THE POLICY OF CLEAN WATER SUPPLY BY IDENTIFYING CRITICAL AREAS IN BANYUWANGI, EAST JAVA

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ABSTRACT

This study aimed to determine the policy of clean water supply in area of clean water crisis in Banyuwangi. The study was conducted in 5 subdistricts, namely Wongsorejo subdistrict, Licin subdistrict, Songgon subdistrict, Kalibaru subdistrict and Pesanggaran subdistrict. Two analyses were conducted in this study, namely; the analysis of the clean water needs and the analysis of clean water availability. Four parameters were used in this study, namely: a) forest area; b) rainfall; c) total area; and d) population. The results showed that among those five subdistricts in Banyuwangi, only Kalibaru subdistrict was considered as area with clean water crisis due to its population of 61,820 inhabitants within an area of 18,741.80 km^2. The result of clean water needs measurement (K) was 353,870.9 m^3/year and groundwater recharges (RC) as 556,633 m^3/year (the clean water needs has not been fulfilled). To this problem, the local governement of Banyuwangi should do reforestation of 0.78% denuded forest in order to cover 30% of forest area in Kalibaru subdistrict according to the Law of the Republic of Indonesia Number 26 Year 2007 about spacial planning. Therefore, the role of forests was extremely needed in order to serve the environment both socially and economically and give advantages to the local community.

Keywords*: clean water, availability, critical areas*

INTRODUCTION

Water is an important element in life because no one can survive without it. Hence, water becomes one of the pillars of life for humans. There is unlimited suppy of water on the earth, but only a little of them is a drinking water. Depleting clean water supply is due to the increasing population which leads to the increasing needs of drinking water. As a result, 40% of the Earth's population will experience a shortage of clean water. This condition will worsen by 2025 where 1.8 billion people will live in areas of clean water crisis. Clean water crisis impact negatively on all sectors, including health. Without hygienic drinking water, there will be 3,800 children die every day due to disease (*Jacques Diouf, Director-General of the Food and Agriculture Organization (FAO)*).

The environmental damage is one of the major causes of the crisis. Coastal erosion causes seawater seepage to the mainland which eventually contaminate groundwater sources. Littering in the river also pollutes the water and makes the water dirty and cannot be used to fulfill our needs. In Indonesia, 60% of the rivers in Sumatra, Java, Bali and Sulawesi are polluted by sewage, ranging from organic materials to coli bacteria and fecal coli causing diarrhea. 5,789 cases of diarrhea were found and those led to 94 deaths (data from the Ministry of Health, 2002).

East Java Province has area of 46,428 km^2 or 4,6428 million ha divided into 38 regions. Among 38 regions, there are five largest regions, namely Banyuwangi, Malang, Jember, Sumenep and Tuban. Of those five, Banyuwangi (see Figure 1) was selected as the location of the study.

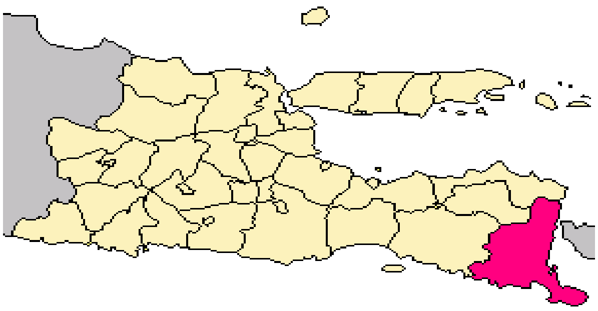

Figure 1. *Map of Banyuwangi District*
Sources: The District of Banyuwangi in 2014.

This study required some important parameters to determine areas of clean water crisis, namely : a) forest area; b) rainfall; c) area; and d) population. The parameter of rainfall was used to measure the amount of groundwater recharge (groundwater reserves supply). The higher intensity of rainfall was, the more groundwater recharge was generated assuming by types of porous land, types of deep rooted and swmall dense leaves vegetation, as well as the width of forest area.

Among the four parameters, the existence of extensive forest area was used as an indicator to measure the balance of the ecosystem as stated by the Law No. 26 Year 2007 on Spatial Planning which described that forest has to cover 30% of watershed and green space (garden) has to cover 30% of total area in urban area. The policy was intended to ensure the optimization of the role of forests in terms of environmental benefits, social benefits and economic benefits for local communities (Robert J. Kodoatie & M. Basoeki., 2005).

To fulfill 30% forested land, it was obtained from the state and local forest areas. in East Java, 1,357,206.3 ha was state forest, while local forests were gradually increase along with the demands of logs and timber. According to satelite image of Landsat 7 ETM year 2006/2008, the local forests was 523,534.68 ha.

According to the difference between the theory of "water balance" (distribution of water equaled to the distribution of inlet water outlet) and the fact, the changes on the state forest area in East Java was from 636,797.07 ha

(2003) to 634,941.02 ha (2006) and the changes of forest area in directed location (Banyuwangi) was 74,071.04 ha (2003) to 51,450.84 ha (2008) (source: the arrangement of forest office region XI Java-Madura, 2009).

RESEARCH METHODS

The location of this study only covered the district of Banyuwangi. Of the 24 subdistricts in Banyuwangi, 5 subdistricts were selected namely Licin subdistrict, Songgon subdistrict, Wongsorejo subdistrict, Kalibaru subdistrict, and Pesanggaran subdistrict. This study was a case study using quantitative approach. Considered as case study because of the limited scope of the study.

Groundwater sampling techniques was randomly taken which was assumed that could cover all samples for the study referred to "purposive random sampling". The data collection techniques was conducted using direct observing and direct interviews with the respondents.

Two samples of groundwater were taken from each subdistrict, while for mapping the distribution of rocks containing groundwater (aquifers) was conducted in 3 point positioning data outcrop of rock by using Global Positioning System (GPS) toin each subdistrict also have five districts and each district Therefore, there were 10 samples of groundwater and 15 samples of rocks taken.

Furthermore, to determine the area considered as area with clean water crisis, two analyses were conducted, namely: 1) analysis of the clean water needs; and 2) analysis of the amount of groundwater recharge (groundwater reserves supply). If the result of the analysis of clean water needs indicated bigger value than the results of the analysis of the magnitude of the groundwater reserves, then the region was considered as area with clean water crisis; when the result indicated the opposite, then the area was not considered as crisis area.

RESULTS AND DISCUSSION

a. Area and Population

Banyuwangi has area of 5,782.50 km^2, divided into 24 subdistricts and 217 villages. Among the 24 subdistricts, five subdistricts were selected to conduct the study considering to the wide area and the population. Among those five subdistricts, Wongsorejo subdistrict has the largest population numbered 75,108 people, 37,016 of men (49.28%) and 38,092 of women (50.72%); while the smallest population was Licin subdistrict which has 28,184 people, 13,951 of men (49.50%) and 14,233 of women (50.50%).

The widest subdistrict was Pasanggaran subdistrict with area of 45,609.62 km^2 and the narrowest subdistrict was Licin subdistrict with area of 11,265.17 km^2. From the area and population in those subdistricts, it was assumed that the number of housing in the Pesanggaran subdistrict was more than in the Licin subdistrict. Furthermore, to determine the subdistricts whether considered as area crisis or not, it was necessary to measure the clean water needs and the clean water supply (groundwater reserves) in selected location.

b. Water Need Analysis

To determine whether the clean water needs of the population in Wongsorejo, Licin, Songgon, Kalibaru and Pesanggaran subdistric in Banyuwangi were equally fulfilled or not, data of the population in each district multiplied by clean water needs in urban/rural area per-day, per-person was needed. The clean water needs in uban area was = 120 liters/day/person; while the clean water needs in the rural was 60 liters/day/person (*The Technical Guidelines of The Balance for Natural Resources Spatial Indonesia, BAKOSURTANAL*). The analysis of clean water needs in the Wongsorejo, Licin, Songgon, Pesanggaran, and Kalibaru subdistrict in Banyuwangi is seen in the Table 1.

Table 1. *The analysis of clean water needs in the study area*

No	Subdistrict	Population	Formula	Measurement Result	
1.	Wongsorejo	75,108	75,108 x 60 l/person/day	4,506,480 l/day	1,644,880.8 m^3/year
2.	Licin	28,184	28,184 x 60 l/person/day	1,691,040 l/day	617,235.5 m^3/year
3.	Songgon	50,878	50,878 x 60 l/person/day	3,052,680 l/day	1,114,238.8 m^3/year
4.	Kalibaru	61.820	61.820 x 60 l/person/day	3.709.200 l/day	1,353,870.9 m^3/year
5.	Pesanggaran	49.009	49.009 x 60 l/person/day	2.940.540 l/day	1,073,307.3 m^3/year

Source: Data analyzed using the analysis of water needs in 2014

The Table 1 showed that the highest clean water needs was in Wongsorejo subdistrict as 4,506,480 l/day with population numbered 75,108 people. The lowest clean water needs was in Licin subdistrict as 1,691,040 l/day with population numbered 28,184 people.

c. Analysis of clean water availability

Analyzing the clean water supply was by measuring the groundwater reserves comparable to the groundwater recharge from the rain. According to *Bakker* and *Pulawski (1983),* the aquifer augments were calculated through augmentation approach as a percentage of annual rainfall average by the following formula:

RC = RF x A x RC (%)

Where:

RC = ground water recharge of annual rainfall (m^3/year).

RF = precipitation of annual average of rainfall in the study area, measured by the Thiessen Polygon (m).

A = area/cistern (each subdistrict) measured using planimeter (GIS), using the program of Arc View version 3.0 (m^2).

RC (%) = augment percentage (%).

d. Rainfall

Calculating groundwater recharge (RC) as the groundwater reserves which was available in every subdistrict was done by measuring annual average of rainfall in every subdistrict discovered beforehand using Polygons Thiessen method (each subdistricts was made into polygons using the Arc View version 3.0 program (Prahasta & Eddy, 2003)).

Table 2. *The analysis of annual average rainfall using Polygon Thiessen in Banyuwangi in 2014*

No	subdistrict	Polygon Thiessen	Result of annual average rainfall
1.	Wongsorejo	Two Polygon Thiessen (light green and red)	(110 + 145)/2 + (211 + 279)/2 = 127.5 + 245 **= 372.5 mm**
2.	Licin	Three Polygon Thiessen (yellow, red, and orange)	(76 + 109)/2 + (211 + 279)/2 + (44 + 75)/2 = 92.5 + 245 + 59.5 = **397 mm**
3.	Songgon	Three Polygon Thiessen (red, yellow, and blue)	(211 + 279)/2 + (76 + 109)/2 + (146 + 210)/2 = 245 + 92.5 + 178 = **515.5 mm**
4.	Kalibaru	Two Polygon Thiessen (light green and yellow)	(110 + 145)/2 + (76 + 109)/2 = 127.5 + 92.5 = **110 mm**
5.	Pesanggaran	Two Polygon Thiessen (light green and yellow)	(110 + 145)/2 + (76 + 109)/2 = 127.5 + 92.5 = **110 mm**

Source: Data of rainfall in 2014 analyzed using Polygon Thiessen.

After discovering the average of annual rainfall in every subdistrict, groundwater recharge will be measured as groundwater reserves supply by multiplying the area of each subdistrict (A) and augment percentage (RC%) (East Java has aquifer types of mix volcanics and sediments of 27 (Bakker and Pulawski, 1983)). Thus, groundwater recharge in the aquifer of every subdistrict could be measured as follows: Groundwater recharge as groundwater reserves available in Wongsorejo subdistrict was:

RC = RF x A x RC (%)

$= (1/1000 \times 372.5) \times (34.39336 \times 10^6) \times 27/100$
$= (0.3725 \times 10^6) \times 34.39336 \times 0{,}27$
$= 372{,}500 \times 9.2862$
$= 3{,}459{,}109.50\ m^3/year.$

Groundwater recharge as groundwater reserves in Licin subdistrict was:

RC = RF x A x RC (%)

$= (1/1000 \times 397) \times (11.26517 \times 10^6) \times 27/100$
$= (0.397 \times 10^6) \times 11.26517 \times 0.27$
$= 397{,}000 \times 3.0416$
$= 1{,}207{,}515.20\ m^3/year.$

Groundwater recharge as groundwater reserves in Songgon subdistrict was:

RC = RF x A x RC (%)

$= (1/1000 \times 515.5) \times (20.77759 \times 10^6) \times 27/100$
$= (0.5155 \times 10^6) \times 20.77759 \times 0.27$
$= 515{,}500 \times 5.6099$
$= 2{,}891{,}903.45\ m^3/year.$

Groundwater recharge as groundwater reserves in Kalibaru subdistrict was:

RC = RF x A x RC (%)

$= (1/1000 \times 110) \times (18.74180 \times 10^6) \times 27/100$
$= (0.110 \times 10^6) \times 18.74180 \times 0.27$
$= 110{,}000 \times 5.0603$
$= 556{,}633\ m^3/year.$

Groundwater recharge as groundwater reserves in Pesanggaran subdistrict was:

RC = RF x A x RC (%)

$= (1/1000 \times 110) \times (45.60962 \times 10^6) \times 27/100$
$= (0.110 \times 10^6) \times 45.60962 \times 0.27$
$= 110{,}000 \times 12.3146$
$= 1{,}354{,}606\ m^3/year.$

Furthermore, compared the analysis of clean water needs to the calculation of the availability of groundwater recharge, it showed the subdistricts that have not or have fulfilled the clean water needs, as seen in Table 3.

Table. *3 List of Subdistricts where the clean water needs has and has not been fullfiled in study area*

No	Subdistrict	Result of analysis of clean water needs	Result of groundwater reserves measurement	Note
1.	Wongsorejo	1,644,880.8 m^3/year	3,459,109.50 m^3/year	Fulfilled
2.	Licin	617,235.5 m^3/year	1,207,515.20 m^3/year	Fulfilled
3.	Songgon	1,114,238.8 m^3/year	2,891,903.45 m^3/year	Fulfilled
4.	Kalibaru	1,353,870.9 m^3/year	556,633 m^3/year	Un-fulfilled
5.	Pesanggaran	1,073,307.3 m^3/year	1,354,606 m^3/year	Fulfilled

Source: Data analyzed using the analysis of clean water needs in 2014

Table 3 showed that clean water needs was fulfilled in the Wongsorejo, Licin, Songgon and Pesanggaran subdistrict, but it was not in Kalibaru subdistrict. People in Kalibaru subdistrict needed helps from the local government through the Department of Energy and Mineral Resources by building the drilling groundwater wells, as well as help from the Department of Forestry and Plantation Banyuwangi by doing “reforestation”.

Solution:

Generally, clean water needs in Banyuwangi was fulfilled except in Kalibaru subdistrict which needed help from the local government through the Department of Energy and Mineral Resources Banyuwangi for water supply. Meanwhile, to overcome the unstability of groundwater reserves, government should do reforestation which could be managed by the Department of Plantation and Forestry Banyuwangi in cooperation with Public Company of Perhutani KPH Banyuwangi.

Furthermore, in the areas which has with significant differences of rainfall intensities have to be carefully supervised, as those areas would affect the average of annual groundwater recharge, for examples flooding in the rainy season and water shortages in the dry season.

In the study areas, the highest rainfall with big difference of maximum and minimum debit was in Giri subdistrict Banyuwangi. In that subdistrict, there was no rain in August, but in January, it had high intensity of rainfall reached 403 mm. For future prevention (long-term plan), restoring the forest functions would balance the ecosystem environment and control the hydrological cycle.

Eventually, any change of land use which cut the forest area should be replaced by other areas which is functioned as forest by undergoing reforestation or reboitation. Delays in replanting trees would have big effects to living beings and the environment around it; for examples, the flood in Bondowoso (2007), floods in Pacet Mojokerto (2010), landslide in Jombang (2014), and more floods and landslides in other places which greatly harm the people for their lives, wealths, as well as the environment. All was because the forest ecosystem functioned in maintaining the environmental balances did not functionate properly.

CONCLUSION

1**.** The effect on reducing state and local forest areas as 0.78% of minimum 30% of the total forest area in Banyuwangi to the amount of groundwater recharge (groundwater reserves) in the study area, indicated that there was only one subdistrict (districts Kalibaru) of five subdistricts in Banyuwangi which had the least amount of groundwater recharge (groundwater reserves) as 556,633 m^3/year (measured using the formula of Bakker and Pulawski).

2. The impact of the changes in state and local forest areas to clean water for the population (measured using double comparison methods, between analysis of clean water needs and analysis of availability of groundwater recharge) showed that in Banyuwangi, in five subdistricts where the study conducted, the clean water needs was fulfilled in four subdistricts (Wongsorejo, Licin, Songgon, Kalibaru and Pesanggaran), except in Kalibaru subdistrict where the needs was not fulfilled.

3. The policy to address the problems of the unstability of groundwater reserves and the clean water shortage was by undergoing replantation, reboitation, and reforestation. Having good hydrological cycle will lead to the balance of water distribution between the volume of rainwater seeped into the ground (inlet) and the volume of rainwater flow out (outlet).

SUGGESTION

1. The long-term policy is to undergo reboitation or reforestation on the barren forest (0.78%) in Banyuwangi to meet the target of minimum 30% of the total area of Banyuwangi according to Law No. 26 Year 2007 about Spatial Planning.

2. Short-term policy was the Government of Banyuwangi strictly prohibits the practice of illegal logging and changing land use, including banning the residencial construction in the area of water infilation.
3. Based on the analysis of clean water needs with parameters of the population and the clean water needs per-person/per-day and the analysis of groundwater reserves with the parameters of forest area, rainfall intensity, and total area of Banyuwangi, the biggest opportunity of the growth of water bottled industry was in Songgon subdistrict, Banyuwangi.

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