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BIOPHYSICAL STUDIES IN KHILAU WATERSHED

Studi Biofisik DAS Khilau

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Abstract

Khilau Watershed (DAS) is one of the sub-watersheds with the status of should be restored. The biophysical conditions of the watershed must be assessed, to determine the suitable actions for land rehabilitation. The purpose of this study was to provide a comparative analysis of baseline data on the biophysical conditions of the Khilau Sub-watershed area based on edaphic and climatic parameters. Data collection method was using cluster sampling in five types of land cover. The data analysis used spatial and laboratory analysis. The results showed that agroforests and annual crops mostly were on moderately steep to steep slopes (15-45%) and all primary forests were in steep slopes (>45%). All the land covers were ultisol. The primary forest has the highest CEC, N-total, P-availability, and C-organic among other land covers. The agroforest has the most acid pH soil among other land covers. The primary forest has the most rapid soil permeability compared to other land covers. The primary forest has the lowest temperature and the highest humidity compared to other land covers

Keywords: Khilau; land cover; soil biophysics; watershed

INTRODUCTION

Soil biophysics played an important role to support the life on earth. Almost all the living things on earth depends on the soil. The main role of soil is as a supporter of living things on earth depends on the physical and chemical properties between soil water and soil solids. The soil shape could be altered by the size and the release of nutrient contained in the soil (Salam, 2012).

The best management in order to create sustainable and healthy land management could be figured out with knowing the soil biophysics condition. According to Doran and Jones (1996), there is a need to understand the soil system to protect the soil and better land management for a healthier environment included hydrosphere, atmosphere, and biota. The connection between oxygen status, gases uptake, and soil as a water biofilter are the examples of particular biophysical soil properties related to environmental consequences (Stepinewski et al., 2002). A better understanding of biophysical properties would lead a better management.

Khilau watershed is one of the primary sub-watershed, located in Kedondong Region which is providing water for the region. The score status of Khilau watershed was low. The damaged condition of the watershed could also decrease the people's welfare at the downstream. In fact, these damages occured due to the improper land use in the area. The changes of land cover from forest to other types of land cover could change the soil characteristics (Sutanto, 2005). The alteration from forest soil to other land covers shall change the soil biophysics. There was a case showed that the changes in land cover from primary forest to agriculture land and farm changed the soil chemical properties entirely (Kizilikaya et al., 2010), especially the primary forest soil has better chemical properties compared to other land covers (Azmul et al., 2016). The soil biophysics must be assessed in order to decide the most suitable land management in the frame of rehabilitation. The aim of this study was to give basic data of comparative analysis consist of soil physical and chemical status and climatic properties that are needed for the land rehabilitation.

MATERIALS AND METHOD

Research Location

Due the low score status of Khilau Watershed, the location selected as the Cross Country Capacity Development (CCCD) site project area based on the Decree of the Indonesian Ministry of Environment and Forestry No. 13 of 2018. CCCD is a collaborative project between the Ministry of Environment and Forestry and the University of Lampung with the funding support from United Nations Development Programme (UNDP). The research location is part of Forest Management Unit (KPH) XI Pesawaran area of the Sub-sub Khilau watershed, Bulok Sub-Watershed, Sekampung Watershed, Pesawaran, Kedondong Sub-district, Lampung. The study was conducted in May 2018 until July 2018.

The tools and materials used in the study were crowbar, plastic, shovel, ground drill, ring samples and labels for soil sampling, and laboratory soil content testing equipment that refers to the references. The material needed in this study was thematic map data with a scale of 1: 30,000 (Figure 1). The thematic maps consisted of land cover classes and district contour maps in 2017. The decision making of land cover classes was carried out based on 2017 land cover map data of Khilau watershed. Based on the map, it was selected that land cover classes in the Khilau watershed were divided into primary forest , rice field, shrub, agroforest, and annual crop.

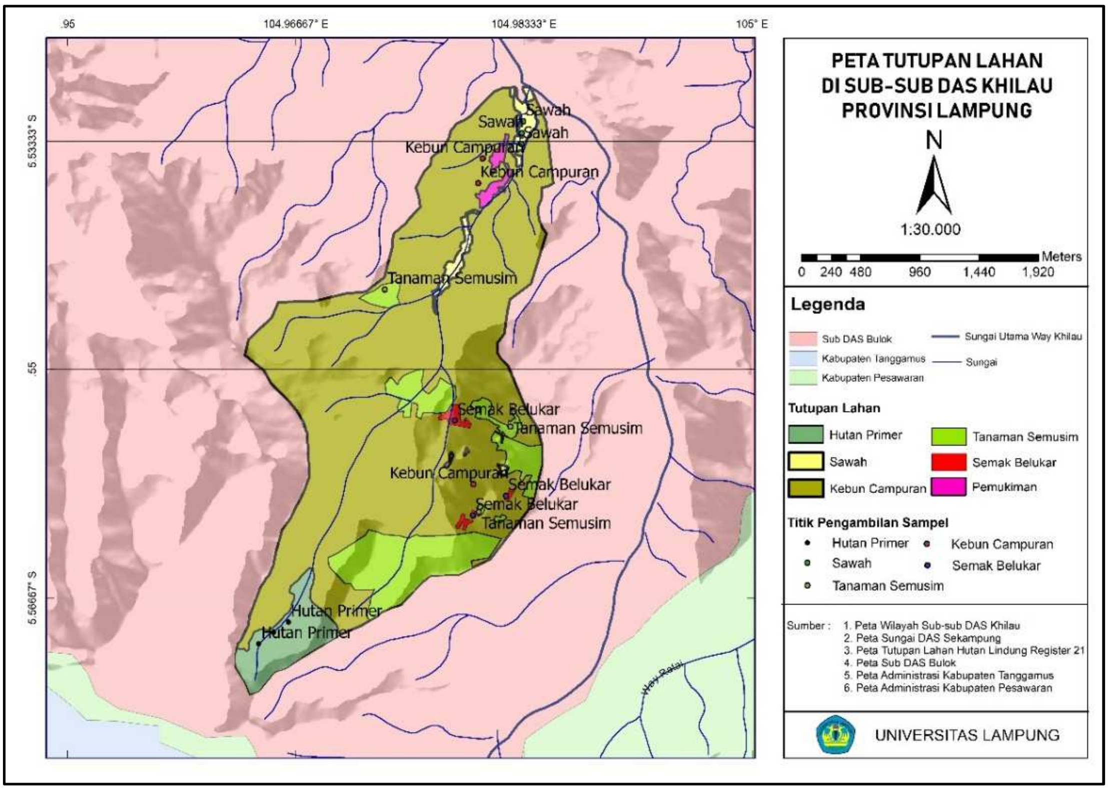


Figure 1. Land cover map in the Khilau Sub-sub watershed of the Bulok Sub Watershed, Sekampung Watershed in Lampung Province.

The samples were taken by cluster sampling method with equal distribution of samples in each class of land cover. Distribution was based on five types of land cover. Primary data were gotten by conducting field observations in each land cover classes with repetition of three times based on the map of the Khilau watershed sub-area.

The primary edaphic samples were temperature, humidity, physical and chemical properties of soil. The edaphic samples in the form of physical and chemical properties of soil were taken destructively and non destructively. Destructive sampling was done by; deciding sample plot randomly in every land cover classes. The sample plot dimension is 20 m x 20 m, and the soil samples were carried out using ground drill with depth of 0-20 cm. The soil samples that has been taken were composited by mixing all of the samples. From the composited soil, 0,5 kg of soil was taken as the sample. Non-destructive sampling was done by; plugging the sample ring to the soil, then immersing the sample ring until the it is embedded in the soil. Then take the sample ring carefully. Each land cover used a replication of three plots, with five drilling points, namely at the top right, top left, bottom right, bottom left and center plot. The composited soils were put into plastic and coded. The explanation of the sample points is can be seen in Figure 2. Climatic data were taken using a thermohygrometer.

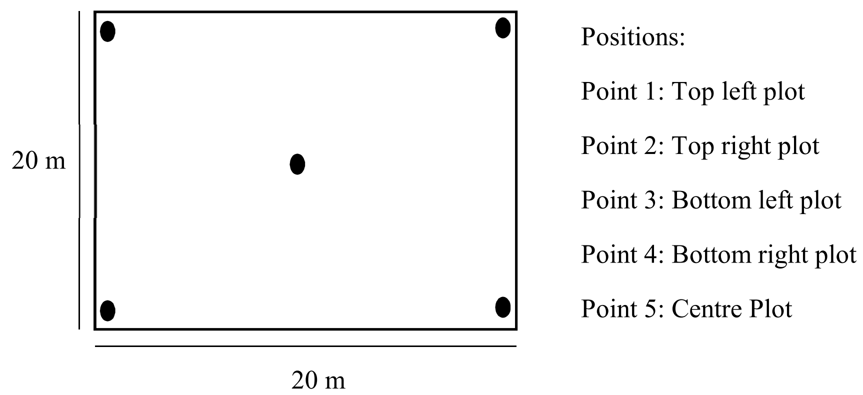


Figure 2. Sample points in the plot

Secondary data studied in the form of climatic. The climatic data used the rainfall data in the Gedong Tataan area from 2011 to 2016.

Data Analysis

The data were analyzed descriptive comparatively by comparing the soil biophysical variables among land cover classes.

RESULTS AND DISCUSSION

The area of the study located in Kedondong Sub District, part of KPH Pesawaran. In this area of study, most of the primary forest had changed to other land cover. The differences of every land cover caused the physical and chemical soil properties changed those refere to the different types of root system (Winanti 1996). There were 5 land cover classes founded as shown in Table 1.

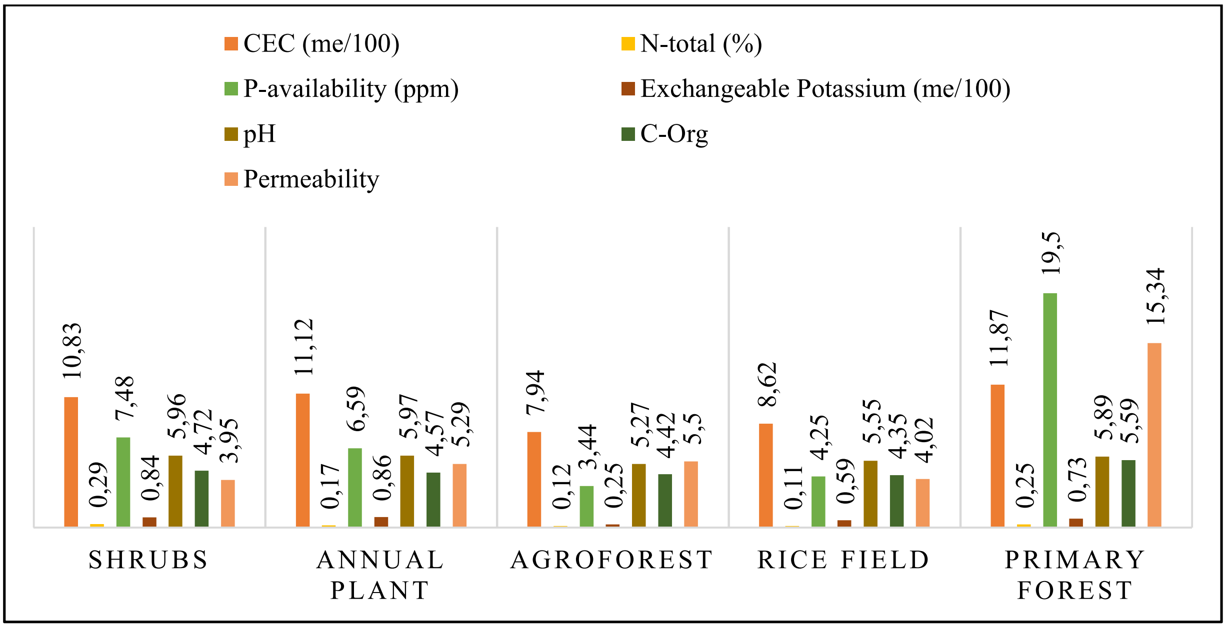
Most of the land cover were located in slopes area >8%, only rice fields located in the flat area. Primary forest has the steepest slopes (45%) compared to other land cover. The largest area were agroforest (457,86 Ha) located in the slopes from 15% to 45%, only slightly less steeper than primary forest. Generally, the steeper the slopes, may caused the nutrient loss more than less steeper slopes (Noor, 2006) due to unstable soil aggregate which caused the erosion, but it did not happen to the primary forest as shown in figure 3. The primary forest had better soil stability due to higher plant density and the distribution of plant roots which spread from shallow to deepest soil solum which lead to better soil erosion resistance.

The erosion could be controlled by having plant diversity to stabilize the soil particles through strong root system in the above and lower ground (Hairiah *et al.*, 2007). Pérés *et al.* (2013) stated that there was a great effect of higher plant diversity towards the aggregate stability, which could decrease the leaching and increasing soil productivity (Septianugraha and Suriadikusuma, 2014). Architectural root traits such as root length could directly impact soil structure through binding and compressing soil particles which influences the soil stability and agregation (Gyssels *et al.,* 2005). Besides that, the root system would effefct the root strength, controlling the erosion along with the increasing slope stability (Macleod *et* al., 2013).

Tabel 1. Land cover classes, slopes and spaces

No	Land Classification	Area(Ha)	%	Gradient (%)	Description
1.	Primary Forest	52,22	8.01	>45%	St
2.	Agroforest	457,86	70.23	15-45%	Ms – St
3.	Rice Field	28,30	4.34	0-8%	F – Nl
4.	Shrub	28,74	4.41	8-15%	Sl-Ss
5.	Annual Crop	84,80	13.01	15-45%	Ms - St
Total		651,92	100%		

Notes: St: *Steep*, Ms: *Moderately Steep*, F: *Flat* , Nl: *Nearly Level*, Sl: *Sloping*, Ss: *Strongly Sloping*.



Figures 3. Physical and Chemical Properties

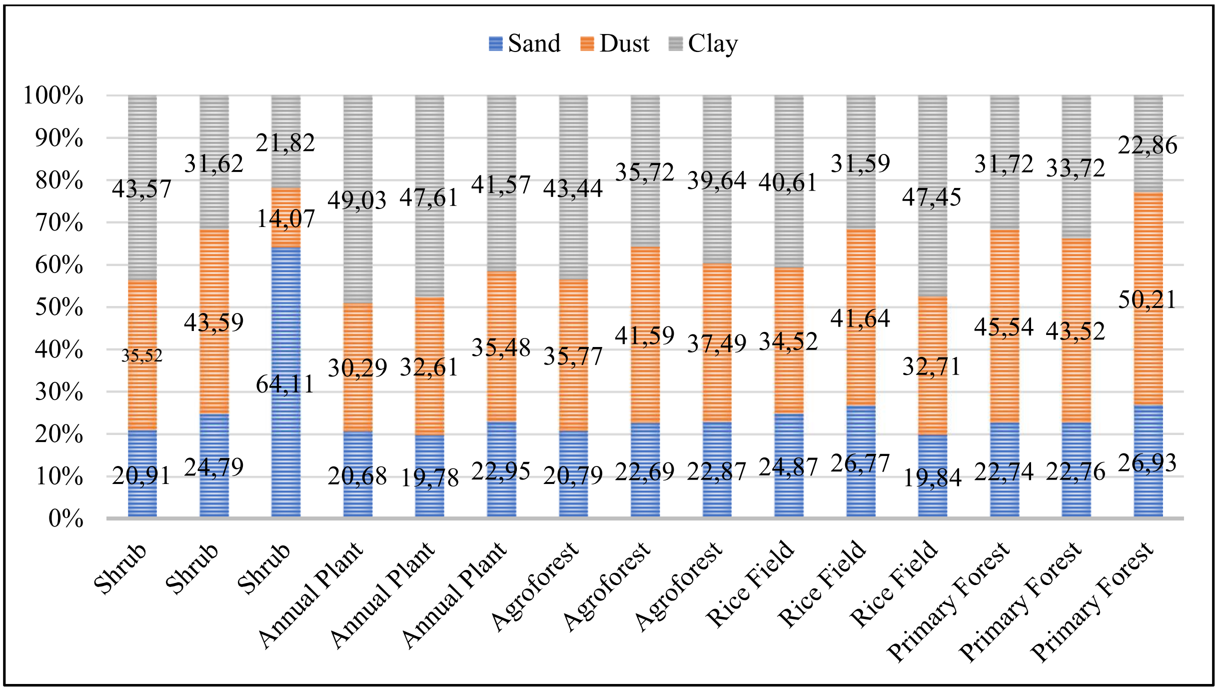
Eventhough the primary forest has the steepest slopes (45%) in term of P-availability, CEC, and permeability it has the best value among other land covers, only slightly lower than shrubs in total nitrogen (0,04%) and little bit lower than annual crops in term of K-exchangeable (0,13 me/100). Soil stability increased under higher plant species richness and some particular species form a functional group of roots that played a significant role (Gould *et al.*, 2016). In mesocosms, higher species richness increased root length and reduced the average root diameter, indicating a response in the abundance of finer roots within the soil system. This behaviour of finer rooting strategies play an integral role in developing soil structural species, leading to more stabilize soil particles (Rilig *et al*., 2015).

Figures 3. showed that all the CEC from five types of land cover were categorized as low. The lower CEC has a less storability to store nutrient (Monde and Thaha, 2001). Low CEC in the five land cover classes were caused by the type of soil classified as ultisol. Ultisol is a soil that has a low fertility rate. Problems arise in ultisol originated from the history of their formation. Ultisol was formed by a very intensive process of weathering and soil formation because it takes place in tropical and subtropical climates, generally hot temperatures and high rainfall. Ultisol has low P, Ca, Mg, Na, K, and organic matters. The low nutrient was caused by the high content of Al and Fe (Prasetyo and Suriadikarta, 2006). It was indicated by the pH, all of the land types were in acid class. Thereby, Acidic pH caused by the Al hydrolysis reaction released H^+ ions and increased the soil acidity (Zannah et al., 2016). The domination of acid cations Al^{3+} and H^+ is found in acid soils (Hardjowigeno, 2010).

Mostly ultisol is not only has a low CEC, but also other nutrient. Based on the research analysis, it was found that all of the land cover had low nutrient. The number of N in the five land cover is in the medium to low class. Usually, acid soil caused the N bounded by the positive ion, lead to the unavailability for plants to be absordbed (Harter, 2007). With the exception in the primary forest, all of the area has the P-availability which categorized as low. The low P-availability in some land covers caused by acid pH and ultisol. Ultisol known as the type of soil with very high Al level, thus binded P and keep it unavailable to plants (Singh et al., 2003). The primary forest has bigger P availability than other land cover because primary forest obtained P supply from the decomposition of organic matter on the forest floor through P mineralization and released processes (Sari et al., 2017). The decomposition produces humic acid and fulvic acid, both reduced the binding of P by iFe and Al. Thereby, this could increase the P in the soil (Rosmarkam and Yuwono, 2002).

Exchangeable potassium was the potassium absordbed by plants from the soil. Figures 3. showed that all land cover except agroforest categorized as medium to high K-exchangeable. The main source of potassium was derived from decomposed organic matter. K has the functions to activate enzymes, regulated the absorption of other elements and root growth (Hardjowigeno, 2007).

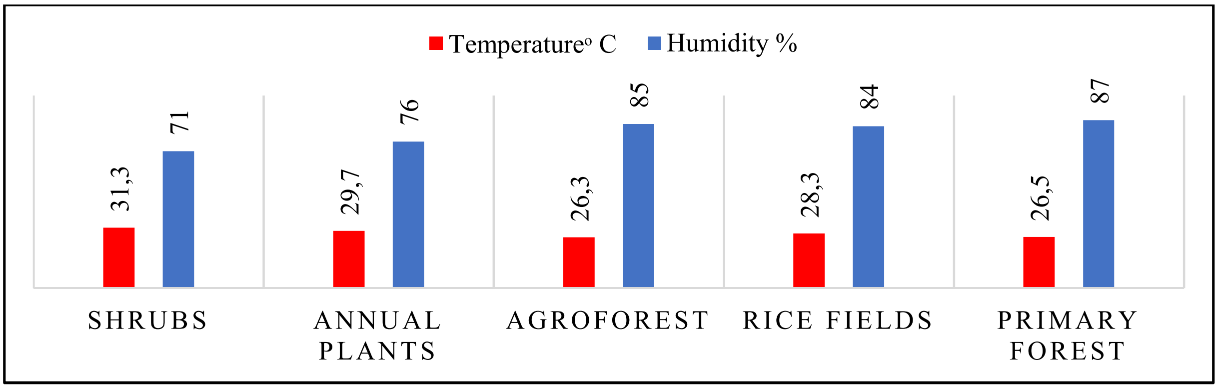
Soil permeability is the soil velocity to be passed by water per unit of time (Hanafiah, 2003). Compared to other types of land cover, the primary forest has fastest permeability rate of 15.34 cm/hour. Related to the ability of plant roots, in general soil that has good permeability will be more easily penetrated by the roots. Soil that has better pores will prevent flooding. Forest land has vegetation in the form of perennials whose roots made the cavities in the soil therefore the water would be easier to infiltrate the soil (Setyowati, 2007). Forest land was developed better than other land cover classes because it has a better role in the decomposing organic matter. The decomposition process on forest soil produced organic acids which were good solvents for rocks and minerals, making it easier to be broken into clays. The role of the density of forest plant roots could accelerate the process of destruction of rock physically therefore the fine fraction will be formed faster (Arifin, 2011).



Figures 4. Soil fraction in the area of study

The soil textures are shown in Figures 4. Primary forests had clay-coated clay, with percent clay not exceeding 35% as shown in Figures 4. Hartati (2008) stated that the optimal limit of clay content is 35% because if it is more than 35%, the plant can be disrupted due to poor soil aeration caused by soil compaction. In the other side, clay has higher erosion rate due to low infiltration rate of the soil, and it lead to increasing the run off (Suprayogo et al., 2011).

In term of soil textures, in generan annual crop and agroforest have higher clay content rather than sand and dust. The high content of clay could make it difficult for water to infiltrae into the soil. Hanafiah (2010), stated that land with high dust and clay content is difficult to be penetrated by plants root so that it could inhibit branching and root development. In addition, rainfall rate in this region was high, categorized the climate as very wet. The high level of rainfall, could caused surface erosion, carried away the soil nutrients and cannot be utilized by the plants.



Figures 5. Temperatures and humidities in five land classes

In general, humidity is directly proportional to temperature. The higher the temperature, the higher the humidity. However, because of the evapotranspiration and vegetation that transpires, the air temperature will decrease gradually.

Temperature measurement on all land cover showed that the lower the temperature, the higher humidity. High and low temperatures and humidity in this area were caused by the type of land cover. The primary forest had the lowest temperature and highest humidity, which was 26.5° C and 87%. Primary forests had a thick canopy cover, releasing O_2 as a result of photosynthesis, absorbing carbon dioxide and able to produce water vapor in the air through thick canopy transpiration, so as to maintain moisture. In accordance with the opinion of Lakitan (2002), the temperature of vegetation on an open surface will be higher when compared to the temperature in the shade because solar radiation received by plants is not reflected back by vegetation (canopy). Canopies form a microclimate could maintain humidity and temperature in the area.

The shrub had the highest temperature of 31.3°C with a humidity of 71%. The high temperature in shrub was caused by the absence of upper-level vegetation, so there was only lower level vegetation were existed. The absence of trees could increase the temperature due to the absence of canopy that could absorb the sunlight because leaves absorb sunlight the most (Brown *et al*. 1994). Light intensity is greatly reduced when passing through the highest canopy layer, and then gradually decreases further in the understorey (Koop and Sterck, 1994). The effectiveness of absorption, inspection, and transmission of sunlight depends on the characteristics of the species, which were shady, leafy, branching or many branches (Sanger, 2016). Sapariyanto (2016) reported that an areas without trees have higher temperatures due to the absence of sunlight absorber. Thus low level of moisture in shrubs was due to the absence of tree canopies which could decrease the temperature and maintain the moisture. Saparianto et al. (2016) showed that trees were able to absorb solar radiation, provide shade, and carry out transpiration so that they could reduce air temperature and increase air humidity.

CONCLUSSION

The primary forest has the highest CEC, N-available, P-available, K-exchangeable, and C-organic compared to other land covers. Rice field has the lowest total N and organic C. Agroforest has an acidic pH compared to other land covers. The primary forest has the most rapid permeability compared to other land covers. All land cover classes had ultisol. The primary forest has the lowest temperature and the highest humidity compared to other land covers.

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