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Analysis of Rainwater Harvesting Methods for Optimizing Small Island Areas: A Case Study in Selaru Island, Indonesia

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ABSTRACT

Water management on islands has an important role because of their limited features. Although each island has different features (size, isolation, geology and topography, climate and hydrology, economic development, etc.) – all affecting water resources and management, all islands face many of the same water-related issues and challenges. This condition is influenced by population growth triggered by the development of natural resources. This research aims to ensure that the rainwater harvesting method as an alternative water source can fulfill distribution deficiencies while maintaining the ecological conditions of small island areas. Water availability is analyzed using the F.J. Mock method, and the existing sources are analyzed using the RWH method. Based on guidelines, the analysis of domestic water needs is 65 L/person/day. The analysis continues with the existing distribution scenario. The results show that the Adaut sub-watershed and the Namtabung sub-watershed are predicted to experience water shortages, and the combined distribution scenario of existing sources and the RWH method can be a solution to overcome water shortages. The RWH method can achieve optimal water distribution in Selaru Island until 2040.

Keywords: *Leadership Style, Service Quality, Community Satisfaction*

1. INTRODUCTION

Activities aiming to develop small island areas are related to the process of making changes to the ecosystem and environment. To anticipate these changes and threats, resource utilization on small islands needs to be carried out in a comprehensive and integrated manner. However, the management activities encounter various obstacles, including ecological aspects, in the form of a decline in environmental quality, such as pollution, ecosystem destruction, and overfishing, and social aspects, such as lack of accessibility and welfare of island communities.

Selaru Island is one of the small outermost islands in Indonesia, with a land area of 353.87 km^2 and it is located on the border with Australia. It is to the south of Yamdena Island and is part of the administrative area of Tanimbar Islands Regency, Maluku Province. Its geographical location makes Selaru Island a buffer zone for exploration activities for the National Strategic Project (PSN) of Masela Block on Yamdena Island (onshore location), where the PSN activities have an impact on population growth, resulting in increased water needs and changes in land function.

Currently, the people of Selaru Island utilize the potential of groundwater sources and shallow wells to meet the community's water needs. Due to limited water potential during the dry season, people try to get water through alternative sources. Thus, the serious challenges are the availability of water sources and the efficiency of water resource management.

Water management on small islands is important due to their limited features. Although each island has different features (size, isolation, geology and topography, climate and hydrology, economic development, etc.) – all affecting water resources and management, all islands face many of the same water-related issues and challenges [1]. This condition is influenced by several factors, such as increasing population growth [2], economic development [3], project consequences, and other human activities affecting the quality and quantity of water resources on the island. Moreover, limited water resources can cause conflicts among sectors that compete for water use, such as agriculture, industry, housing, and the environment. Such conflicts can hinder efforts to achieve balance in water management [4]. Problems of the availability and efficiency of water resource management on small islands are challenges that require serious attention and immediate solutions since small islands have various advantages but have limitations in various aspects at the same time.

This research aims to ensure that the rainwater harvesting method as an alternative water source can meet the shortage of water distribution by still maintaining the ecological conditions of small island areas.

2. METHODS

This research was conducted in the Selaru Island area, located in Tanimbar Islands Regency, Indonesia, with sub-watershed divisions including the Adaut, Omela, and Namtabung sub-watersheds. Furthermore, the water demand for each sub-watershed is calculated based on the water usage provisions of SNI 6728.1:2015, resulting in a water usage level for the Selaru Island area of 65 L/person/day. Additionally, the Regulation of the Minister of Public Works Number 18 of 2007 concerning the implementation of the development of drinking water supply systems stipulates that the standard for non-domestic demand is 20% of domestic water demand.

The preparation of hydrological data was carried out using the F.J. Mock method, where the surface flow discharge (surface water measurement) was calculated by measuring speed and wetted sectional area (velocity-area method). This method was carried out by measuring the velocity of water flow at several points along the water source and the wetted area (cross-sectional area of the river) at each point. The water discharge was then calculated by multiplying the average velocity by the wetted area.

The quality of river water was tested using laboratory methods, which is an essential process in evaluating the environmental condition of water sources. First, the water sample was taken from a location representative of the river where the researcher wanted to assess the water. After that, physical parameters, such as temperature and turbidity, and chemical parameters, such as pH, dissolved oxygen, nitrate, phosphate, and heavy metals, were measured. Biological parameters were also assessed by identifying living organisms like bacteria, algae, and macroinvertebrates. . The water samples were then analyzed in the laboratory using appropriate methods, organoleptic, photometric, spectrophotometric, titrimetric, SNI 06-6989.25-2005, SNI 06-6989.4-2009, SNI 06-6989.16-2009, SNI 06-6989.12-2009, and SNI 06-6989.20-2009. The analysis results are compared with the applicable standards of water quality, and then the conclusions are drawn to evaluate the quality of the water source. Information from the results of analysis and interpretation is presented in a report that describes the water quality condition, which may lead to further actions to maintain or restore good water quality according to applicable guidelines and standards.

Water distribution using the rainwater harvesting method can certainly be implemented since the research area can fulfill three basic components, including 1) catchment, the roof becomes the catchment of rainwater; 2) delivery system, a system for channeling rainwater from the roof to the reservoir through gutters; and 3) storage reservoir, rainwater storage using barrels, tubs, and ponds (Chao, et, al, 2004). The output of this process is that water management using this method can be implemented on small island areas, which have many limitations.

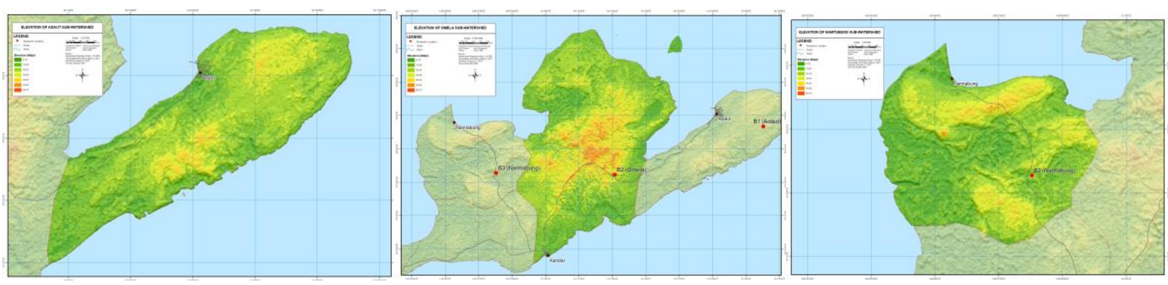
3. RESULTS AND DISCUSSION

3.1 Weatershed

According to the Decree of the Minister of Public Works No. 374/KPTS/M/2014 dated August 29, 2014, concerning Water Resources Management in the Yamdena-Wetar Archipelago River Basin, Selaru Island is designated as Selaru Watershed.

Figure 1. Selaru Island with sub-watershed divisions

Figure 1 above presents the sub-watershed division of Selaru Island using ArcGIS 10.8 software, including the Adaut, Omela, and Namtabung Sub-watersheds, along with the potential of land and water potential in each sub-watershed.



[a] [b] [c]

Figure 2. Details of the Sub-watersheds

Figure 2 [a] shows the Adaut Sub-watershed with an area of 4,644.51 Ha. The lowest elevation is 10 meters, and the highest elevation is 40 meters. Adaut village at the Adaut Sub-watershed is at an elevation of 10 meters, with settlement areas of 30.56 Ha, while the total non-settlement area is 4.614 Ha.

Figure 2 [b] shows the Omela Sub-watershed with an area of 12,976.80 Ha. The lowest elevation is 10 meters, and the highest elevation is 50 meters. The entire area of the Omela Sub-watershed is non-settlement land.

Figure 2 [c] shows the Namtabung Sub-watershed with an area of 4,405.6 Ha. The lowest elevation is 10 meters, and the highest elevation is 40 meters. Namtabung village at the Namtabung Sub-watershed is at an elevation of 15 meters, with settlement areas of 21.43 Ha, while the total non-settlement area is 4,384.2 Ha.

3.2 *Water Demand*

The amount of domestic water demand in each sub-watershed is calculated using the following formula:

$$P = P1 \times SPM \div P3$$

Where:

P = Water demand
P1 = Population
P3 = 86,400 sec
SPM = Minimum Service Standard

Table 1. Water Demand in 2040
Table source: analysis results

No.	Description	Unit	Water Demand in 2040 (l/s)		
			Simulation 1	Simulation 2	Simulation 3
	ADAUT VILLAGE				
A	Population	person	7,107	8,627	8,728
	Consumption per person	l/d	65	65	65
	Water demand	l/s	5.346	6.490	6.566
B	Domestic water demand	l/s	5.346	6.490	6.566
C	Non-domestic water demand	l/s	1.069	1.298	1.313
D	Total water demand (B+C)	l/s	6.416	7.788	7.879
	NAMTABUNG VILLAGE				
A	Population	person	4,948	6,471	6,506
	Consumption per person	l/d	65	65	65
	Water demand	l/s	3.722	4.868	4.894
B	Domestic water demand	l/s	3.722	4.868	4.894
C	Non-domestic water demand	l/s	0.744	0.974	0.979
D	Total water demand (B+C)	l/s	4.467	5.842	5.873

Based on the analysis results in Table 1 above, the water demand in Adaut Village in 2040 is 6.416 l/s in Simulation 1, 7.788 l/s in Simulation 2, and 7.879 l/s in Simulation 3.

Meanwhile, the water demand of Namtabung Village in 2040 is 4.467 l/s in Simulation 1, 5.842 l/s in Simulation 2, and 5.873 l/s in Simulation 3.

3.3 *Water Availability*

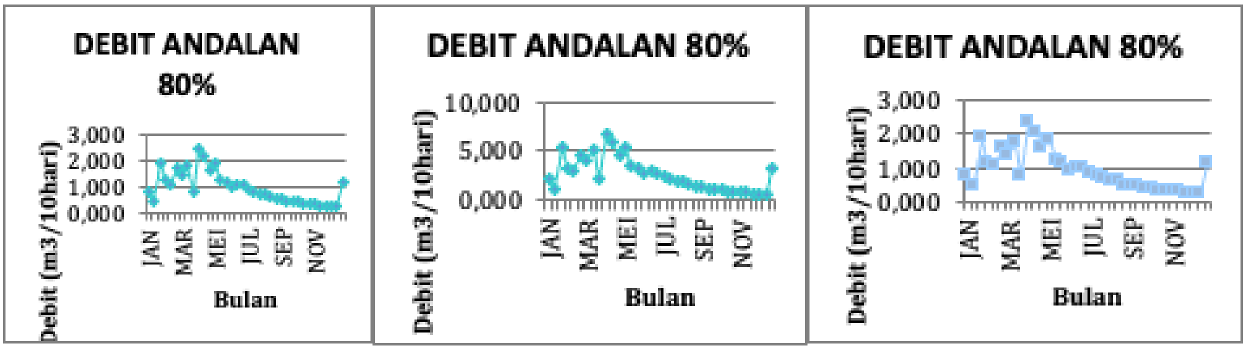
1. **Rain**

Daily rain data for 2000-2017 were obtained from the BMKG Saumlaki station. Based on this data, it can be seen that daily rainfall data is usually used to simulate plant water needs and reservoir operations.

Dependable Discharge

Dependable discharge is used to meet the water needs. It is calculated using water balance analysis by F.J. Mock based on monthly rainfall, number of rainy days, evapotranspiration, and hydrological characteristics of the irrigation area. The analysis of water availability in this study uses a dependable debit of 80%.

Dependable discharge refers to river flow discharge considered the "main discharge" or "normal discharge" as a reference for planning and managing water resources. This discharge often represents the historical or statistical average of the water flow in a river over a specific period, such as a year or month. Dependable discharge is used to measure the water availability that can be utilized in various sectors, such as agricultural irrigation, domestic water demand, industry, and the environment. This study analyzes the dependable discharge in the Adaut, Omela, and Namtabung Sub-watersheds



[a] [b] [c]

(*Source: Analysis Results*)

Figure 3. Dependable Discharge of Adaut, Omela, and Namtabung Sub-watersheds

Figure 3 [a] above shows that the Adaut Sub-watershed, with an area of 46,450 km², has an 80% dependable discharge potential of 24,700 l/s after calculating the rainfall.

Figure 3 [b] above shows that the Omela (Kandar) Sub-watershed, with an area of 129,770 km², has an 80% dependable discharge potential of 69,100 l/s after calculating the rainfall.

Figure 3 [c] above shows that the Namtabung Sub-watershed, with an area of 44,060 km², has an 80% dependable discharge potential of 23,500 l/s after calculating the rainfall.

Analysis of Source Water Quantity

The quantity of water sources is observed in the Adaut Sub-watershed, which consists of Wesuri and Timur water sources, the Omela Sub-watershed originated from the Omela water source, and the Namtabung Sub-watershed obtained from the Saphelange water source. The results are shown in the table below:

Table 4. Water Discharge of the Adaut, Omela, and Namtabung Sub-watersheds
Table Source: Analysis Results

No.	Sub-watershed	Village	Water Source	Water Discharge (l/s)	Water Availability 50% x Discharge (l/s)
1	Adaut	Adaut	Wesuri	5.00	2.50
			Pantai Timur	6.34	3.17
2	Omela	Kandar	Omela	2.50	1.25
3	Namtabung	Namtabung	Sapalange	10.17	5.09

Table 4 shows an analysis of the observation results of water sources in the Adaut Sub-watershed, namely Waesuri and Pantai Timur, with a discharge of 11.34 l/s, which can manage water availability of 5.57 l/s. The Namtabung Sub-watershed, with the Saphelange water source, has a discharge of 10.17 l/s, which can manage 5.09 l/s.

Analysis of Water Source Quality

After identifying several sources with adequate quantities as water sources in the Selaru Island sub-watersheds, the quality of the water sources is tested. This water sample quality test was carried out at the Testing Laboratory, namely the Ambon Class II Environmental Health Engineering and Disease Control Center, Maluku Province, using several test parameters according to Government Regulation No.22 of 2021 concerning the Management of Water Quality and Control of Water Pollution. Water samples were taken from water sources on Selaru Island. The results can be seen in the following table.

Table 5. Results of Water Quality Test for Adaut and Namtabung Sub-watersheds
Table Source: Environmental Health Engineering Center (BTKL) Ambon

Parameter	Unit	Maximum Allowable Level	K919 Testing Results				Detection Limit
			Waesuri Adaut	Pantai Timur Adaut	Omela Kandar	Namtabung	
PHYSICAL							
Turbidity	NTU	25	0.82	0.63	0.93	1.59	0.024
Taste	-	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	-
Odor	-	Odorless	Odorless	Odorless	Odorless	Odorless	-
Temperature	°C	±3°C	28.1	28.1	28.3	28.1	-
TDS	mg/l	1000	200.9	265	575	274	1
CHEMICAL							
Iron (Fe)	mg/l	1	0.0589	0.0599	0.0561	0.0636	0.0313
Detergent	mg/l	0.5	0.0084	0.0095	0.0125	0.0146	0.001
Cadmium (Cd)	mg/l	0.005	0.0009	0.0005	0.0009	0.0006	0.0003
Hardness, $CaCo^3$	mg/l	500	216	210	316	202	72.71
Nitrate	mg/l	10	1.824	1.761	2.116	3.425	0.003
Nitrite	mg/l	1	<0.0017	<0.0017	0.0031	0.478	0.0017
pH	mg/l	6.5-8.5	7.94	7.68	8.02	7.8	-
Zinc	mg/l	15	0.2058	<0.033	<.0330	<0.033	0.033
KMM04	mg/l	10	<0.003	<0.003	<0.003	<0.003	0.003
Manganese	mg/l	0.5	<0.0350	<0.0350	<0.0350	<0.0350	0.0339
Sulfate	mg/l	10	2.3737	<0.1651	32.041	3.5543	0.1651

The results of the sample tests in the water sources of Adaut Namtabung sub-watersheds meet the maximum allowable levels of all elements based on physical and chemical parameters. In other words, the water sources of the Adaut and Namtabung sub-watersheds meet the required quality standards.

Analysis of Rain Water Harvesting (RWH)

Table 6. Simulation-1 of Residential and Water Supply
Table Source: Analysis Results

No	Village	Population in 2040 (people)	Housing Needs in 2040 (unit)	House Needs Addition (backlog) until 2040 (unit)	Total Number of House Needs Addition in 2040 (unit)	Water Distribution (l)	Water Supply (l/day)
1	Adaut	7,101	1,420	248	1,668	60	100,068
2	Namtabung	4,948	990	397	1,387	60	83,208
	Total	12,049	2,410	645	3,055	-	

Table 7. Simulation-2 of Residential and Water Supply
Tabel Source: Analysis Results

No	Village	Population in 2040 (people)	Housing Needs in 2040 (unit)	House Needs Addition (backlog) until 2040 (unit)	Total Number of House Needs Addition in 2040 (unit)	Water Distribution (l)	Water Supply (l/day)
1	Adaut	8,627	1,725	552	2,278	60	136,668
2	Namtabung	6,471	1,294	702	1,996	60	119,748
	Total	15,098	3,020	1,254	4,274	-	

Table 8. Simulation-3 of Residential and Water Supply
Tabel Source: Analysis Results

No	Village	Population in 2040 (people)	Housing Needs in 2040 (unit)	House Needs Addition (backlog) until 2040 (unit)	Total Number of House Needs Addition in 2040 (unit)	Water Distribution (l)	Water Supply (l/day)
1	Adaut	8,728	1,746	573	2,319	60	139,116
2	Namtabung	6,506	1,301	709	2,010	60	120,600
	Total	**15,234**	3,047	**1,282**	**4,329**	**-**	

Table 6 shows the housing needs in each village due to normal population growth (Simulation 1), with a water supply for Adaut village of 100,060 l/day and Namtabung village of 83,208 l/day.

Table 7 shows the housing needs in each village due to normal population growth (Simulation 2), with a water supply for Adaut village of 136,668 l/day and Namtabung village of 119,748 l/day.

Table 8 shows the housing needs in each village due to normal population growth (Simulation 2), with a water supply for Adaut village of 139,116 l/day and Namtabung village of 120,600 l/day.

1. Adaut Sub-watershed

Table 9. Simulation-1 of RWH Water Distribution Analysis in Adaut Village
Table Source: Analysis Results

Description	Number of Days	Rainfall (mm)	Rain Volume (m3) (c/1000) * A	Rain Distribution Volume (l/day)	Rain Distribution Volume per Month (m3) (b^e)/1000	Daily Volume (m3) d-f	Cumulative Volume (m3)
January	31	201	20	100,068	3,102	(3,082)	96,165.35
February	28	315	32	100,068	2,802	(2,770)	78,453.31
March	31	188	19	100,068	3,102	(3,083)	96,165.35
April	30	340	34	100,068	3,002	(2,968)	90,061.20
May	31	395	40	100,068	3,102	(3,063)	96,165.35
June	30	162	16	100,068	3,002	(2,986)	90,061.20
July	31	203	20	100,068	3,102	(3,082)	96,165.35
August	31	84	8	100,068	3,102	(3,094)	96,165.35
September	30	153	15	100,068	3,002	(2,987)	90,061.20
October	31	191	19	100,068	3,102	(3,083)	96,165.35
November	30	155	16	100,068	3,002	(2,987)	90,061.20
December	31	275	28	100,068	3,102	(3,075)	96,165.35
Total	365	2,662					
Minimum							

Description	Number of Days	Rainfall (mm)	Rain Volume (m3) (c/1000) * A	Rain Distribution Volume (l/day)	Rain Distribution Volume per Month (m3) (b^e)/1000	Daily Volume (m3) d-f	Cumulative Volume (m3)
Maximum							

Table 10. Simulation-2 of RWH Water Distribution Analysis in Adaut Village
Table Source: Analysis Results

Description	Number of Days	Rainfall (mm)	Rain Volume (m3) (c/1000) * A	Rain Distribution Volume (l/day)	Rain Distribution Volume per Month (m3) (b^e)/1000	Daily Volume (m3) d-f	Cumulative Volume (m3)
January	31	201	20	136,668	4,237	(4,217)	131,337.95
February	28	315	32	136,668	3,827	(3,795)	107,147.71
March	31	188	19	136,668	4,237	(4,218)	131,337,95
April	30	340	34	136,668	4,100	(4,066)	123,001.20
May	31	395	40	136,668	4,237	(4,197)	131,337.95
June	30	162	16	136,668	4,100	(4,084)	123,001.20
July	31	203	20	136,668	4,237	(4,216)	131,337.95
August	31	84	8	136,668	4,237	(4,228)	131,337.95
September	30	153	15	136,668	4,100	(4,085)	123,001.20
October	31	191	19	136,668	4,237	(4,218)	131,337.95
November	30	155	16	136,668	4,100	(4,085)	123,001.20
December	31	275	28	136,668	4,237	(4,209)	131,337.95
Total	365	2,662					
Minimum							107,147.71
Maximum							131,337.95

Table 11. Simulation-3 of RWH Water Distribution Analysis in Adaut Village
Table Source: Analysis Results

Description	Number of Days	Rainfall (mm)	Rain Volume (m3) (c/1000) * A	Rain Distribution Volume (l/day)	Rain Distribution Volume per Month (m3) (b^e)/1000	Daily Volume (m3) d-f	Cumulative Volume (m3)
January	31	201	20	139,116	4,313	(4,292)	133,690.48
February	28	315	32	139,116	3,895	(3,864)	109,066.94

March	31	188	19	139,116	4,313	(4,294)	133,690.48
April	30	340	34	139,116	4,173	(4,139)	125,204.40
May	31	395	40	139,116	4,313	(4,273)	133,690.48
June	30	162	16	139,116	4,173	(4,157)	125,204.40
July	31	203	20	139,116	4,313	(4,292)	133,690.48
August	31	84	8	139,116	4,313	(4,304)	133,690.48
September	30	153	15	139,116	4,173	(4,158)	125,204.40
October	31	191	19	139,116	4,313	(4,293)	133,690.48
November	30	155	16	139,116	4,173	(4,158)	125,204.40
December	31	275	28	139,116	4,313	(4,285)	133,690.48
Total	365	2,662					
Minimum							109,066.94
Maximum							133,690.48

The analysis results of the rainwater harvesting distribution in the Adaut Village are explained in Tables 9 to 11 below:
Table 9. The RWH distribution in Simulation-1 is 96,165.31 m³ or 6.18 l/second.
Table 10. The RWH distribution in Simulation-2 is 131,337.95 m³ or 8.45 l/second.
Table 11. The RWH distribution in Simulation-3 is 133,690.48 m³ or 8.60 l/second.

2. **Namtabung Sub-watershed**

Table 12. Simulation-1 of RWH Water Distribution Analysis in Namtabung Village
Table Source: Analysis Results

Description	Number of Days	Rainfall (mm)	Rain Volume (m3) (c/1000) * A	Rain Distribution Volume (l/day)	Rain Distribution Volume per Month (m3) (b^e)/1000	Daily Volume (m3) d-f	Cumulative Volume (m3)
January	31	201	20	83,208	2,579	(2,559)	79,962.89
February	28	315	32	83,208	2,330	(2,298)	65,235.07
March	31	188	19	83,208	2,579	(2,561)	79,962.89
April	30	340	34	83,208	2,496	(2,462)	74,887.20
May	31	395	40	83,208	2,579	(2,540)	79,962.89
June	30	162	16	83,208	2,496	(2,480)	74,887.20

July	31	203	20	83,208	2,579	(2,559)	79,962.89
August	31	84	8	83,208	2,579	(2,571)	79,962.89
September	30	153	15	83,208	2,496	(2,481)	74,887.20
October	31	191	19	83,208	2,579	(2,560)	79,962.89
November	30	155	16	83,208	2,496	(2,481)	74,887.20
December	31	275	28	83,208	2,579	(2,552)	79,962.89
Total	365	2,662					
Minimum							65,235.07
Maximum							79,962.89

Table 13. Simulation-2 of RWH Water Distribution Analysis in Namtabung Village
Table Source: Analysis Results

Description	**Number of Days**	**Rainfall (mm)**	**Rain Volume (m3) (c/1000) * A**	**Rain Distribution Volume (l/day)**	**Rain Distribution Volume per Month (m3) (b^e)/1000**	**Daily Volume (m3) d-f**	**Cumulative Volume (m3)**
January	31	201	20	119,748	3,712	(3,692)	115,077.83
February	28	315	32	119,748	3,353	(3,321)	93,882.43
March	31	188	19	119,748	3,712	(3,693)	115,077.83
April	30	340	34	119,748	3,592	(3,558)	107,773.20
May	31	395	40	119,748	3,712	(3,673)	115,077.83
June	30	162	16	119,748	3,592	(3,576)	107,773.20
July	31	203	20	119,748	3,712	(3,692)	115,077.83
August	31	84	8	119,748	3,712	(3,704)	115,077.83
September	30	153	15	119,748	3,592	(3,577)	107,773.20
October	31	191	19	119,748	3,712	(3,693)	115,077.83
November	30	155	16	119,748	3,592	(3,577)	107,773.20
December	31	275	28	119,748	3,712	(3,685)	115,077.83
Total	365	2,662					
Minimum							93,882.43
Maximum							115,077.83

Table 14. Simulation-3 of RWH Water Distribution Analysis in Namtabung Village
Table Source: Analysis Results

Description	Number of Days	Rainfall (mm)	Rain Volume (m3) (c/1000) * A	Rain Distribution Volume (l/day)	Rain Distribution Volume per Month (m3) (b^e)/1000	Daily Volume (m3) d-f	Cumulative Volume (m3)
January	31	201	20	120,600	3,739	(3,719)	115,896.60
February	28	315	32	120,600	3,377	(3,345)	94,550.40
March	31	188	19	120,600	3,739	(3,720)	115,896.60
April	30	340	34	120,600	3,618	(3,584)	108,540.00
May	31	395	40	120,600	3,739	(3,699)	115,896.60
June	30	162	16	120,600	3,618	(3,602)	108,540.00
July	31	203	20	120,600	3,739	(3,718)	115,896.60
August	31	84	8	120,600	3,739	(3,730)	115,896.60
September	30	153	15	120,600	3,618	(3,603)	108,540.00
October	31	191	19	120,600	3,739	(3,720)	115,896.60
November	30	155	16	120,600	3,618	(3,603)	108,540.00
December	31	275	28	120,600	3,739	(3,711)	115,896.60
Total	365	2,662					
Minimum							94,550.40
Maximum							115,896.60

The analysis results of the rainwater harvesting distribution in the Namtabung village are explained in Tables 12 to 14 below:
Table-12. The RWH distribution in simulation-1 is 79,962.89 m³ or 5.14 l/second.
Table-10. The RWH distribution in Simulation-2 is 115,077.83 m³ or 7.40 l/second.
Table-11. The RWH distribution in Simulation-3 is 115,896.60 m³ or 7.48 l/second.

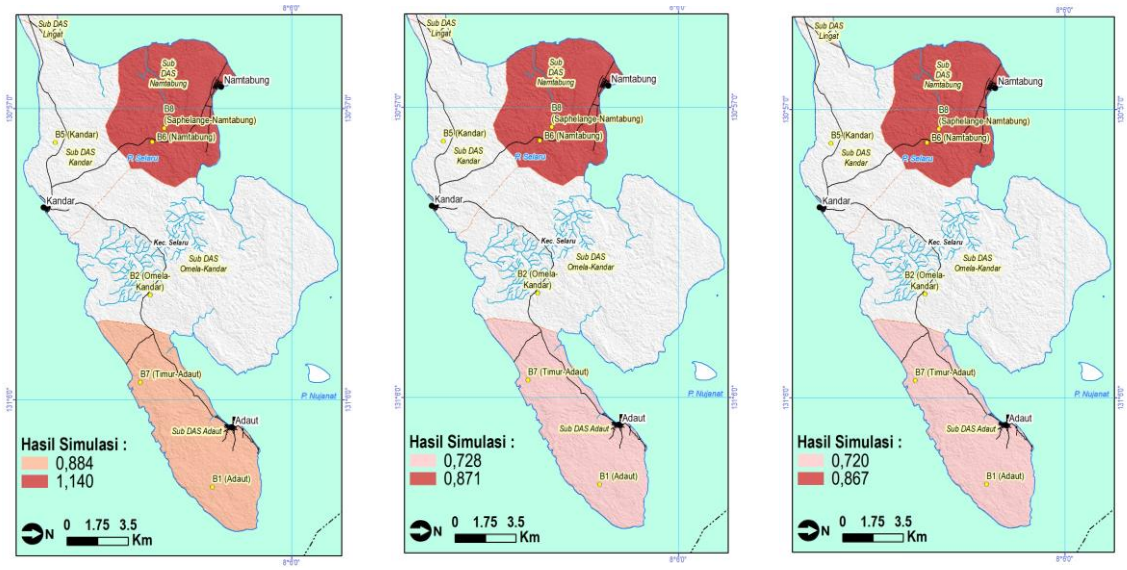
3.4 Water Distribution

Based on the analysis conducted on water requirement (population growth) and availability (existing sources), the existing distribution scenarios and rainwater harvesting method can be conducted until 2040, with the following results:

Table 4. The existing distribution scenarios of the sub-watersheds for 2040
Table Source: Analysis Results

Sub-watershed / Simulation	Adaut			Namtabung		
	Requirement (L/second)	Existing Distribution (L/second)	Simulation Result (L/second)	Requirement (L/second)	Existing Distribution (L/second)	Simulation Result (L/second)
Simulation-1	6.415	5.670	0.884	4.466	5.090	1.140
Simulation-2	7.788	5.670	0.728	5.842	5.090	0.871
Simulation-3	7.879	5.670	0.720	5.873	5.090	0.867

Source: Analysis Results



(a) (b) (c)

Figure 4. The distribution of the existing scenario of the sub-watersheds for 2040

Table 4 and Figure 4 present the water distribution of the sub-watersheds of the existing scenario for 2040.

The Adaut sub-watershed on Simulation-1 is 0.884, while the Namtabung is 1.140. The Adaut sub-watershed has insufficient water, yet the Namtabung is still sufficient, as presented in brown in Figure 4(a).

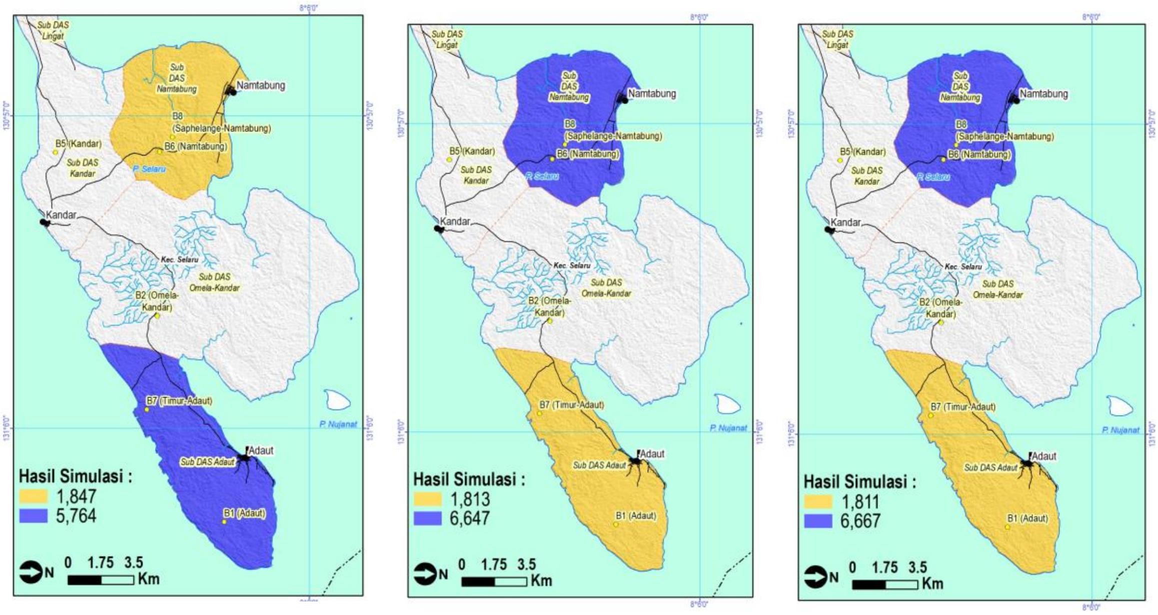
The Adaut sub-watershed on Simulation-2 is 0.728, while the Namtabung is 0.871. Both sub-watersheds have insufficient water, presented in brown in Figure 4(b).

The Adaut sub-watershed on Simulation-3 is 0.720, while the Namtabung is 0.867. Both sub-watersheds have insufficient water, presented in brown in Figure 4(c).

Table 5. The distribution of the RWH scenario of the sub-watersheds for 2040
Table Source: Analysis Results

Sub-watershed / Simulation	Adaut				Namtabung			
	Re qui re	Exi sti ng	R W H	Si mu lati	Re qui re	Exi sti ng	R W H	Si mu lati

Simulation-1	6.415	5.670	6.180	1.847	4.466	5.090	5.140	5.764
Simulation-2	7.788	5.670	8.450	1.813	5.842	5.090	7.400	6.648
Simulation-3	7.879	5.670	8.600	1.811	5.873	5.090	7.450	6.667



(a) (b) (c)

Figure 5. The distribution of the RWH scenario for sub-watersheds in 2040

Table 5 and Figure 5 present the water distribution of the sub-watershed of the existing scenario for 2040.

The Adaut sub-watershed on Simulation-1 is 1.847, while the Namtabung is 5.764. The water distribution at both sub-watersheds in this condition is surplus, presented in brown in Figure 5(a) and yellow and blue.

The Adaut sub-watershed on Simulation-2 is 1.813, while the Namtabung is 6.648. The water distribution at both sub-watersheds in this condition is surplus, presented in brown in Figure 5(b) and yellow and blue.

The Adaut sub-watershed on Simulation-3 is 1.811, while the Namtabung is 6667. The water distribution at both sub-watersheds in this distribution condition is surplus, presented in brown in Figure 5(c) and yellow and blue.

CONCLUSION

Based on the existing source scenario, the Adaut sub-watershed will experience a shortage of water distribution of 0.884 l/second in Simulation-1, 0.728 l/second in Simulation-2, and 0.720 l/second in Simulation-3. Meanwhile, the Namtabung sub-watershed will have a water distribution of 0.871 l/second in Simulation-2 and 0.867 l/second in Simulation-3. Adding rainwater harvesting methods to existing sources can fulfill the shortage of water distribution in the Adaut and Namtabung sub-watersheds. Moreover, the RWH method is appropriate for water distribution to reach optimum in the small island area of Selaru until 2040.

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