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The Impact of Forest Damage Due to Human Economic Activities on Water Availability in Tahura (Case Study in R Soerjo Tahura East Java)

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ABSTRACT

Grand Forest Park (Tahura) is a nature conservation area for research, education, recreation, and human welfare. However, many Tahura such as Tahura R Soerjo in East Java is experiencing worrying conditions due to the exploitation of forests as a source of support for the community's economy. In Tahura, it was found that 3,814 Ha of Pine Forest had been converted into industrial and agricultural areas. This condition causes vegetation damage to reach 20% which also causes hydrological damage. Lack of understanding about the intangible benefits of forests, especially hydrology, will be detrimental to life in the future. If the hydrology is damaged, Tahura will lose the function of climate control and water management. The springs of the Brantas River that support ±40.64 million people in East Java will be threatened. For this reason, in this study, water discharge measurements were carried out based on forest types and land slope level tests using Freidman analysis because the data were not normally distributed. The measurement results show that there are significant differences in discharge, both based on forest type and based on the level of slope. It is hoped that from the results of this study, the government can make preventive policies to prevent and deal with this problem so that clean water from Tahura can be used sustainably.

Keywords: *Tahura, Land conversion, Hydrology, Water Discharge, Human Behavior.*

1. INTRODUCTION

Forests are the source of the world's lungs, in which there are many natural potentials that humans can exploit to meet their economic needs. But over time, the forest continues to be exploited on a large scale so that it continues to be damaged. To keep the forest sustainable, the government established a conservation forest called Tahura (Taman Hutan Raya). With the existence of Tahura, it is hoped that the forest can be protected and can be used sustainably. But in reality on the ground, there are still many Tahura whose condition is not good, one of which is R Soerjo Tahura which is located in four areas in East Java, to be precise in Pasuruan, Malang, Jombang, and Mojokerto. The damage to Tahura is caused by many factors, one of which is the unfavorable economic condition of the surrounding community. This is evidenced by data from the Central Statistics Agency (BPS) of East Java which recorded that in March 2020 as many as 4,419.10 thousand people (11.09 percent) of the population of East Java were still in the shackles of poverty. Increasing economic problems have become a major factor for people who do not work and do not have a source of income to further exploit forests, especially since the Covid-19 pandemic hit. This exploitation occurs in various forms, one of which is the conversion of large areas of land into agricultural, residential, industrial and open land areas. This is reinforced by the results of research by the Research and Development Agency (Balitbang) of East Java with the University of Jember, which found that 3,814 hectares of Tahura land had been converted into pine forests [2]. This conversion has caused vegetation damage that disrupts the hydrological area, which will endanger the 40.64 million people who depend on the Tahura water source for their livelihoods. To prevent the current deteriorating hydrological conditions, the researcher wants to measure the water discharge in several watersheds around Tahura, to find out how severe the real conditions in the field are. In this study, researchers grouped Tahura Forest into 4 parts based on their management, namely virgin forest, bamboo forest, critical forest, and cultivated forest. Researchers also classify the slope level on each land into 3 parts, namely the 0-29% slope level is called LS1, the 30-59% slope level is called LS2, and the 60-90% slope level is called

LS3. The results of this study are expected to be used as a reference source of information for the government in determining the prevention and rehabilitation policies of Tahura.

2. LITERATURE REVIEW

2.1. Forest

Forest is a large collection of land that is overgrown with many trees and is not owned and maintained for individuals [3]. According to Encyclopaedia Britannica, forests can also be considered as complex ecological systems, because trees are the dominant form of life [4]. In Law (UU) No. 14/1999, the definition of forest is an ecosystem unit in the form of a landscape containing living natural resources, that are dominated by forests that are mutually exclusive and cannot be separated. In general, it can be ascertained that the forest is a collection of trees that are one of the world's oxygen suppliers, absorb carbon and protect soil and air ecosystems. In the world there are various types of forests based on their territory and in Indonesia itself, there are approximately 6 types of forests based on their climate, including tropical rain forests, mangroves forests, savanna forests, monsoon forests, to swamp forests scattered throughout the region [5]. In this study, the researchers classified Forests based on their management into 4 types, namely virgin forest, bamboo forest, critical forest, and cultivation forests.

2.2. Hydrology

Hydrology is a branch of geography that deals with the movement, distribution, and quality of water throughout the Earth, including water cycles and resources [6]. The study of hydrology includes hydrometeorology (water in the air and gaseous form), potamology (surface runoff), limnology (relatively calm surface water such as lakes and reservoirs), geohydrology (groundwater), and cryology (solid water such as ice and water snow) and water quality. The existence of a hydrological balance is needed in order to continue to supply clean water sources.

2.3. Water Discharge

In hydrology, discharge is a volumetric flow rate of water transported through a given cross-sectional area [7]. Discharge data is the most important information for water resource managers. Peak discharge (flood) is needed to design flood control buildings, while data for small flow discharge is needed for planning the allocation (utilization) of water for various purposes, especially during the long dry season. The average annual flow rate can provide an overview of the potential of water resources that can be utilized from a watershed. Discharge is the rate of water flow (in the form of water volume) that passes through a cross-section of the river per unit of time. In the SI system of units, the amount of discharge is expressed in cubic meters per second (m3/s). Measurement of water discharge can be done by measuring the speed of water flow in a container with a certain cross-sectional area. Flow velocity can be measured by direct method and indirect method.

2.3.1 Direct Method

The direct method can be used by the method of using a current meter (measurement of flow velocity), the method of using a float (usually at high discharge) and the method of storage (usually in a shower). Discharge Measurement Current Meter Method, to obtain flow velocity data using a flow velocity measuring device (Current meter) in the form of a propeller-shaped device connected to a recording box (a monitor that will record the number of rounds as long as the propeller is in the water) then inserted into the river to be flow rate is measured. The speed of water flow will be determined by the number of revolutions per second which is then calculated the average speed of water flow during a certain time interval. Meanwhile, to obtain the wet cross-sectional area using a measuring instrument/ meter. After obtaining the river flow velocity and wet cross-sectional area, the river flow rate can be calculated using a mathematical equation using the basic formula for water discharge according to [8] namely :

$$\mathbf{Q = A\ V}$$

Information:

Q = The discharge (m3/s)

V = Speed (m/s)

A = The wet cross-sectional area (m2)

2.3.2 Indirect Method

The indirect method uses a hydraulic formula, for example the Manning formula, the Chezy formula.

2.4. Human Behavior

Human behavior is an ability and capacity that is expressed mentally, physically, and socially by individuals or groups of humans to respond to internal and external stimuli throughout their lives [9]. A person's specific personality traits, temperament, and genetics tend to be consistent, but other behaviors change as a person moves between life stages or because of economic or social circumstances. it is part or all of the thoughts and emotions which are then manifested by values or actions. Human behavior is shaped by psychological traits, and there are several personality types depending on the person, as well as the environment that results in different actions and behaviors.

2.5 Land conversion

Land conversion is a change in the function of either the whole or part of the land from its initial function into another function, which results in negative impacts on the environment and the potential of the land itself [10]. Land conversion is usually caused by factors that broadly include the need to meet the needs of a growing population and their increasing economic demands towards a better quality of life. According to Kustiawan, land conversion is defined as the mutation of land in general regarding the transformation in the allocation of land resources from one use to another [11].

2.6 Slope

The slope level of the slope determines erosion, the steeper or longer the slope, the greater the soil erosion. If erosion occurs, it will cause high surface runoff and low soil air infiltration, making it difficult for plants in the forest to absorb air. If air infiltration in the forest is disturbed, it will cause reduced water storage by trees or plants in the forest. According to [12], the described soil moisture content describes the relationship with the ability of the soil to hold water is very critical conditions. In general, the steeper the land, the higher the erosion rate, this will cause damage to the watershed which will also cause siltation of river air. According to [8], there are 7 types of Soil Slope which can be seen in table 1. However, based on field conditions that are not too much different, the study regrouped them into 3 types, namely LS1 with a slope level of 0-29% (flat to slightly sloping), LS2 with a slope level of 30-59% (sloping to slightly steep), and LS3 a slope level of 60-90% (steep to very steep).

Table 1. Slope Classification

Slope Level (%)	Slope Class	Relief Shape
0-3	A	Flat
3-8	B	Slightly Sloping
8-15	C	Sloping
15-30	D	Slightly Steep
30-45	E	Steep
45-60	F	Very Steep
60-100	G	Steep

3. RESEARCH METHODOLOGY

3.1 Time and Location

The study was conducted in the watershed (DAS) around Tahura as shown in Figures 1 and 2. The discharge measurement was carried out 5 times, on 4 forest types and 3 slope types.

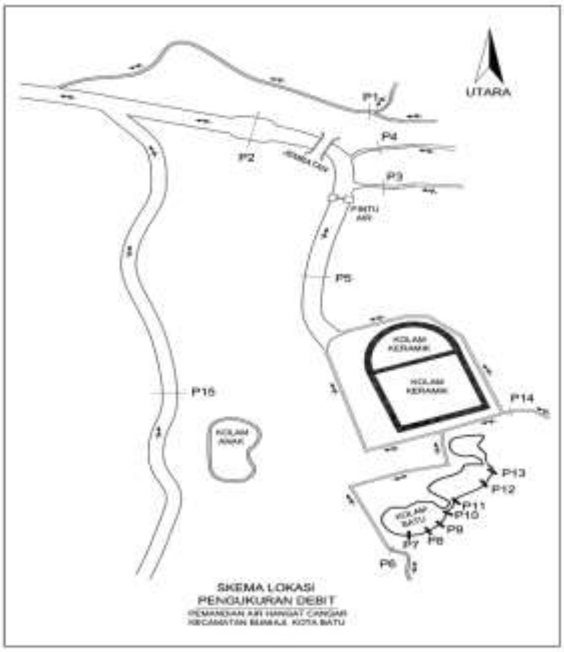

Figure 1. Around Cangar Hot Springs, Batu, Malang

Figure 2. Around Pasuruan, Jombang and Mojokerto

3.2 Data Collection and Analysis Techniques

Data collection is done by direct observation of Tahura. The method used to measure the discharge is the current meter and the storage method. After that, data analysis was carried out using Microsoft Excel and Statistical Package for the Social Sciences (SPSS 24).

This research is a type of comparative research with a quantitative approach Two-Way ANOVA (Analysis of Variance) if the data is normal (p-value >0,05) and if it is not normal then an analysis is carried out nonparametric using the Freidman test.

3.2.1 Descriptive Statistical Analysis

The descriptive statistics of this study include maximum, minimum, mean, standard deviation, skewness, and kurtosis. In this case, there are 2 descriptive analysis tests, namely the discharge analysis based on the type of land conversion and the second discharge analysis based on the slope level.

3.2.2 Two Way ANOVA (Analysis of Variance)

ANOVA (Analysis of variance) is an analytical method used to see the average of 2 or more populations [13]. Two way ANOVA test was conducted to see compare the mean difference between the groups that have been divided on the two independent variables. There is also one dependent or dependent variable [14]. According to [13], the ANOVA hypothesis will compare the mean of several populations represented by several sample groups. The mathematical hypothesis is as follows:

H0: µ1 = µ2 = µ3 =… = µc

-All population mean has no effect
-No treatment effect (no variation in group mean)

H1 : Mean influential population

-There must be at least 1 different population mean
-There is a treatment effect
-Not all population means are different (some pairs have similarities)

3.2.3 Freidman Test

The test with the Friedman test is the same as in the two-way analysis test in parametric statistics. This test was introduced by [15] and is included in the nonparametric test that does not require the assumption of a normal distribution and unknown population variation. The data scale used can be ordinal. Friedman test is an alternative that is performed if the test in ANOVA (Analysis of Variance) does not meet the assumptions. Each sample gets a different treatment (repeated measurement). Friedman Formula :

$$\chi_r^2 = \left[\frac{12}{(nxk)(k+1)} x \sum_{j=1}^{k} (R_j)^2\right] - [(3n)(k+1)]$$

Rumus Uji Friedman

Information:
χ_r^2 = khai-squared value of Friedman's bidirectional tier
n = number of samples
k = number of sample groups
1,3, 12 = constant

4. RESULTS AND DISCUSSION

4.1 Observation Results

Observations were made directly on 5 sampling times, which were then grouped based on forest type and slope level. The results of the observations can be seen in table 2. From the table, it can be seen that from the first experiment to the 5th experiment the highest discharge was found in virgin forest types which had a slope level of 0-29%, and in the first experiment until the 5th experiment, the lowest water discharge was found in critical forest types which had a slope level of 60-90%.

Table 2. Observation results of discharge measurements at 4 types of Forest and 3 Slope Level in Tahura

N experiment / Forest Type	Slope Level	I	II	III	IV	V
Virgin Forest	LS1 (0 – 29) %	260,72	204,16	184,14	649,02	216,34
Virgin Forest	LS2 (30 – 59) %	101,39	93,18	120,16	314,73	104,91
Virgin Forest	LS3 (60 – 90)%	64,61	88,14	70,18	222,93	74,31
Bamboo Forest	LS1 (0 – 29) %	212,24	180,17	200,18	592,59	197,53
Bamboo Forest	LS2 (30 – 59) %	99,50	98,20	108,24	305,94	101,98
Bamboo Forest	LS3 (60 – 90)%	16,08	20,18	30,28	66,54	22,18
Critical Forest	LS1 (0 – 29) %	11,31	25,08	21,72	58,11	19,37
Critical Forest	LS2 (30 – 59) %	21,11	8,03	20,24	49,38	16,46
Critical Forest	LS3 (60 – 90)%	7,80	15,64	6,32	29,76	9,92
Cultivation Forest	LS1 (0 – 29) %	3,58	1,83	3,08	8,49	2,83
Cultivation Forest	LS2 (30 – 59) %	1,57	1,40	1,83	4,80	1,60
Cultivation Forest	LS3 (60 – 90)%	1,18	1,04	1,20	3,42	1,14

4.2 Descriptive Analysis Results

4.2.1 Descriptive analysis based on Forest Type

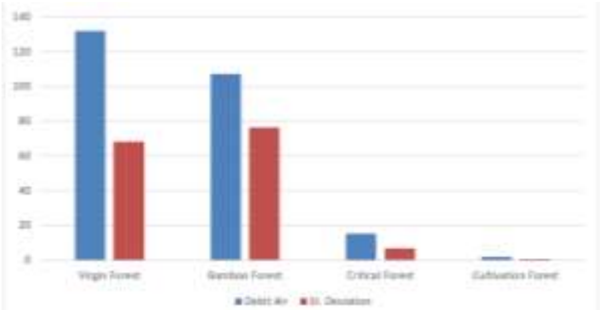

Figure 3. Graph of descriptive analysis based on forest types

The results of the analysis show that the 4 groups of forest types, have the standard deviation values, and the average water discharge has varying values. Based on the results in graph 1, it can be seen that the highest average discharge in the virgin forest is 131.8 liters/sec with a standard deviation of 68.3 liters/sec. Then the second highest is found in the bamboo forest which produces a water discharge of 107.2 liters/sec with a standard deviation of 76.5 liters/sec. Critical forest water discharge produces an average of 15.2 liters/sec with a standard deviation of 7 liters/second. And the lowest average water discharge is in the cultivated forest, which is 1.8 liters/sec with a standard deviation of 0.9 liters/sec.

4.2.2 Slope Level descriptive analysis

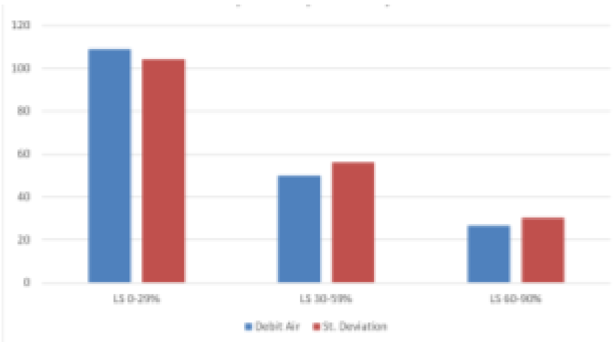

Figure 4. Graph of Slope Level descriptive analysis

The results of the analysis show that in 3 slope levels, the standard deviation and average water discharge have varying values (graph 2). The results of the analysis show that the 3 slope levels have varying standard deviation values and average water discharge (graph 2). Based on the results in graph 2, it can be seen that the highest average flow rate is at a slope level of 0-29% is 109 liters/sec with a standard deviation of 104.3 liters/sec. Then at a slope of 30-59% produces a water discharge of 56.2 liters/sec with a standard deviation of 50.1 liters/sec. Water discharge at a slope level of 60-90% produces an average of 26.8 liters/sec with a standard deviation of 30.3 liters/sec.

4.3 Normality Test Results

The normality test was conducted to determine whether the data of land conversion and slope level were normally distributed or not. The explanation is as follows:

4.3.1 Normality Test on Forest Types

Based on the table, it can be seen that the significance value based on Forest Type, it can be seen that virgin forest, bamboo forest, and critical forest are good or normal because the value is greater than (0.05). Meanwhile, for cultivated forest and virgin forest, the significance value is less than 0.05, so it can be said that the data for the two forests is not normally distributed.

Table 3. Normality Test on Forest Types

Forest Type	Statistic test	Sig.
Virgin Forest	0.235	0.165
Bamboo Forest	0.176	0.200*
Critical Forest	0.204	0.200*
Cultivation Forest	0.290	0.028

4.3.2 Normality Test on Slope Level

Based on the table, it can be seen that the significance values of LS1, LS2 and LS3 are not normal. This not normal, because the sig.< 0.05.

Table 4 . Normality Test on Slope Level

Slopes Level	Statistic test	Sig.
LS1 (0 – 29 %)	0.289	0.006
LS2 (30 – 59 %)	0.269	0.016
LS3 (60 – 90 %)	0.254	0.031

4.4 Two Way ANOVA Result

Due to the forest type and slope level that do not meet the assumption of a normal distribution, the Two Way ANOVA (Analysis of Variance) cannot be applied, so that statistical analysis techniques are changed using non-parametric analysis using the Friedman test.

4.5 Freidman Test Result

The Friedman test in this study was used to determine whether there were differences in the effect of forest type and slope level on water discharge.

Table 5. Freidman Result

Chi-Square	Sig.	N
21.733	0.000	36

Based on the table above, the chi-square value is 21.733 with a significance value of 0.000 which is smaller than 0.05. So it can be said that each forest types and slope level have a different effect on the water discharge of Tahura.

5. CONCLUSION

From direct observations in the field, it is shown that virgin forests are still natural, the water discharge is the most. The opposite results were obtained in the type of cultivated forest which showed very low discharge yields. This result is reinforced by the results of the descriptive test which also shows that the highest water discharge is obtained in virgin forests and the lowest is in the cultivated forests. The results of the descriptive test also explain that the steeper the slope (LS1, 0-29%) the greater the water discharge, and the steeper the slope (LS3, 60-90%) the less water discharge that can be accommodated. Freidman's statistical test is in line with the descriptive test, where the test results show that there are differences in water discharge in various forests and types of slope levels.

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