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Water Security in Ambon City

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Abstract

Water security is the ability of the community to maintain sustainability water needs, both in sufficient quantities and acceptable quality. Ambon City is one of the biggest centers of activity in Maluku Province because Ambon City is the capital of Maluku Province. Clean water management in Ambon City shows that Ambon City still needs an increase in clean water production capacity due to springs in Sirimau District has experienced a crisis since the beginning of 2016. The method used in this study based Indonesian National Standard 6728.1: 2015 concerning the preparation of the spatial balance of natural resources section 1 – resources water. From the analysis results, it is obtained that the projected water demand in Ambon City in 2039 is 4.092 m^3/second consists of household water needs 1.441 m^3/second, non-domestic water needs 0.432 m^3/second, industrial water needs 1.195 m^3/second, livestock water needs are 0.044 m^3/second and agricultural-horticultural water needs are 0.980 m^3/second. The total debt of available water resources infrastructure in Ambon City in 2018 is 0.282 m^3/second consisting of Drinking Water Provider System. Based on the results of the water balance analysis, the water demand in Ambon City is still high has not been fulfilled because water needs are greater than the availability of water. However, Ambon City has the potential for mainstay discharge of 250.424 m^3/second which can be used to meet water needs in the city of Ambon. Recommendation water resource infrastructure to accommodate the mainstay discharge is in the form of the building as many reservoirs 168 units with a total storage capacity of 30.350 million m^3/second with an estimated construction cost of the reservoir IDR 1,308,692,000,000.

Keywords: Water Security, Water Demand, Water Availability, Mainstay Discharge, Water Balance, Ambon City

Introduction

Massive population growth and industrial development was followed by high land requirements for industry and housing, increased water demand, increased environmental pollution, and increased runoff surface. The problems that arise must be stated in a measurable urban water security concept, which can describe the response of a city in dealing with water problems, namely a city has the ability in responding to water needs, ensuring environmental and ecosystem health, maintaining water sustainability, coping disaster and independence to overcome the extreme conditions of global weather change (Wuysang, 2016).

The Maluku Islands is one of the regions in eastern Indonesia which has a level development inequality very high region. The condition infrastructure of the islands in the eastern part of Indonesia indeed relatively behind compared to the islands of Central and West. This condition is characterized by the value of this coefficient the second-highest value after the Papua region. Increasing water, food and energy security will also be a strategic issue in the long run, remember that the Maluku Islands is one of Indonesia's food bases based on fisheries and marine products, so that support to maintain the quality of waters in the Maluku Islands is a necessity main things to do (Maluku Infrastructure Development Master Plan, 2017). Average rainfall in the Province Maluku is below 1500 mm per year (Meteorology, Climatology and Geophysics Agency, 2016). The climate characteristics are inclined to dry and lack of surface water certainly need infrastructure support for water supply in the form of storage rainwater that is adaptive to nature with high evaporation (Maluku Infrastructure Development Master Plan, 2017).

Ambon City is one of the largest centers of activity in the Maluku province because Ambon City is the capital of Maluku province. In accordance with government regulation number 13 of 1979, the total area of Ambon City is 37,700 hectare with land area of 35,945 hectares (Central Statistics Agency, 2017). Based on disaster analysis, 80% of Ambon city area dominated by drought with a risk area of 29,753 hectare and extreme weather with a risk area of 21,220 hectares. Ambon City has moderate annual rainfall of around 1,000-3,000 mm/year, but water scarcity still often occurs mainly during the dry season. The impact of the drought in Ambon City is the availability of raw water in Ambon City particular in the area of Batumerah, Negeri Nusaniwe (Gunung Nona).

Based on the Climate classification according to Schmidt and Ferguson (1951), Ambon City is classified as a type B climate characterized by the average dry month (rainfall <60 mm) is 1.67 months and the wet month (rainfall> 100 mm) is 9.58 months with a Q value of 17.4%. During 2016 the highest rainfall in Ambon City occurred in July amounted to 914 mm with 28

days of rain, while the lowest rainfall occurred in February which was 34 mm with 113 days rain. Climatic conditions also contribute to the threat of disasters, especially droughts, floods, and landslides.

The drought in Ambon City is less influential in the agricultural sector, this is due to the agricultural sector not yet a leading sector in Ambon City. People who work as farmers will have alternative income others and the need for agricultural foodstuffs will be obtained from the regency around Maluku, Sulawesi Province South, North Sulawesi, and East Java. The impact of the drought in Ambon City is on the availability of raw water in the City Ambon, especially in the area of the State of Batumerah, Negeri Nusaniwe (Mount Nona), where when drought occurs then public spending will increase to buy water. Regional Water Supply Company Data on water management in Ambon City shows that Ambon Island still needs to increase its clean water production capacity due to springs in Sirimau District experiencing a clean water crisis since early 2016. Research on water security in the Ambon City aims to:

1. Knowing how much water needs in the city of Ambon.
2. Knowing how big the potential of water resources is in Ambon City.
3. Identifying the availability of water resources infrastructure in Ambon City.
4. Identifying the spatial water balance between water needs, availability and potential in Ambon City.
5. Determine infrastructure recommendations for water security.

The study of water security in Ambon City, the discussion is limited on several things, namely the calculation of projections water needs based on Indonesian National Standard 6728.1 2015 and water security analysis based on water balance.

Theoretical Basis

Water security is vital in human life, and is closely related to food and energy security, as the link between water, food, and energy security (Head, 2010). This is closely related to the conditions of balance between utilization of water resources to support various sectors of life, by conserving water resources (Asdak, 2015). Although all the world community has agreed that water security needs to be considered, both for managing water resources, also in sustainable development in general, but there is no agreement on how to define water security. Until now it has not been agreed on what the minimum water security value is for households, urban areas, watersheds, and countries can develop sustainably without worrying about drought and flood that might occur.

UN-Water (2013) formulates the notion of water security as follows: "Water security is defined as the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability. "

The definition provides a very comprehensive understanding of water security. Translation free from the definition of water security is the ability of the community to maintain sustainability in fulfillment water needs, both in sufficient quantities and acceptable quality, meeting those water needs intended to maintain the sustainability of life, the well-being of humanity, and socio-economic development, guarantee protection of water pollution and water-related disasters, and preserve ecosystems in a peaceful and atmosphere stable political conditions.

Water security according to the Asian Water Development Outlook (AWDO, 2013) consists of 5 dimensions, namely:

1. Household Water Security: meeting the needs of household clean water and sanitation for all residents.
2. Economic Water Security: fulfilling water needs to support food production (irrigation, fishery farming), industry, trade, etc.
3. Urban Water Security: meeting water needs to support ongoing urban and regional activities travel.
4. Environmental Water Security: maintaining the quality of the aquatic environment (pollution control, erosion, etc.), flow river maintenance (environmental flow).
5. Water Resilience to Water Disasters: flood control, landslides, drought.

Specifically, the water security of some literature is the water security of social and environmental functions and economics with dimensions of household water security, economic water, urban water, environmental water, and disaster water. In carrying out water resources management activities, in addition to understanding the objectives and water management systems for meeting human and environmental needs also requires an understanding of the science of hydrology and water systems. The relationship between successful management with hydrology and water systems is very strong, namely the presence of water in form the amount, time and quality associated with the hydrological process and the water system.

Water balance (water balance) is a balance of input (inflow) and water output (outflow) somewhere in the period certain so that it can find out the amount of water excess (surplus) or deficiency (deficit). While according to Seyhan (1990). It can also be interpreted that the water balance is a quantitative relationship between water received by land (input) and water

coming out / lost from the land (output) and changes in water reserves in the soil. During a certain time interval, the total water input in a given space must be equal to the total output plus changes in reserves. Water balance equation is used to predict the availability of water in a room or region. The usefulness of knowing the condition water in surpluses and deficits can anticipate possible disasters and can also be used to utilize water the best. The general water balance model is to use climatological data.

Based on Indonesian National Standard 6728.1: 2015 concerning Spatial Balance Sheet Planning for Natural Resources - Section 1 Water Resources, water balance is information about the potential, availability and use balance water resource requirements for a certain period of time. Water balance calculation is done based on a comparison between the availability of water by taking into account the talking points (for example weir or reservoir) with a total water needs in the area it serves, not taking into account the use of optimization in the event of deficit water. The steps for analyzing water balance can be explained as follows:

1. Calculate the availability of water that will serve certain administrative areas as central points of need which also calculated the water needs.
2. Calculate the balance of water between the points of need with the area of water availability that serves it.
3. Projection of needs so that future water needs can be estimated.

According to the river basin water resource planning manual prepared by the Directorate General. Water resources Kimpraswil Department in 2001, the focus of the study of water resource development includes potential calculation activities water resources, analysis of existing and future years' water demand and at the same time making analysis balance of water resources, as well as providing alternative water resources that can be utilized.

Literature Review

Kumalajati (2015) for calculating water needs in the Keduang River Basin, standards and formulas used based on the Indonesian National Standard 19-6728.1-2002 (National Standardization Agency, 2002) and Criteria Planning of the Directorate General of Human Settlements (Public Works Office, 1996) with a standard table of water requirements for each interest. This research shows that the increase in water demand is caused by an increase in the population of year on year, whereas the decrease in water availability is caused by a decrease in infiltrated water which is affected by trends in land cover changes that occur. Changing the direction of land change from current trends to conservative changes to water need to be made to anticipate water deficits that will occur in the future front.

Gain (2016) in his research presents the criteria for a multi-spatial analysis framework to provide an assessment of global water security. Research shows that African, South Asian and Middle Eastern countries experience very low water resistance. Other areas of high water scarcity, such as parts of the United States, Australia, and Southern Europe, showing better values of the Global Water Safety Index (GWSI), due to management performance, safety and good quality, and accessibility.

Wuysang (2016) developed a theoretical framework for city water security from several key dimensions (household, environment, and economy). The dimensions chosen depend on the situation and subjectivity. Research shows that indicators and variables developed from the theoretical framework of city water security have a very strong relationship with city level and condition of a city so that indicators and variables for each city will be very varied adapted to the conditions of the city.

Waluyo (2018) uses water security indicators adopted from ADB (2016) but is developed and adapted to the availability of data and characteristics of river basins in Indonesia. This research shows that irrigation water security in river areas in Indonesia is generally in "moderate" condition. Efforts that can be made to improve irrigation water-resistance are to develop and improve irrigation network performance, increase the reliability of water supply by building reservoirs and reservoirs, and reduce water use pressure by saving water.

Material and Methods

The research method used is a secondary survey method, carried out through secondary data collection which is a confirmation of the results of previous studies or based on information from the agencies concerned with water resource management such as Public Works Agency, Regional Water Supply Company, and Central Statistics Agency. Water demand in Ambon City is calculated based on standards and formulas used in the National Standards Indonesia 19-6728.1-2015 (National Standards Agency, 2015).

1. Problem identification and literature review
   Identifying problems and literature studies of previous research and theories used.
2. Secondary data collection
   Secondary data is archival data obtained from related agencies. Data used in research are:

Table 1: Data Used in Research

No	Data Type	Data Source
1	Hydroclimatological Data	Climatology and Geophysics Meteorology

No	Data Type	Data Source
		Agency (Pattimura Meteorological Station), Central Statistics Agency Ambon City
2	Region Profile Data	Data in Figures, Central Statistics Agency Ambon City
3	Spatial Planning and Ambon City Region, City Regulations Ambon	Spatial Geographic Information System
4	Water Resources Infrastructure	National Water Resources, Counters Peta, Public Works Agency
5	Drought Disaster Map	Disaster management Agency Ambon City Area

3. Analysis of water demand
   The calculated water needs are a household, urban and industrial water needs, agricultural water needs, and livestock water needs.
4. Analysis of availability
   Analysis of the availability of reliable discharge is calculated using the mock method, as well as identifying water sources existing in Ambon City such as springs, reservoirs, reservoirs, lakes, and others.
5. Recommendations for water security infrastructure
   Water resilience infrastructure recommendations are made if the water demand is greater than the available availability. In recommending water security infrastructure, it is necessary to pay attention to the Ambon City Spatial Plan, carrying capacity of environmental capacity, disaster-prone areas, and infrastructure aesthetics.

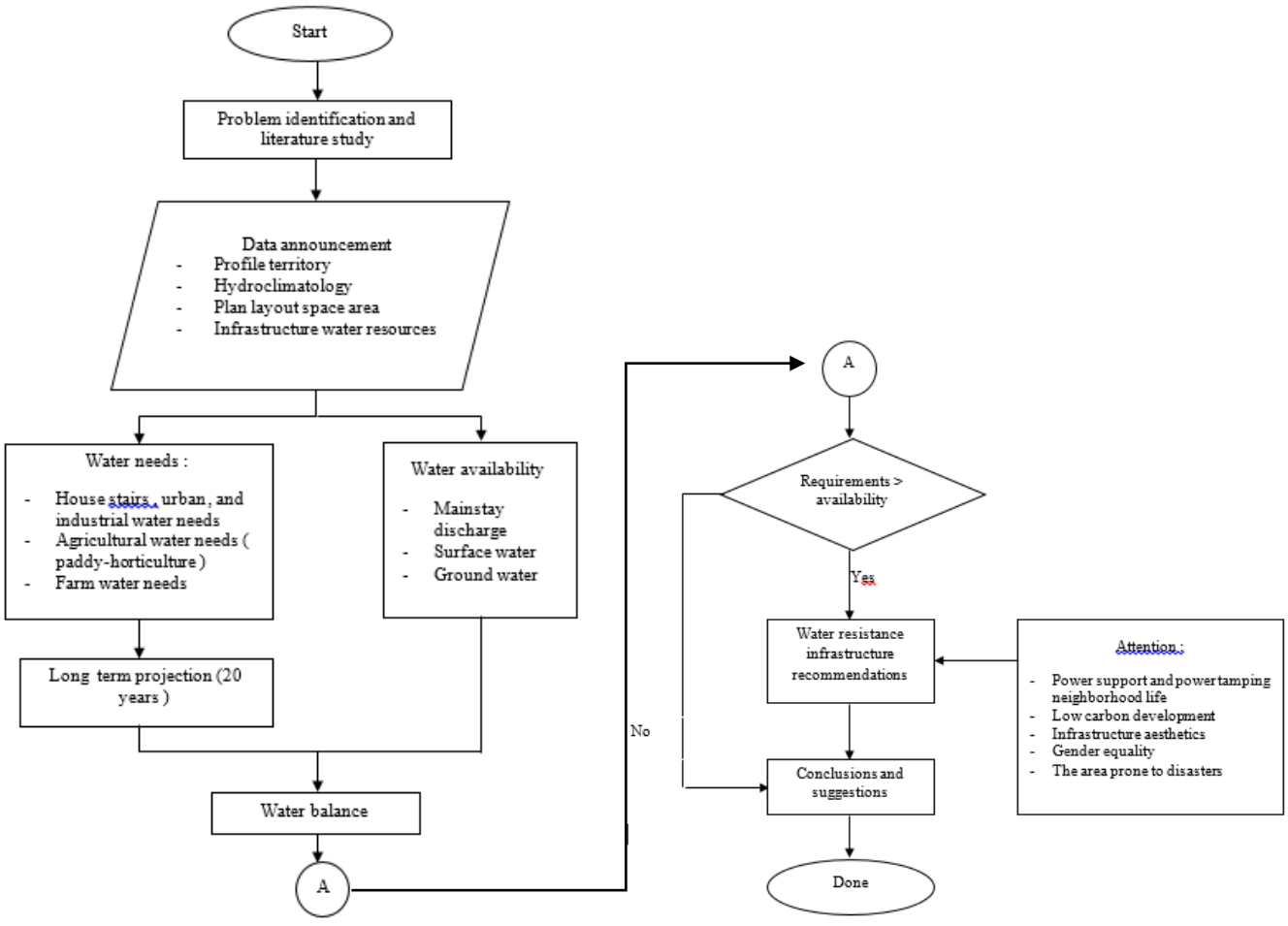


Figure 1: Research Flow Chart

Result and Discussion

Planning for Clean Water Needs Analysis

The calculation of clean water needs to be planned as optimal as possible so that in the development plan water security in the city of Ambon in operation can meet the needs of the use clean water, both for needs domestic and non-domestic needs in the city of Ambon. The projected water needs in Ambon City include household water needs, industrial water needs, the water needs of rice fields, gardens, livestock, and others. Based on Standards National Indonesia 6728.1 in 2015, water demand for the non-domestic sector is assumed to be between 15% -30% of the total household clean water usage.

Table 2: Total Water Needs in Ambon City

No.	Water Needs m^3/seconds	Year					
		2016	2020	2024	2029	2034	2039
1	Household water needs	0.495	0.595	0.716	0.903	1,140	1,441
2	Non domestic water needs	0.149	0.179	0.215	0.271	0.342	0.432
3	Industrial water needs	1,195	1,195	1,195	1,195	1,195	1,195
4	Livestock water needs	0.001	0.013	0.024	0.038	0.052	0.044
5	Agricultural water needs - horticulture	0.082	0.203	0.364	0.568	0.774	0.980
6	Total	1,922	2,184	2,514	2,975	3,503	4,092

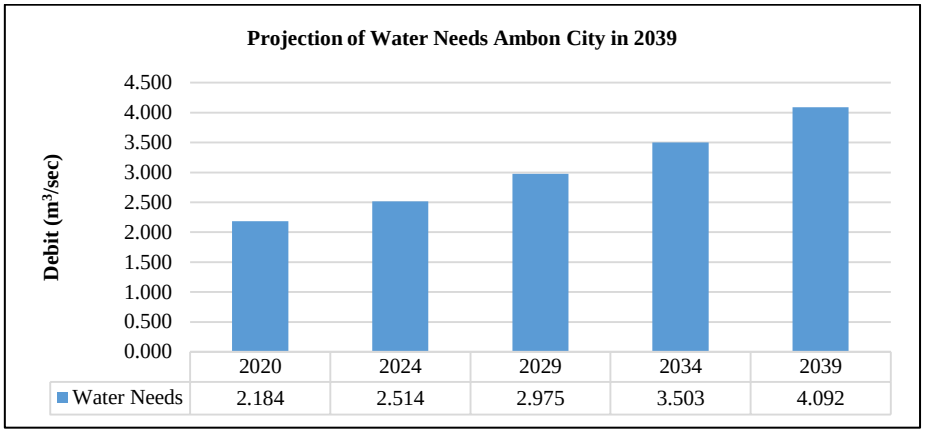


Figure 2: Projection of Water Needs Ambon City in 2039

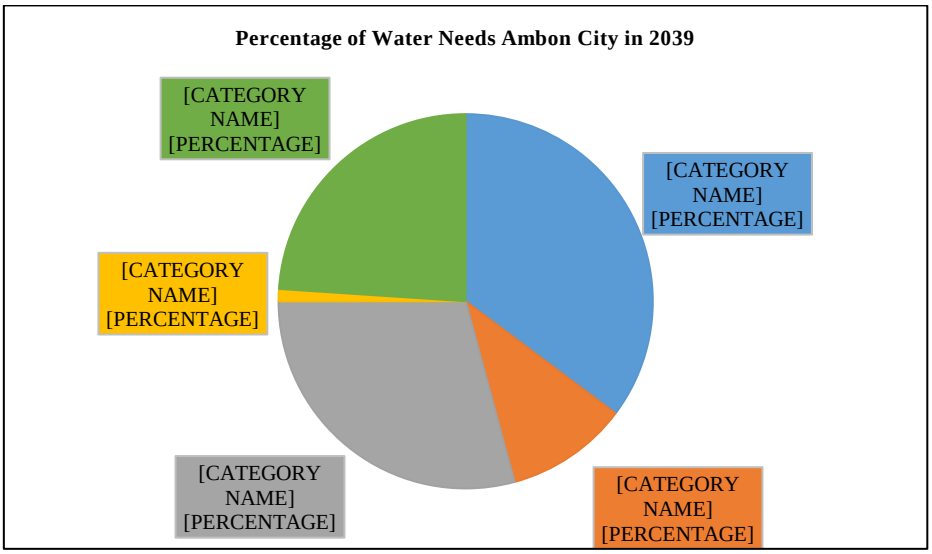


Figure 3: Percentage of Water Needs Ambon City in 2039

Based on the results of the analysis of water demand, can be concluded that the water demand is the most dominant in Ambon city 2039 is the household sector with a percentage of 35.22%.

Water Supply Infrastructure Analysis

The capacity of clean water sources from the Regional Drinking Water Company is still lacking to serve the needs of Ambon City. So there are still many residents who use groundwater sources to meet their daily needs. If this matter it is feared to be left alone (especially those who utilize deep groundwater sources) Ambon in the future. So that the right planning is needed to increase the capacity of clean water sources in order to meet and serve the needs of Ambon City residents up to 100%.

Table 3: Water Availability in Ambon City

No.	Availability	Capacity
1	Raw Water of Hasat Hamlet in Soya Village	10 L/Sec
2	Drinking-Water Supply System in Region Strategic General Hospital Area Dr. M. Haulussy District Nusaniwe	1 L/Sec
3	Drinking Water Provider System	271 L/Sec
4	Total	282 L/Sec (0.282 m^3/sec)

Source: Maluku Provincial Budget Implementation E-monitoring, Ciptakarya, 2018

Potential Analysis of Water Resources

Water sources that can be developed in Ambon City come from rainwater. Based on hydro climatological data, then potential evapotranspiration can be calculated using the Penmann Modification method that takes into account temperature, radiation sun, humidity and wind speed. Data used for calculation of potential evapotranspiration include data climatology last 10 years, namely 2008-2017. Mainstay discharge analysis using the FJ Mock method using climatology data in the form of bulk data rain, the number of rainy days and the results of evapotranspiration. The results of the mainstay discharge analysis are as follows :

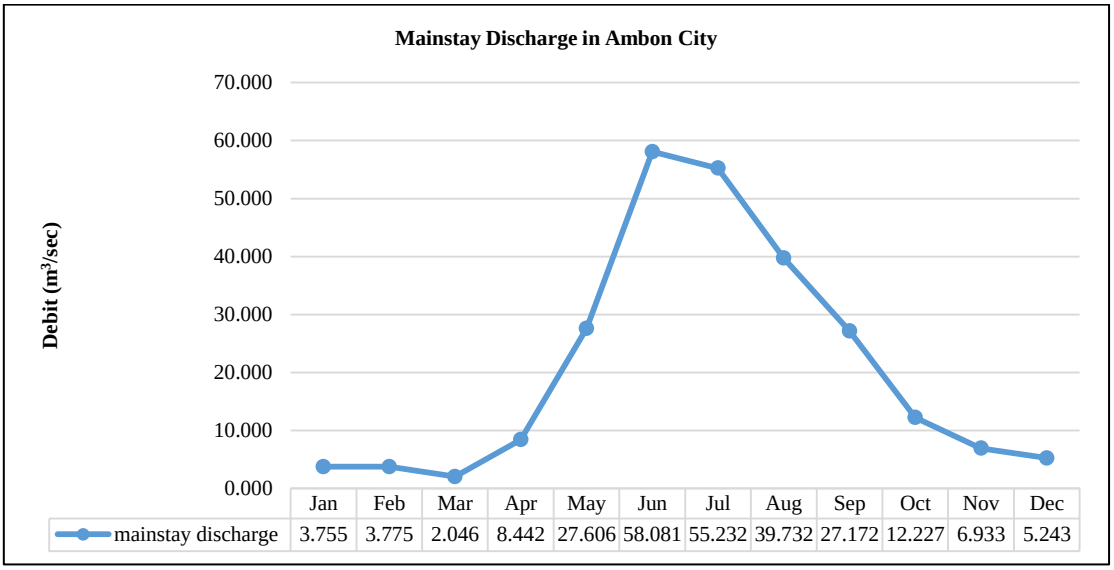
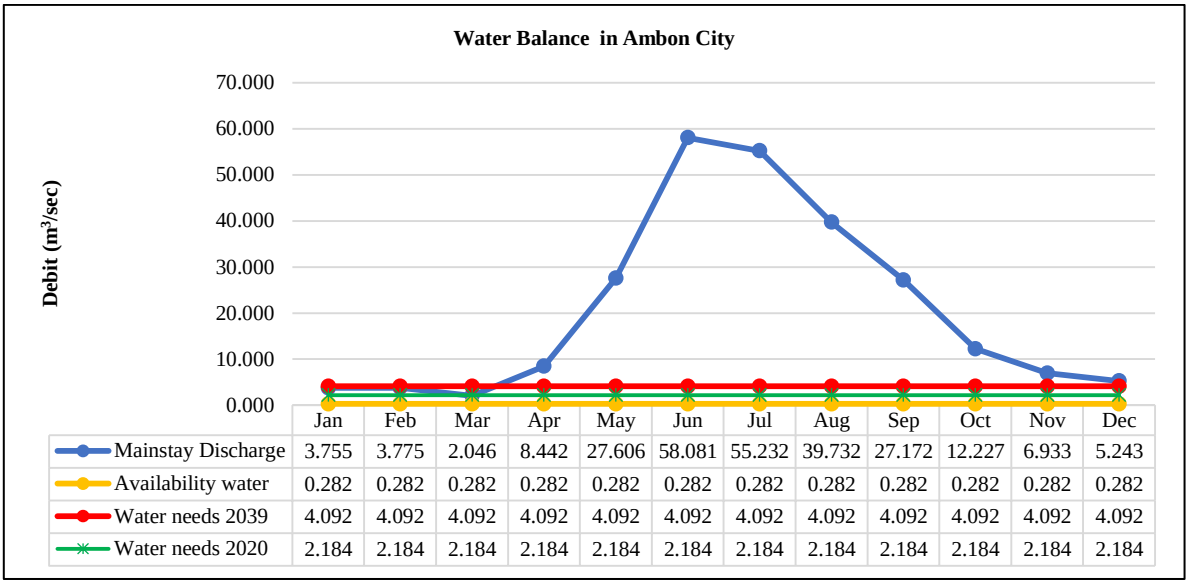


Figure 4: Mainstay Discharge in Ambon City

Water Balance Analysis

Water balance is a comparison of the potential of water resources, installed water supply infrastructure and water demand in the area to see the capacity of its water resources within a certain period. The following are the results of the balance sheet calculation water in Ambon City.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mainstay Discharge	3.755	3.775	2.046	8.442	27.606	58.081	55.232	39.732	27.172	12.227	6.933	5.243
Availability water	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282
Water needs 2039	4.092	4.092	4.092	4.092	4.092	4.092	4.092	4.092	4.092	4.092	4.092	4.092
Water needs 2020	2.184	2.184	2.184	2.184	2.184	2.184	2.184	2.184	2.184	2.184	2.184	2.184

Figure 5: Water Balance in Ambon City

Based on the water balance analysis graph, the availability of water building infrastructure installed or available in Ambon City has not been able to meet the existing water needs. The graph of water potential Ambon City on December – April is located below the graph of water demand, therefore, it is necessary to build a water building infrastructure to accommodate the existing water potential so that the water needs in Ambon City can be met until 2039.

Development Program Planning

Based on water balance analysis, there is a gap between the water needs that must be served compared with the availability of existing water resource infrastructure. This causes the need for developing infrastructure to meet water needs in Ambon City. Infrastructure development planning is made in the form development program with a 5-year period of 20 years to 2039. Development planning each period is as follows:

Table 4: Water Supply Program Plans in Ambon City

No	Development Period	2020-2024			2025-2029			2030-2034			2035-2039		
		Projection	%	Program	Projection	%	Program	Projection	%	Program	Projection	%	Program
1	Domestic, Urban and Industrial Water Needs	1,934	70	1,488	2,126	100	2,369	2,369	100	2,677	2,677	100	3,069
2	Animal Husbandry Water Needs	0.010	70	0.017	0.024	100	0.038	0.038	100	0.052	0.052	100	0.044
3	Horticultural Agricultural Water Needs	.163	20	0.073	.364	50	.284	0.568	80	0.619	.774	100	0.980
4	Total Water Needs	2,107		1,578	2,514		2,691	2,975		3,349	3,503		4,092
5	Development Program			**1,296**			**1,113**			**0.658**			**0.743**

Based on the figure, it can be seen that the program to fulfill the water demand for each period has increased with the target at the end of the program period in 2039, it has fulfilled the required water needs. In determining the capacity for a pool, an operation study is needed a simulation of the operation of a reservoir for a period of time according to a set of rules set. A review of operations can only analyze a selected critical period, that is, at the time of very flow low. Monthly data is most commonly used, but for a large pool that holds a pool for several years, the annual interval will be quite satisfying. The method used to calculate the capacity of a reservoir is wrong one of them is the ripple method. The following figure is the result of capacity calculation using the ripple method.

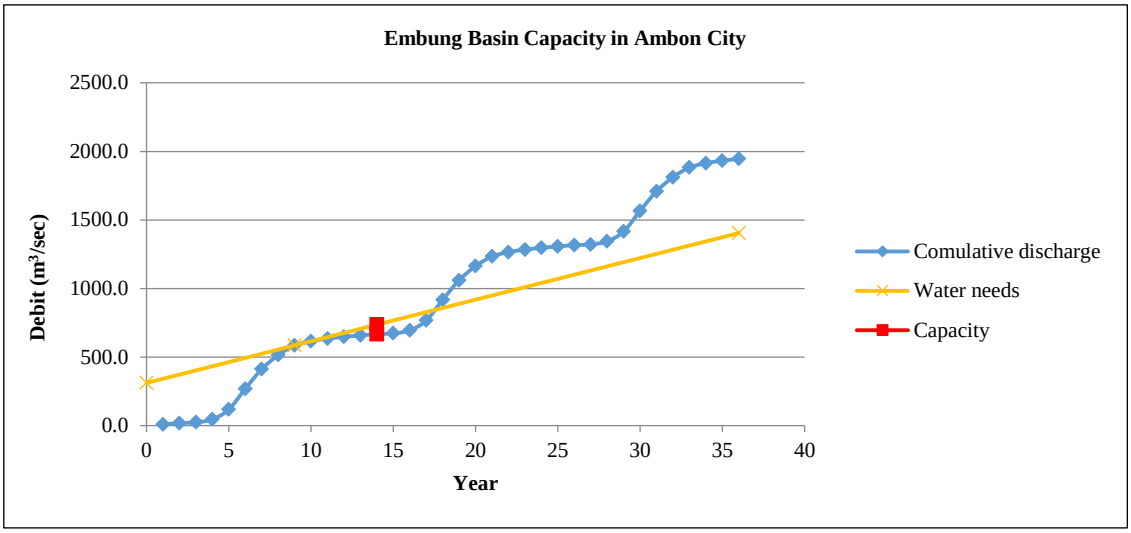


Figure 6: Embung Basin Capacity in Ambon City

Based on the calculation using the ripple method, the following results are obtained:

Table 5: Storage Capacity in Ambon City

No.	Period	2020-2024	2025-2029	2030-2034	2035-2039
1	Total Needs (m^3/ sec)	2,107	2,514	2,975	3,503
2	Program Requirements (m^3/ sec)	1,578	2,691	3,349	4,092
3	Volume (m^3)	4,089,496	6,975,072	8,679,540	10,606,161

The total storage capacity of the four periods is 30,35 million m^3. To meet the water needs in Ambon City Water Resources infrastructure development is needed in the form of reservoirs spread in each district. Dam works to accommodate excess water in the event of rain, water is stored for supply when the dry season arrives. Based on the calculation results obtained the number of reservoirs in each period.

The total number of reservoirs for the entire period is 168 reservoirs with a total area of 139.5 hectares, spread over each district in the city of Ambon. The determination of the location of infrastructure development is based on the location of the Region The biggest river flow.

The results of determining the location of the reservoir must pay attention to the topographical conditions of Ambon City which consists mostly of a bumpy to steep area of ± 280 km² (87% of the total area of Ambon City) and a flat area of ± 42 km^2 (13% of the total land area). Areas with a high risk of drought occupy a proportion of ± 0.1% of the total area Ambon City is in the District of Nusaniwe. Areas that are said to have a moderate level of threat of drought are mostly controlled by the geological and geomorphological characteristics of the region, especially rock characteristics.

Project Financing Estimates

Calculation of the cost of planning the embung construction program in Ambon City, using the program planning costs construction of the Way Apu dam in Buru Regency, Maluku Province as a reference. Development program planning embung in Ambon City with a total reservoir of 30,350 million m^3, the required cost is IDR 1,308,692,000,000. The details of financing in each period are as follows :

Table 6: Financing of Embung Planning in Ambon City

No.	Period	2020-2024	2025-2029	2030-2034	2035-2039
1	Total Needs (m^3/sec)	2,107	2,514	2,975	3,503
2	Program Requirements (m^3/sec)	1,578	2,691	3,349	4,092
3	Volume (m^3)	4,089,496	6,975,072	8,679,540	10,606,161
4	Funding (IDR)	176,339,084,759	300,765,107,745	374,261,780,944	457,337,675,515

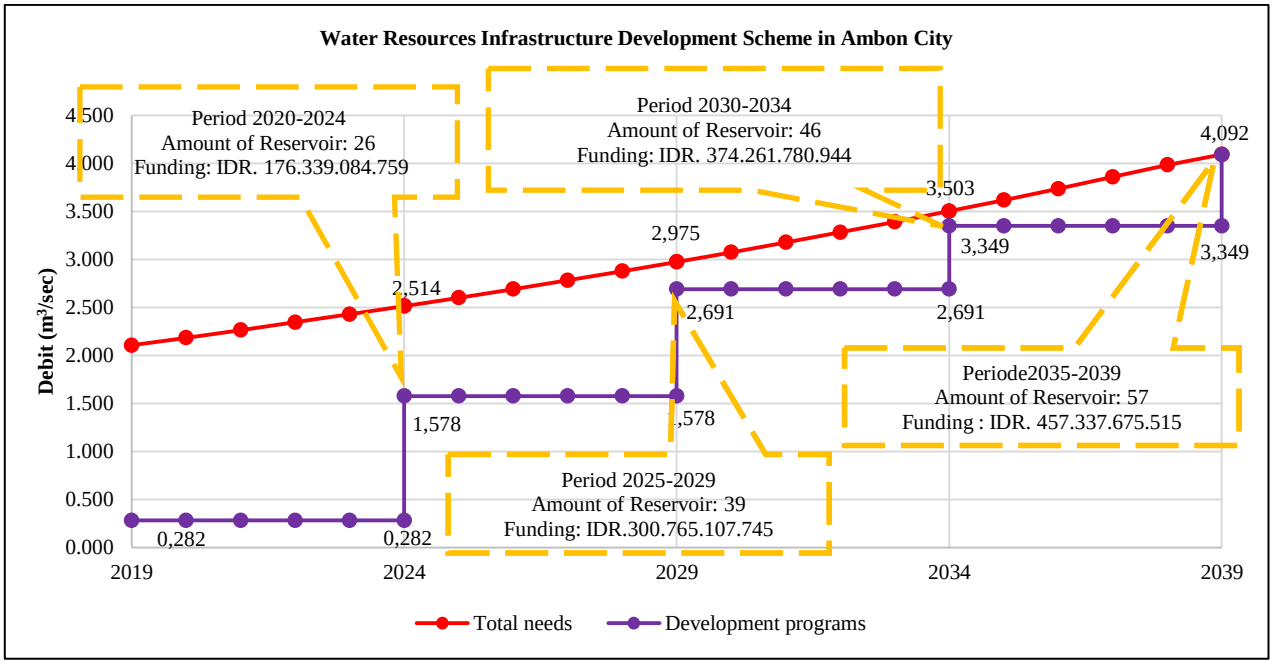


Figure 7: Water Resources Infrastructure Development Scheme in Ambon City

Conclusions and Recommendations

Based on the analysis that has been done, the conclusion is that water demand in Ambon City in 2039 is 4,092 m^3 / second which consists of household water needs 1,441 m^3/second, non-domestic water demand 0.432 m^3/second, industrial water demand 1,195 m^3/second, livestock water needs are 0.044 m^3/second and horticultural agricultural water needs 0.980 m^3/second. The total potential of the mainstay discharge in Ambon City in 2039 is 250.424 m^3/second originating from rainfall in Ambon City area. The total debt of the availability of water resource infrastructure in Ambon City in 2018 is 0.282 m^3/second consists of Drinking Water and Raw Water Supply Systems in the Ambon City area. Based on the results of the water balance analysis, it is known that the water demand in Ambon City has still not been fully met a maximum of up to 20 years to come. That is due to the availability of water resources infrastructure in Ambon City is still very limited. So that recommendation is needed to maintain a balance between needs water and the availability of existing water. The mainstay discharge graph shows the potential for water in December-April below the water demand line, therefore, in those months it takes a reservoir to fulfill water needs in Ambon City. Based on the analysis of the storage by the ripple method, the storage capacity needed to fulfill water demand in Ambon City is 30,350 million m^3 . Recommendations for water reservoirs in the form of as many as 168 reservoirs scattered in the location of the largest River Basin in several areas in Ambon City. The reservoir development plan is divided into 4 periods with estimates the costs required are IDR. 1,308,692,000,000.

The suggestions that can be conveyed in this analysis include the following:

1. Completeness of data is very much needed in calculating water demand projections, availability of infrastructure Water power and rainwater potential calculation.
2. Water resilience infrastructure recommendations are made if the water demand is greater than the available water supply.
3. In recommending water security infrastructure, it is necessary to pay attention to the Regional Spatial Plan, carrying capacity environmental capacity, disaster-prone areas, and aesthetic infrastructure in Ambon City.
4. Further research is needed to determine the location of the reservoir in Ambon City.
5. Periodic maintenance is needed on the infrastructure of water resources that have been built so that distribution clean water to residents and other sectors can run well.

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