

The linkage between household water consumption and rainfall in the semi-arid region of East Nusa Tenggara, Indonesia

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Abstract. Several studies have shown that the amount of water consumption by communities will depend on the factors of water consumption patterns that are influenced by social, cultural, economic and local climate conditions. Research on the linkage between rainfall and household water consumption in semi-arid areas of Indonesia has never been done. This study has been conducted on 17 regions in NTT, and case study has taken samples in one town and one village. The research used survey and documentation method. The results show that the average amount of household water consumption in semi-arid region of East Nusa Tenggara is 107 liters / person / day. Statistical test results using Pearson correlation found $r = -0.194$ and $\text{sig} = 0.448$. This means that there is a negative correlation between rainfall and household water consumption. The greater the rainfall the smaller the consumption of water, or the smaller the rainfall the greater the consumption of water, but the linkage is not significant. Research shows that the amount of household water consumption will be influenced by many interrelated factors and none of the most dominant factors, including the size of the rainfall that occurs in a region.

Keywords: East Nusa Tenggara, household water consumption, rainfall, semi-arid

1. Introduction

UNICEF and WHO estimate that 1.1 billion people lack access to improved water supplies [1]. Until now, the problem of clean water is still a complicated problem in a number of regions in Indonesia. The reach of water services nationwide reaches about 76% by the end of 2015 through piped and non-piped networks. Most of the Regional Water Company (PDAM) as drinking water service operators are still having problems with their performance. Report of [2] recorded about 20% of 383 PDAMs in Indonesia are categorized as 'sick', 30% 'less healthy' and 50% 'healthy'. Whereas the government target at the end of 2019 access to drinking water services must reach 100%, while the rate of water demand is higher due to population growth and development activities. Clean water supply is affected by many factors including consumption patterns are influenced by the social, cultural and economic [3]. Research conducted [4] indicates that income, housing type, members per household, the presence of outdoor uses (garden and swimming pool), the kind of species planted in the garden and consumer behaviour towards conservation practices play a significant role in explaining variations in water consumption. Research [5] states that the most significant determinants for increases in water demand are population growth, climate change, and the type of urban development that occurs. The strategy to meet drinking water needs in areas with limited water resources capacity can be done by minimizing



the wasteful use of domestic water (households) with public facilities that can be utilized together [6]. The study conducted at Regional Kupang by researcher [7] states that the potential of existing water sources, is difficult to meet the needs of community drinking water in the long term. Therefore, the water resource management paradigm for multisector needs to be adjusted according to the semi-arid region specificity, with the main priority for drinking water needs. Potential rainfall that occurs should be optimized utilization as a source of raw water, through the construction of reservoirs, other rain water storage facilities and accompanied by conservation efforts. Previous study [8] said that extreme changes in the availability of surface water would be a serious problem in sustainable water management in semi-arid climate areas. The NTT area which is the study area is a semi-arid climate area [9], [10], [11], which continues to be problematic to date in the provision of clean water for its citizens. This shows that there is a relationship between climate and water availability in a region. But the extent to which rainfall factors affect the level of clean water consumption for household needs is not yet known and is an interesting problem that needs to be studied, especially in semi-arid NTT. Research on rainfall conducted by study [12] at 20 rain stations in Iran shows the variability of rainfall in arid and semi-arid regions. Research studied [13] rainfall in China revealed that each rain station has different characterizations. The results of this study demonstrate the recognition of the characteristics of rainfall from recorded time series data which is essential for sustainability of water availability and future management of water resources. A study of the rainfall characteristics in Kupang by study [10] found that rainfall occurs in high intensity in a short time duration. In general there is an increasing trend of rainfall, number of rainy days, and maximum daily rainfall. Rainfall in the wettest month gets wetter and dries up the driest month, resulting in increasing run-off and smaller infiltration of water into the soil, resulting in flooding during the rainy season and drought during long droughts. The aim of this research is to know the amount of household water consumption in semi-arid area of East Nusa Tenggara, which is reviewed in 17 districts through 15 PDAMs as drinking water operators in the region. Therefore, the amount of water used by the community from other sources outside the PDAM pipeline network is not a part of this study. The two areas that have been studied for in-depth research are Ende City representing rural areas, and Hane Village represents poor areas. The study also examined the correlation between rainfall and household water consumption in each of the studied areas.

2. Research Method

The study area is East Nusa Tenggara Province (NTT) which is generally a semi-arid region with rainfall ranging from three to four months, even in some areas, rainfall only lasts for two months of the year [7], [11]. Average rainfall that recorder in meteorology/climatology stations was between 600 - 2700 mm [9], [14]. Areas in NTT have different temperature. From 10 meteorology/climatology stations in NTT, the highest temperature in 2015 was 37.4°C and the lowest was 8.8°C. Typically, NTT is a hot area with average temperature of 26 - 28°C all year in 2015 with some exception areas that have average temperature of 19.9°C. NTT is an archipelago province with 1.192 numbers of island, 432 island with names, and 44 inhabitants island. Big islands in NTT usually called Flobarmorata (Flores, Sumba, Timor, Alor, and Lembata). The area of NTT lands is 47,931.54 km². NTT Province has 21 regency and one city, 306 districts and 3268 villages. Astronomically, East Nusa Tenggara Province is located between 8° - 12° South Latitude, and between 118° - 125° East Longitude [14].

The data were collected by survey method to assess the household water consumption in Hane Village, TTS Regency and Ende City, Ende Regency. The sample size is 22 - 30 households in each region selected by cluster random sampling. Reserched study [15] argue that household surveys are a useful method for assessing water needs and demand. In urban areas, conducted by grouping the population according to the economic level of the family. In this study the economic level is based on the type of house construction, the lower economy is indicated by the simple building, the middle economy is indicated by a semi-permanent and permanent building, and a capable economy indicated by the type of permanent house building with storey building. The selected sample is household using only clean water from PDAM and recorded through water meter. In the village area, grouping according to the level of community education. Group 1 is the education of the head of household

(KK) graduated from elementary school or not. Group 2 finished junior high school, while group 3 graduated undergraduate education. Next, each group was randomly selected for each of the 7-10 samples. Data retrieval time is done for one month, in 2017. Study [5] found that water consumption dependent on household size, seasonal use, education level and the size of the property's outdoor space. While study [15] discusses how household consumption of water is affected by income. Documentation method was used to obtain data on household water consumption from 15 PDAMs in 17 regions in NTT through study [2]. Rainfall data obtained from the Agency of Meteorology and Geophysics of NTT (BMKG NTT) with five-year data length from 2012 - 2016.

The analysis is done by statistic of mean test to know the average number of household water consumption in liters/person/day. To know the linkages between rainfall and household water consumption used Pearson-corellation statistical analysis using SPSS ver.21.

3. Results and Discussion

3.1. Rainfall

Through the results of data analysis of average rainfall for five years obtained the fact that, the average of rainfall in East Nusa Tenggara is 1445 mm/year. However, there are several wet climates with high rainfall of 2893 mm/year in Manggarai Regency, and East Sumba with relatively dry climate with average rainfall of 863 mm/year. The amount of rainfall in the NTT region by region, as shown in Table 1.

Table 1. Average rainfall in NTT, by regency/city (2012 – 2016) [18].

No	Regency/City	Annual rainfall (mm)	No	Regency/City	Annual rainfall (mm)
1	Kupang City	1486	9	Manggarai	2893
2	Kupang Regency	1884	10	Manggarai Barat	1196
3	Timor Tengah Selatan	1610	11	Ngada	1321
4	Timor Tengah Utara	1651	12	Ende	1261
5	Belu	1480	13	Sikka	976
6	Rote-Ndao	1721	14	Flores Timur	1478
7	Sumba Timur	830	15	Lembata	856
8	Alor	1027	Average (mm)		1445

Researched studied [10] in Kupang found that rainfall occurs in high intensity in a short time duration. The average number of rainy days in Kupang is 80 days a year. The average amount of rainfall in Indonesia ranges from 1000 - 5000 mm per year. Study [11] said that Indonesian rainfall patterns are influenced by several factors, such as, monsoon, Inter-tropical Convergence Zone (ITCZ), El Nino - Southern Oscillation (ENSO), and other regional circulations in Pacific and Indian oceans. Indonesia rainfall patterns are divided into three main areas, they are: (i) monsoon region (type A) is the dominant pattern in Indonesia, because it covers almost the entire territory of Indonesia. The area has a peak in November to March (NDJFM), which is influenced by wet northwest monsoon, and a trough in May to September (MJJAS), that is affected by the dry southeast monsoon, so it can be distinguished clearly between dry and rainy seasons, (ii) equatorial region (type B) has two peaks in October to November (ON) and March to May (MAM). This pattern is influenced by a shift to the north and south from ITCZ or equinox point (culmination) of the sun and (iii) local climate region (type C) has a peak in June to July (JJ) and a trough in November to February (NDJF). This pattern is the opposite of pattern A.

3.2. Household Water Consumption

The household water consumption study was conducted in 17 regency/city in NTT served by 15 PDAMs operating in the area. The results showed that the total household water consumption was 107 liters/person/day, lower than the minimum water requirement according to Indonesian Government standards of 122 liters/person/day. Details of household water consumption by regency/city in NTT as shown in Table 2.

Table 2. Household water consumption by regency/city in NTT.

NO	Name of PDAMs/Region	Population served (persons)	Water consumption (liters/day)	Water consumption (liters/person/day)
1	Kupang City (parts of Kupang city)	23,256	1,505,434	65
2	Kupang Region (Kupang City, Kupang regency and Sabu regency)	200,552	20,178,202	101
3	Timor Tengah Selatan	41,719	3,930,250	94
4	Timor Tengah Utara	35,240	4,144,694	118
5	Belu (include Malaka regency)	200,552	18,413,568	92
6	Rote-Ndao	10,530	1,224,029	116
7	East Sumba	45,312	8,756,986	193
8	Alor	23,310	3,684,010	158
9	Manggarai	81,310	8,981,453	110
10	West Manggarai	19,078	2,351,722	123
11	Ngada	39,576	4,703,530	119
12	Ende	53,262	6,440,083	121
13	Sikka	70,492	5,128,531	73
14	East Flores	82,453	3,587,846	44
15	Lembata	12,304	996,624	81
Average (liters/ person / day)				107

From Table 2, it is known that the highest household water consumption in East Sumba regency is 193 liters/person/day and lowest in East Flores is 44 liters/person/day. Interesting data is indicated by the amount of household water consumption in Kupang City, the capital city of NTT province, which is categorized by big city with population > 500 thousand people, that is water consumption only reaches 65 liters/person/day served by *PDAM Kota Kupang* or only Reaches 83 liters/person/day if included which is served by *PDAM Kabupaten Kupang*. Whereas the standard of clean water consumption is 170 liters/person/day. Study [7] reported that the fulfillment of drinking water needs in Kupang City and surrounding areas, mostly obtained through dug wells whose water quality has been contaminated. Study [17] states that over-exploitation of ground water not only causes a reduction in the availability of water but also result in the degradation of water quality. These data indicate that the Government through PDAM has not been able to meet the community's need for clean water. The result of research data analysis proves that the fulfillment of household clean water needs in the semi-arid region of NTT is still experiencing a complicated problem, because most of the region has not been able to meet the needs of clean water for the community. Only three areas (East Sumba Regency, Alor Regency and West Manggarai Regency) are able to fulfill household water supply. Researchers [1] states that major challenges to providing safe water on a global basis: (1) contamination of water in distribution systems, (2) growing water scarcity and the potential for water reuse and conservation, (3) providing sustainable water supplies for megacities, and (4) reducing global and regional disparities in access to water and developing financially sustainable water services.

The 2015 MDGs target for drinking water is the percentage of households with sustainable access to a rural drinking water source of 65.81% and for urban areas of 75.29% or an average of 68.87%. Targets that have not been achieved in many areas in NTT. Challenges to achieving targeted drinking water services for communities are quantity, quality, continuity, funding aspects including funding sources, affordability, services for the poor, management and institutions.

3.3. Case study of household water consumption in urban and rural areas of NTT

Ende City located on the southern coast of Flores Island. The drinking water service in Ende City is done by PDAM Tirta Kelimutu Ende. Water sources come from: springs, boreholes and streams, with a production capacity of 101 liters/sec. The population in the Ende Regency is 263,201 person. The coverage of drinking water services is only 20% of the total population or the population is served by 53,262 person [2]. The result of data analysis from 22 household samples shows that household water consumption in Ende City is 96 liters/person/day. With a population of 106,584 people, the minimum standard of household water consumption is 150 liters/person/day. This shows that the fulfillment of

household water needs has not been fulfilled in Ende City. Although the average amount of water consumption is 96 L/person/day, the data also shows that there is a high deviation in household water consumption in Ende City. Lowest is 40 L/person/day, while the highest is 210 liters/person/day. Study [4] indicates that income, housing type, members per household, the presence of outdoor uses (garden and swimming pool), the kind of species planted in the garden and consumer behaviour towards conservation practices play a significant role in explaining variations in water consumption. The number of households using clean water according to minimum eligibility standards is 6 households or 27% of the total sample, the remaining 73% is below the standard. The results of this study are in line with what is said by UNICEF and WHO estimate that 1.1 billion people lack access to improved water supplies [1].

Hane village is located in TTS Regency. The results of the analysis on the household samples studied show the total consumption of household water consumption in Hane Village is 48 liters/person/day. With a population of <3000 people the minimum standard of water consumption is 60 liters/person/day. This indicates that the fulfillment of the need for household water in quantity has not been fulfilled in Hane Village. Although the average amount of water consumption is 48 L/person/day, the data also show that there is a high deviation in household water use in rural areas of Hane. The lowest is 21 L/person/day while the highest is 80 L/person/day. The number of households using clean water based on minimum standards of eligibility by the Indonesia Government is only 7 households or 23% of the total sample, the remaining 77% below the standard. Source of clean water utilized for the fulfillment of household needs comes from: springs, rivers and rural piping networks. The supply of drinking water through the rural pipeline network has not run continuously and there is still rotation, in the dry season the debit decreases drastically and there is no drainage. Similarly, water sources from springs and rivers experience a very large reduction of discharge and even drought so that household water needs become disrupted.

3.4. *The linkage between household water consumption and rainfall*

Statistical test result using Pearson correlation between rainfall and household water consumption rate is $r = -0.194$ and $\text{sig} = 0.448$ (Table 3). Mean rainfall is negatively linkage to household water consumption, and the correlation is not significant. The linkage caused is the greater the rainfall of an area the less the level of water use, or vice versa. This study shows that, the amount of rainfall will help minimize water consumption in a region, although not significant.

Table 3. The correlation value between rainfall and the amount of household water consumption.

Descriptions		Rainfall	Water consumption
Rainfall	Pearson Correlation	1	-.194
	Sig. (2-tailed)		.488
	N	15	15
Water consumption	Pearson Correlation	-.194	1
	Sig. (2-tailed)	.488	
	N	15	15

4. Conclusion

The average amount of household water consumption in semi-arid NTT is 107 L/person/day. In urban areas, only 27% of households use water according to minimum standards, as well as in rural areas only 23% of households. Research shows that the fulfillment of household drinking water needs in most areas of NTT has not been met in terms of quantity. There is a negative correlation between the variable of household water consumption and rainfall occurring in the semi-arid region of NTT. The greater the rainfall will be to minimize the consumption of household water consumption, and the smaller the rainfall will result in greater household water consumption, although the statistical test shows that the correlation is not significant. Research shows that the amount of household water

consumption will be influenced by many interrelated factors and none of the most dominant factors, including the size of the rainfall that occurs in a region. This research needs to be developed again to obtain more detailed results. But at least the results of this study further reinforce that the problem of water supply is still a joint problem, which needs to be taken prompt and appropriate strategic steps by the Government with the support of all components of society.

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