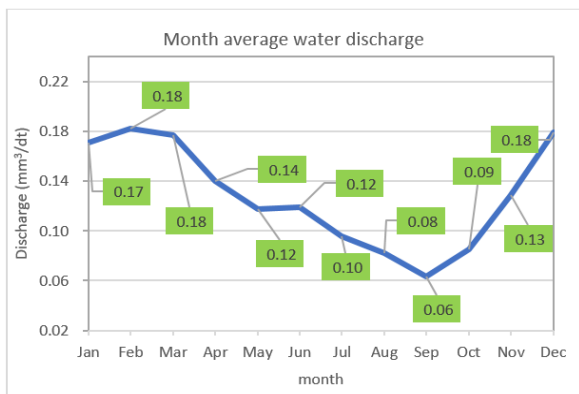


Figure 7. Month Average Water Discharge in 2001-2020

The most reliable discharge for water demand was obtained in February, March, and December with a discharge value of 0.18 m³/s and the smallest occurred in with a discharge value of 0.06 m³/s. The availability of water in the *Embung Kampung Banjar* will be used to fulfill the water demand of the local population, the need for watering plants, and also the drinking water demand of livestock, especially during the dry season, when very little rain occurs. The reservoir is expected to be fully filled at the end of each rainy season so that it can be used during the dry season.

4.2. Water Demand

The amount of urban water demand according to the density criteria (people per hectare) is taken at 25-35. This is because the Population of Banjarbaru City is 506,884 people with an area of 37,130 Ha, so a population density of > 100 people/ha is obtained. The standard of household water demand is based on the type of city and population. Banjarbaru City is a type of big city whose accuracy criteria are more than 100, and the number of urban water demand taken is 25-35. The standard amount of non-domestic water demand according to the Population of Banjarbaru City is 40.

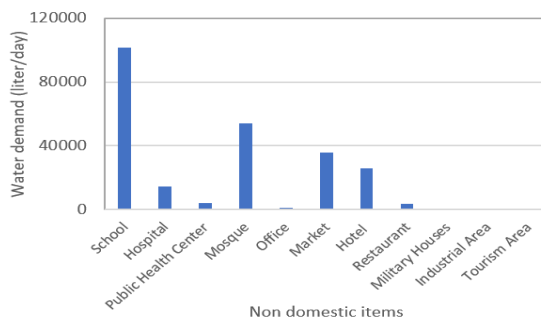


Figure 8. Non-Domestic Water Demand

In Banjarbaru city, non-domestic water demands include water for public facilities such as schools from kindergarten to college, public and private hospitals, public health centers, mosques, government and non-government offices, traditional markets, hotels, restaurants, military houses, and some tourism area.

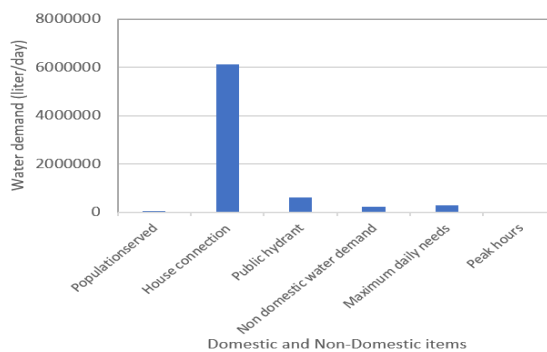


Figure 9. Domestic and Urban Water Demand

The population served is 45,273 people with a house connection (SR) of 90% times the population served multiplied by 150 liters. The water requirement for a public hydrant (KU) is 90% times the house connection (SR). All water requirement includes domestic and non-domestic water demands, and maximum daily needs in peak hours.

The results of the analysis of water demand, the City of Banjarbaru is included in the category of a large city type with a population of 506,884 people. It can be concluded that the total number of non-domestic water demand in 2020 after the *Embung* was built was 240,593.4 Liters/day, and the total number of household and urban water demand was 7,289,740 Liters/day. The population reduction that occurred in 2020 in South Banjarbaru District impacts the amount of water demand in the service area.

Long-term development planning by taking into account the population for the next five years, ten years, 15 years, 20 years, and 25 years using the Geometric Method as shown in Figure 10.

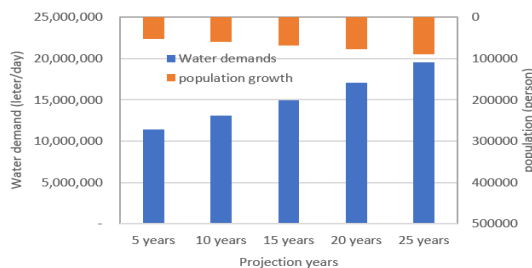


Figure 10. Projection of water demand and population growth after the construction of the *Embung*

The increase in population is used to calculate population projections for five years, ten years, 15 years, 20 years, and 25 years after 2020. Based on population projection, residents served as many as 88,987 people in the next 25 years. This population projection will be used to calculate the need for domestic and non-domestic water in Banjarbaru city.

The projected total domestic water demand after the construction of the *Embung* is 7,807,526 liters/day in 5 years, 8,937,414,318 liters/day in 10 years, 10,230,759.48 liters/day for 20 years, 1,1621,681,5 liters/day, and at 25 years as many as 1,3406,046.2 liters/day.

The projection of total household and urban water demand after the construction of the *Embung* is 11,366.893 liters/day; in 10 years, it is 13,045,123.53 liters/day; in 15 years, it is 14,932,900.78 liters/day; in 20 years as many as 17,093,784.53 liters/day, and at 25 years as many as 19,567,575.3 liters/day.

4.3. Water Balance

Analysis of the water balance that is planned to meet domestic and non-domestic water demand is carried out on population data in 2020, at the time of the start of office

relocation in Banjarbaru city. The population growth area is taken in South Banjarbaru District. The analysis of water available to fulfill water demand in the service area of *Embung* in 2020 as shown in Figure 11.

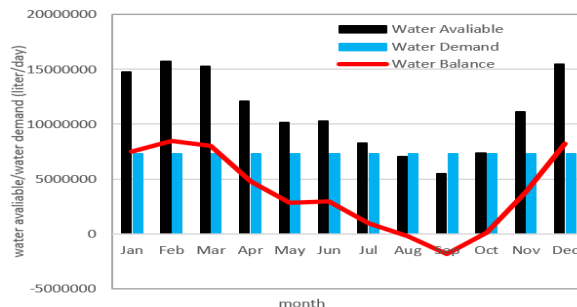


Figure 11. Water Balance Analysis

The water balance obtained by the construction of the *Embung Kampung Banjar* and the water demand to be obtained a surplus water balance for most of the year, except for August and September. In August has a deficit of water as much as 220,829.51 liter/day, and in September, the deficit as 1,815,842.40 liter/day. The highest deficit value occurred in September. It is necessary to regulate the water resource system to cope with these conditions, given the increase in population after 2020 with the movement of office complexes accompanied by the movement of the provincial capital in 2022. Analysis of water demand is carried out on population growth of 5 years, 10 years, 15 years, 20 years, and 25 years as shown in Figure 12.

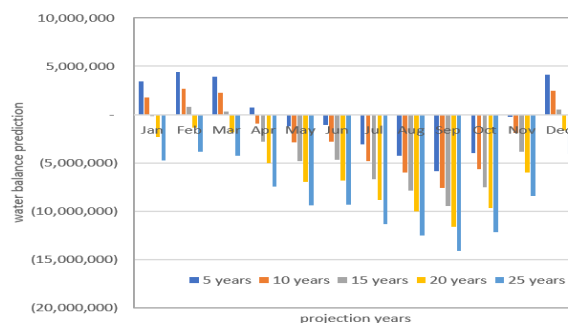


Figure 12. Water Balance for projected to meet water demand

Based on the current water availability data, it is projected to meet water demand for the 5 years, 10 years, 15 years, and 20 years to 25 years projections. It can be seen that water available only can fulfill the water demand in five years projections in January, February, March, April, and December. The deficit of water from May to November. The water deficit occurs from May to November. The water deficit occurs throughout the year to meet water demand for population projections for 20 years and 25 years.

4.4. Water Quality Analysis

Water quality testing at the Embung Kampung Banjar took four samples in the Embung service area, namely Inlet, Outlet, and Paring River.

The tool used in this test is U-50 HORIBA (multi-water quality checker). This test is to determine the parameters contained in the water sample. The test is carried out by dipping the U-50 HORIBA (multi-water quality checker) tool into a water sample from which water quality data will be taken.

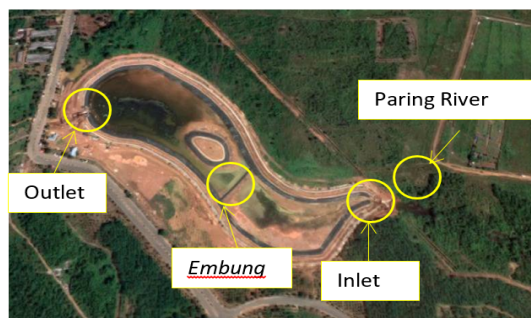


Figure 13. Location of Water Quality Sampling Data

Table 2. Water Quality Sampling Data

No.	Parameter	Unit	Max rate allowed	Inlet	Outlet	Em-Bung	Paring River
A. Physical							
1	Turbidity	Scala NTU	25	0.73	0.93	1.03	0
2	Water temperature	°C	air temperature ± 3 °C	30.51	30.34	30.22	29.46
B. chemical							
1	Ph	Mg/L	6,5-9,0	6.77	7.16	7.06	6.4
2	Total Dissolved Solid (TDS)	Mg/L	1500	0.007	0.002	0.002	0.007

Water sampling for 4 locations consisted of an inlet for the first sample, an outlet for the second sample, an Embung for the third location, and the paring river for the fourth sample. Based on the test at the 4 locations, it can be taken from the data that the water quality in the service area of the Embung Kampung Banjar meets the class D water standard. Water turbidity less than 25 NTU. Water temperature based on air temperature ± 3 °C. the average maximum air temperature for the last 5 years is 32.27°C. The degree of acidity of the water (pH) is around 7. TSD less than 1500 Mg/l. It can be used for agriculture, urban businesses, industry, and hydroelectric power plants that can be used by the community around Banjarbaru District.

5. Discussion

5.1. Water balance as water resource management

Water quality testing consists of physical, chemical, and biological tests. Based on the tools available at the Hydraulic Laboratory, Faculty of Engineering, Lambung Mangkurat University, the only tests that can be done are physical and chemical tests. The measured water quality includes physical and chemical quality, which consists of water turbidity measurement, water temperature, degree of acidity of the water (pH), and total Dissolved Solid (TDS).

In the physical test, the results obtained from the U-50 HORIBA (multi-water quality checker) tool get turbidity and temperature parameters, while for chemical testing, the results obtained are Ph and Total Dissolved Solid (TDS). From the physical and chemical tests, the parameters of the four samples met the maximum allowable levels. Based on direct observation, it was also found that the water entering and leaving the reservoir was tasteless, odorless, and colorless.

Water balance in the unit of South Kalimantan Province Offices based on water available in upstream Embung in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after Embung construction is still quite adequate as much as 45,611,711.64 liter/day. The construction of the Embung Kampung Banjar is a good solution to overcoming the current problems of water resource management in Banjarbaru City as the new capital city of South Kalimantan province.

A well-managed reservoir can be used as a water provider to cover water demand in the dry season from water stored in the rainy season. The average annual rain that occurs based on observations at the Banjarbaru climatology station is around 2439.99 mm/year for 20 years, so it has the potential to be captured and utilized. The *Embung Kampung Banjar* is the solution for current water demand. However, in the future, with the increase in population, it is necessary

to build other reservoirs or other water source supplies in the South Kalimantan government office.

5.2. Water resources management as water conservation and tourism.

The Banjarbaru City Government's planning during the construction of the Embung Kampung Banjar was to function as water conservation as an Embung for groundwater storage, watering plants, and water tourism. Embung also uses to reduce water runoff to Banjarbaru city and water plants. The Banjarbaru city government's planning was in accordance with the conditions when direct observations were made in the field.

Until now, water available needed to fulfill the need for clean water in the service area, namely South Banjarbaru District; it is still served by PDAM Intan Banjar. So the building of Embung still functions more as water conservation for groundwater storage and tourism with the jogging tracks around Embung. In addition to the need for rainwater storage during the rainy season, there is also a need for infiltration areas that are used to replace lands that have changed functions into office areas that are massively closed, and covering an area of 500 ha, it is necessary to take into account how much water runs over the surface considering that Banjarbaru city is a city with a clay soil structure, so it is an area that really needs good groundwater infiltration, considering that the groundwater level in Banjarbaru City is quite deep.

6. Conclusion and Implication.

6.1. Conclusion

The conclusions obtained from this research on a simple method of water balance analysis to predict the performance of water resource management in the unit of South Kalimantan province offices based on water available in upstream *Embung* in the year 2020 as 133,090,606.2 liter/day to fulfill water demands in service area as 87,478,894.55 liter/day after Embung construction is still quite adequate as much as 45,611,711.64 liter/day. Although until now, PDAM *Intan Banjar* still provides sufficient water to meet water demand in the service area.

The construction of the reservoir is one of the methods applied by the South Kalimantan provincial government in managing water resources for conservation in the future. In order to increase the population in the future, it is necessary to think about other water sources to meet the water demand caused by population growth.

6.2. Future Research

This research had a small scope of the area of water resources management in the new unit of government offices, with an area of 500 ha. Changes in land use covering

an area of 500 ha also need to be considered regarding groundwater storage in the future and the effect of land erosion that can occur, considering that Banjarbaru City is a city with varying land heights.

In general, the relocation of the provincial capital will also cause the transfer of public facilities and other activities. It means needed more water resources management in the future on a larger scale.

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