

## Carrying Capacity Analysis of Sustainable Groundwater Sources (Case Study in Sumberjati Village, Sillo District, Jember Regency)

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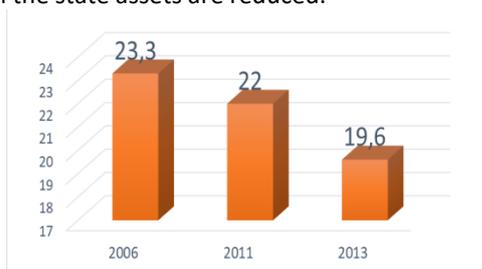
### Abstract

Sumberjati Village is one of water supply area in East Jember Regency. The existence of natural resources potential, which is groundwater sources, give an impact to the excessive use of that common goods by local and nearby village. If this condition continues, in the long term, there will be water scarcity in Sumberjati Village. Therefore, the aim of this study is to analyse the carrying capacity of sustainable groundwater resources in Sumberjati Village. This research is using Principal Component Analysis (PCA) as main methods, which consist of 3 (three) components: (i) soil water resources (ii) environment; and (iii) social economy. Based on PCA analysis results, it is known that that for the groundwater resources component, variables that have a positive effect on the carrying capacity of groundwater resources in Sumberjati Village are; (i) number of water sources, and (ii) water wasted amount. While for the environmental component, the variables that have a positive effect is; (i) water quality, (ii) land conservation, (iii) erosion prevention, (iv) water pollution prevention, and (v) water distribution. For the Socio-Economic component, the variables that have a positive effect on the carrying capacity of groundwater resources are; (i) the ability to pay for water, and (ii) the number of households who can access the water

**Keywords:** Groundwater Resources, Principal Component Analysis, Sumberjati Village

### INTRODUCTION

Economic development is basically paradox (it causing opportunity cost) toward environmental sustainability. It is often seen from the existence of economic activities that tend to damage environmental sustainability. Indeed, some experts always consider the paradox, because the economic growth has to increased, but in the other hand, the environmental sustainability is neglected. [1] contend that the damaged of environmental sustainability (over exploitation) has an impact in the increase of foreign exchange in the short term, but in the long run the state assets are reduced.



Source: Central Bureau of Statistic, 2017

Figure 1 Data of Critical Land Area in Indonesia (in million Ha)

Based [2], the extent of critical land in Indonesia in 2006, 2011, and 2013 has decreased drastically (figure 1). In 2006, the number of critical land in Indonesia reached 23.3 million Ha, fell to 22 million Ha in 2011 and fell back in 2013 to 19.6 million Ha. The area of critical land decreasing, provides several assumptions such as: (i) the government's efforts through its policy implementation are appropriate (successful in reforestation, rehabilitation and reclamation program) and (ii) the community efforts to prevent land become critical through cultivation system, considered quite effective.

However, the declining trend of critical land submitted by [2] needs to be analyzed further. It is not because the number of deforestation in Indonesia actually increase significantly. Central Bureau of Statistic's data on 2017 said that during the year 2009 to 2015, the number of deforestation reached 1.09 million Ha. The largest deforestation contributed by forest fires (74.7%) and the 25.3% is due to the opening of new land. For East Java, in 2015 the deforestation rate reaches 7,749.2 Ha.

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From the large numbers of deforestation in Indonesia and East Java, one of the main motives is none other than the economy motives. In fact, [3] stated that the economic system is a subsystem of the global ecosystem, and one of the main goals of environmental economics is to determine the long-term sustainability of revenue and economic growth, and increase the opportunity cost of individual ownership (sacrificing individual ownership or management) to keep the ecosystem sustainability.

Referring to data and facts about the environment and economy, this research is intentionally implemented in Sumberjati Village, Silo Sub-district, Jember Regency. Sumberjati Village is deliberately chosen because this village has the potential of abundant water resources. However, the abundance of water resources in this village still raises a polemic because it has not been managed optimally. It is seen from the water distribution system that still manage by certain people, so that the community who live in the lower part of the village does not get water supply. On the other hand, there is a hamlet which is the owner of the springs, can not use the water (take water directly) because it is utilized by the other hamlet and villages which forming the water shelters.

The Homogeneous of socioeconomic conditions (consisting of almost uniform ethnicities and professions) should have a positive impact on water governance, but acculturation (the influence of social character of each hamlet so different) is appears to impacts the governance of Sumberjati Village's water resources over the years.

This research is considered very important where the similar researches focused on the study of environmental supporting power, especially water resources, is very rarely encountered in East Java. Thus, the main purpose of this research is to answer the above problem formulation. To that end, the purpose of this study focused on the analysis of the carrying capacity of sustainable water resources in Sumberjati Village, Silo Sub-district, Jember District.

## **LITERATURE REVIEW**

The literature review is deliberately used in this study to support the reinforcement and deepening of the material to be presented. Because the focus of this study was to determine the sustainable capacity of ground water and to form a more targeted policy recommendation, so the literature review used in this study is: (i) The

concept of environmental carrying capacity, and (ii) Utilization of ground water, that explained as follows.

### **1. The concept of environmental carrying capacity**

Resources and the environment are a basic component that supports how humans survive. The accelerated pace of economic growth and human resources has been increasing environmental issues in recent decades. To that end, some researchers provide an illustration that the issues of environmental carrying capacity is very important to be studied more deeply. [4] provides an explanation of where the environmental carrying capacity itself is a multiplier factor consisting of: environmental, soil, socio-economic, water availability, and reflections of how the interconnection of all these carrying capacity goes in one area and the resources specifically.

Furthermore [5] stated that the carrying capacity of the environment is the ability of the environment to support human life, other living things, and the balance between the two. Other opinions related to the understanding of carrying capacity are presented by [6], where in the ecological context, the environmental carrying capacity is the number of population or community that can be supported by the resources and services available in the ecosystem. Factors that affecting the limitations of ecosystems to support livelihoods are the number of available resources, population and consumption patterns.

The concept of environmental carrying capacity in the ecological context is closely related to natural capital. However, in the sustainable development context, a community not only has natural capital but also human capital, social capital and artificial environmental capital. Therefore, in the context of the sustainability of a region, the carrying capacity of the regional environment is the number of populations or communities that can be supported by the available resources and services because of the natural, human, social and environmental capital they have.

### **2. Ground Water Utilization**

The groundwater utilization is starting from 10,000 years ago in Egypt. The groundwater utilization is done by the people of Egypt with a tool called saqiya or noria which is a simple pulley to lift water from the bottom of the cliff or in the soil to meet the needs of drinking water and irrigation [7]. But [7] also stated that this

technology is newly developed rapidly in 7,000 years ago, after it found more modern pulleys in Egypt. In fact, this groundwater utilization technology continues to grow and spread to areas such as Mesopotamia, the Indus River Basin, Latin America to the Roman and Greek empires. For now, [8] said that the development of groundwater utilization is directed at 7 (seven) things, such as:

**a. Fulfilling the necessities of life**

Human life can not be separated from water. Humans may not eat in a certain period of time, but humans can die if not drinking water. People usually use ground water for drinking, bathing, washing, cooking and other necessities.

**b. Irrigation**

Irrigation is very important in agriculture. If rainfall is low, farmers need irrigation systems to irrigate the rice fields. The irrigation system should be supported with sufficient water availability. One solution of that problems is the presence of groundwater.

**c. Clean Water Providers**

Another benefit of ground water is as a provider of clean water naturally. Groundwater is enclosed in a layer of soil and is protected by rocks. Its location which is in the ground and has passed some rocks, make the ground water as a source of water that does not need to be filtered again because the rocks in the soil has become a natural filter for the soil, so the groundwater cleanliness was assured.

**d. Power Supply**

In general, hydroelectric power plants utilize surface ground water in the form of reservoirs, lakes or rivers. However, there are power plants that also utilize ground water as a source of electricity provider. In areas that have not been touched by the electricity provider, people use underground river water to make their own electricity sources by making their own power supply sourced from underground river water flows

**e. Natural Laboratories**

Groundwater location that can be seen clearly is in the cave. Researchers can use the existence of underground rivers in the cave as natural laboratories. The location is in open space, which making the ground water source in the cave is quite easy to study. Many things can be examined by experts. That's because there are many unique organisms that inhabit in underground rivers. Not only underground river organisms that can be explored, the cave that protects the river can also be explored. Cave exploration is related to the

science of geography because many caves is have rock crystals such as stalagmites and stalactites.

**f. Tourism**

For adventurers and tourists, underground rivers can be used as an alternative tourist attractions. Tourists can perform various activities such as black water rafting and diving in depth of underground rivers.

**g. Fulfilling the Industrial Needs**

Industries also need water as their raw material, for example is the bottled drinking water industry that uses a lot of ground water. In addition, other industries such as the batik industry also require a lot of water in the process of making batik cloth. Fulfillment of industrial water needs is only from groundwater sources.

**MATERIALS AND METHODS**

In this study, several aspects that are taken into consideration as the compiler of the research method include:

1. Research Location

Because of the uniqueness and cases related to how to compensate natural resources, Sumberjati Village, Silo District, Jember Regency was deliberately chosen. This is not because the village has abundant water resources, but because it cannot be used properly by the community to meet the needs of clean water. Furthermore, the source of springs in this village is used by other villages to fulfill the household clean water needs.

2. Research Material

The data used in this study is primary data and secondary data. Primary data is obtained by interviewing respondents through questionnaire assistance. The number of samples taken was 110 respondents which is spread in 3 (three) hamlets. The data is intentionally divided based on the main variables, as in table 1 below:

Table 1 Components (factors) and Variables Compiler in Research

No	Main Components	Variables
1	Ground Water Resources	Water Discharge
		Water Sources Quantity
		Wasted Water Amount
2	Environment	Water Quality
		Land Conservation
		Erosion Prevention
		Water Pollution
3	Social-Economies	Water Distribution
		Income
		Land Ownership
		Ability to Pay for Water

No	Main Components	Variables
		Number of Household Who Can Access The Water

Source : Analysis Data, 2018

Secondary data is obtained from the agencies related to the implemented policy in helping Sumberjati Village people get clean water. Secondary data are also obtained from the literature review which is relevant to this research topic.

3. Data Analysis Method

Data and information obtained in this study will be analyzed qualitatively and quantitatively. Quantitative approach is done with PCA (Principal Component Analysis) analysis. PCA is used for [4] (i) calculating the relationship between coefficient and determinant indicators, and (ii) calculating the eigenvalue and eigenvector. Principal Component is a representation of the contribution and cumulative contribution to the total variant. The stages in the calculation are:

a. Forming covariant matrix

$$R = (r_{ij})$$

Where rij is a representation of regression coefficient.

b. Calculating the contribution of each varian in the components

$$C_i = \frac{x_i}{\sum_{j=1}^k \gamma_j}$$

Ci is a representation of each varian contribution which is identified in the main components, and xi is explained the normalization of samples which represented with 1 (or 100%).

c. Calculating Components Matrix

$$IN_{in} = \sum_{j=1}^k (r_j \times x_{ij})$$

INin is sample number (n) in the principal component tested and xij is sample normalization test.

d. Evaluating and Calculating Indexes.

$$CIN_i = \sum (IN_{in} \times C_i)$$

While, the quantitative data is strengthened with qualitative analysis.

**RESULT AND DISCUSSION**

Based on data processing using SPSS 20, the results obtained are as table 2 below:

Table 2. PCA Statistic Result Communalities

	Initial	Extraction
IN1	1.000	.425
IN2	1.000	.580
IN3	1.000	.735
IN4	1.000	.561
IN5	1.000	.798
IN6	1.000	.837
IN7	1.000	.658
IN8	1.000	.642
IN9	1.000	.484
IN10	1.000	.422
IN11	1.000	.688
IN12	1.000	.695

Extraction Method: Principal Component Analysis.

The results interpretation of PCA statistical analysis evaluation is as follows.

Table 3. PCA statistical analysis evaluation Result

No	Koponen Utama	Variabel	Pengaruh
1	Ground Water Resources	Water Discharge	Negative (has no effect)
		Water Sources Quantity	Positive
		Wasted Water Amount	Positive
2	Environment	Water Quality	Positive
		Land Conservation	Positive
		Erosion Prevention	Positive
		Water Pollution	Positive
		Water Distribution	Positive
3	Social-Economies	Income	Negative
		Land Ownership	Negative
		Ability to Pay for Water	Positive
		Number of Household Who Can Access The Water	Positive

Source : Analysis Data, 2018

From the results of data processing, it can be explained as follows:

1. Ground Water Resources

The main components of groundwater resources that affect the carrying capacity of groundwater resources in Sumberjati Village consist of; (i) water discharge, (ii) water sources, and (iii) water wasted amount. Of the three components, water discharge has a negative significance value (no effect) on groundwater resources. From the research results and running data, water discharge does not affect the carrying

capacity of groundwater resources in the Sumberjati Village is because basically the amount of water discharge in that village is very large and stable throughout the year. While the number of water sources and the water wasted amount have a positive impact on the carrying capacity of ground water resources. That is, if the number of water sources in Sumberjati Village drastically reduced, it can be concluded that the reserve of ground water resources in the village also reduced. While the amount of wasted groundwater also has positive implications. Therefore, the higher the amount of wasted water, it can maintain or support the existence of ground water resource reserves in Sumberjati Village in the long term

## 2. Environment

Several environmental components that affect the carrying capacity of sustainable groundwater resources in Sumberjati Village, as a whole (water quality, land conservation, erosion prevention, pollution prevention, and water distribution) have positive significance values. This means that if the component is disturbed (damaged), then in the long term, the ground water reserves Sumberjati Village will be effected.

## 3. Social-Economies

The main components of Socio-Economic that affects the carrying capacity of groundwater resources in Sumberjati Village consists of 4 (four variables). Where 2 (two) of them have negative significance value (no effect) and the rest (2 variables) have positive significance value. The level of income and land ownership is considered has no effect in the carrying capacity of ground water resources in Sumberjati Village.

This is because, until now, the level of income and land ownership has nothing to do with the level of exploitation of water sources in Sumberjati Village. However, the ability to pay for water and the extent of households that get clean water is have a significant effect. If households ability to pay for water is reduced, then some of the revenue generated from water conservation efforts for conservation is reduced. This affects the carrying capacity of water resources in Sumberjati Village. Similarly, with the number of households that get water supply. If more households are getting water supplies, then the number of exploitation of water resources also increases. It is not surprising that this variable (the Number of People Obtaining Water) has a positive influence on the carrying capacity of water resources in Desa Sumberjati.

## CONCLUSION AND SUGGESTION

Based on the research result that conducted in Sumberjati Village, Silo District Jember Regency related to the sustainable groundwater carrying capacity, it is known that:

1. The main components of groundwater resources affecting the carrying capacity of sustainable groundwater resources are; (i) water sources number, and (ii) water wasted amount.
2. The main components of the environment that affect the carrying capacity of sustainable groundwater resources are; (i) water quality, (ii) land conservation, (iii) erosion prevention, (iv) water pollution, and (v) water distribution.
3. The main components of the social-economies that affect the carrying capacity of sustainable groundwater resources are; (i) the ability to pay for water, and (ii) number of household who can access the water.

Then, from the research results, it is known that some policy recommendations that can be taken are:

1. The synergy of the community and government apparatuses is needed to maintain the amount of water resources, implementing a water related policy (that is 75% for irrigation), maintaining water quality, land conservation, erosion prevention, pollution prevention, water distribution, and water distribution managements.
2. It is expected that there is awareness from the community to have synergy in water utilization, especially distribution. So that the management of water distribution to some households can be implemented properly

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