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Suitability of agroforestry system against climate conditions in Tugu Utara Village, Cisarua Sub-District, Bogor

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Abstract. Indonesia with style agrarian agricultural potential with a very large agricultural area of 40.6 million hectares. However, agricultural patterns are applied by people still tend to conventional monoculture (99.6%). Application of a monoculture in some areas does not fit with the rules of ecological, causing vulnerability to natural disasters of drought, floods, landslides, and loss of habitat function. This study aims to determine the suitability of land in the study site for the implementation of the agroforestry farming system. Mixed methods through surveys, interviews, and desk study. Tugu Utara village an upstream watershed area (DAS) Ciliwung dominated by natural forests of primary and secondary, agriculture, and gardening. Agricultural commodities featured in this area are classified as vegetables and seasonal plants found only one species of perennials that *Camelia cinensis*. Agriculture-based agroforestry should be applied in this area because it is based on the study of microclimates compatibility and also serves to enhance regional resilience against natural disasters especially floods and landslides.

Keywords: agricultural, agroforestry, land suitability, microclimates

1. Introduction

Indonesia as an agricultural country has 40.6 million hectares of agricultural land with its huge potential [1]. However, existing land management is still not optimal, since we need an agricultural system that can optimize the existing land resources. Therefore the potential environmental condition of the agricultural sector holds a strategic role in the national economy [2]. Efforts are applied in agricultural practices in Indonesia the majority is still limited to conventional farming systems (99.6%) [3]. This farming system is still being conducted by the public because it is considered the most profitable [4,5].

Conventional farming practices that are already running a challenge for the farmers to be able to farm in a more environmentally friendly and maintain its sustainability. In response to this, the arise a new agricultural concept to try to suppress the chemical input as small as possible. Through it expected biophysical quality can be maintained and productivity can be improved [6]. Agriculture concept that began to be known since the 1990s was later named as a sustainable agricultural system [7]. Fundamentally the concept of sustainable agriculture puts on the maintenance of the production capacity of the environment to continue or overtime can be realized [8].

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Sustainable agriculture combined with agroforestry system is one of many ways to reduce greenhouse gas emissions (GHG). These are thought to have contributed to carbon sequestration. Agroforestry systems that combine seasonal plants with woody plants, can increase carbon storage, and even reduce carbon loss caused by erosion. Currently, several types of perennials are being developed in an effort to implement agroforestry systems in Indonesia, especially by small farmers plateau.

Based on the results of research on the development of marginal land management model that is done by Triwanto [9] can be deduced as follows: (1) Model development of agroforestry by communities around the forest area intercropped can improve produce and welfare of those with B/C ratio of rice (3.091), maize (2,288), peanuts (2,809); (2) Model agroforestry development can affect the growth and development of staple crops; (3) Model development of agroforestry can increase public awareness about the forest to maintain the forest fertility. It becomes an important point that must be understood by the public to switch to conventional farming practices sustainable agriculture-based agroforestry systems because it provides greater benefits.

Research on public perception on agroforestry management in Way Besai sub watershed Lampung by Wulandari [10] shows the perception is influenced by the value systems such as customs, the prevailing belief in society, and personality traits such as temperament, character, and habits. On the other hand, factors such as age and type of work did not affect perception, while the area of land owned factors, education, income, and a number of training have been followed very real distinguishing perception.

2. Method

The study was conducted in Tugu Utara village, Cisarua Sub-District, Bogor in October-December 2018 using a mixed method approach, surveys, interviews, and desk study. A desk study was conducted to complement primary data obtained through surveys and interviews. The data obtained from the Meteorology and Geophysics Agency Bogor Regency include data on rainfall, humidity, and temperature within the last 10 years (2008-2018). The data were analyzed using descriptive statistics explorative to explain in detail the problems that occurred at the sites.

3. Results and Discussion

Regions in the research area are dominated by natural ecosystems both primary forest, secondary forest, and plantation. Can be seen in Figure 1 that based on land cover maps, the majority of Tugu Utara Village area used as plantations, especially tea plantations. Outside the tea plantation area communities also developed the cultivation of vegetables and other seasonal crops. Generally, farmers in the research area of monoculture farming systems that were substantially less in accordance with the characteristics of the land. Such discrepancy reflected a fairly steep elevation reached 27°. These conditions are very susceptible to erosion when exposed to high rainfall and/or the wind is quite strong. Therefore, during the rainy season down in this area is frequently flooded with material sufficiently dense soil sediment.

Based on the survey result as listed in Table 1, vegetables become a commodity in this region, people have a very high tendency to cultivate vegetables because it takes a short time and considerable profit. Nevertheless, began appearing complaints from people who claimed that the productivity of cultivated vegetables is no longer optimal. This is reflected in the high cost of land management and crop yields are not ideal. This means that agricultural productivity has decreased, but the cost of land management has increased.

The superior commodity at this location is classified as vegetable crops, there are only one species of perennials that tea. Basically, the seasonal crop monoculture farming practices provide unfavorable impact on the ecosystem. Moreover, this is the upstream region which has a very high rainfall intensity. Cultivation of seasonal crops has a high susceptibility to an erosion of the slopes and farmland. Therefore, the ideal farming practices to be applied is based agroforestry with chronic staple

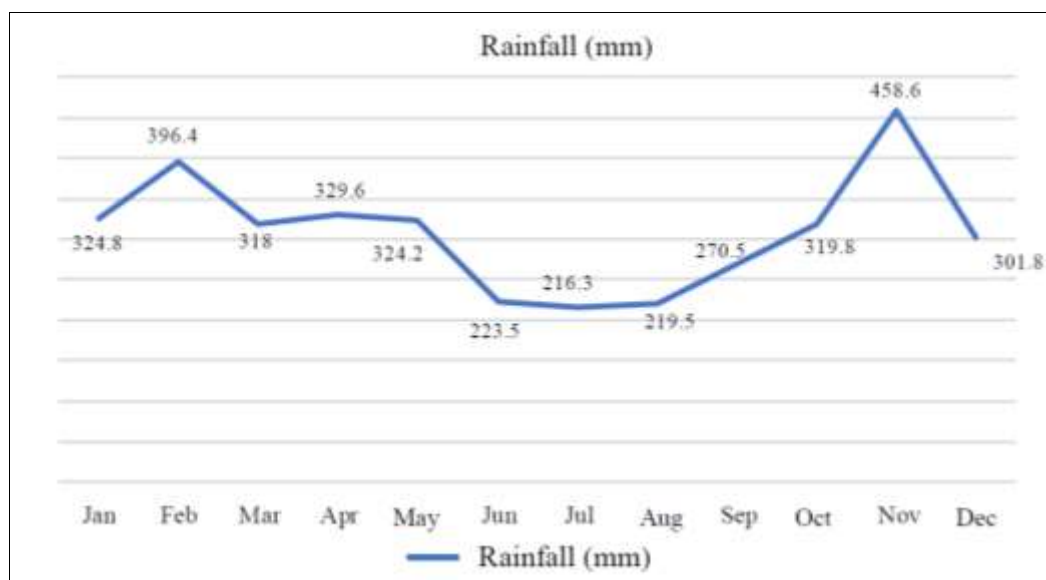
crops. While the vegetables can be grown on the sidelines of the perennials, as the root system of perennials have a stronger holding capacity to the soil structure, so that the susceptibility to erosion can be minimized.

Table 1. Agricultural Commodities featured in the research area.

No.	Type of commodity		Information
	Local names	Scientific name	
1	Broccoli	<i>Brassica oleracea</i>	annuals
2	Cabbage	<i>Brassica oleracea</i>	annuals
3	Cabbage	<i>Brassica oleracea</i>	annuals
4	Cauliflower	<i>Brassica oleracea</i>	annuals
5	Bean	<i>Phaseolus vulgaris</i>	annuals
6	Potato	<i>Solanum tuberosum</i>	annuals
7	Carrot	<i>Daucus carota</i>	annuals
8	Chili	<i>Capsicum sp</i>	annuals
9	Red onion	<i>Allium Cepa</i>	annuals
10	Tea	<i>Camelia cinensis</i>	perennials

Source: research data, 2018

When viewed from the microclimates of research location, agroforestry farming practices is possible to implement [11]. Climatic conditions provide support and suitability with various types of perennials that have economic and ecological value. Therefore, agroforestry with fruit trees or other woody plants is ideal to be applied, for example, coffee, durian, mangosteen, cacao, agarwood-producing plants, and so forth. Of course, the selection of the main species adapted to the conditions of the microclimate includes precipitation, temperature, and humidity as presented in figure 1, 2, and 3.

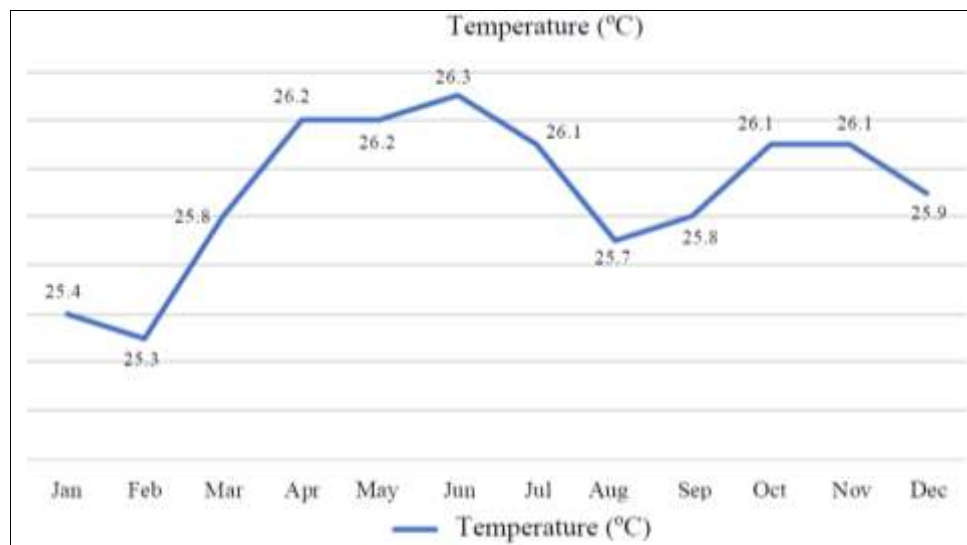


Source: BMKG Bogor, 2018 (processed)

Figure 1. The average of monthly rainfall at the study site based on time series data from 2008 to 2018.

Rainfall in the study site every month was fluctuated with the highest intensity in November and the lowest in August. At the time of highest rainfall intensity, generally farmers grow the crop that was resistant to the abundance of water, for example, broccoli, cabbage, and potatoes. These three types of

vegetables that have characteristics water-loving plants, so that when water is plentiful amount keeps growing and growing even be optimal [12]. While in June to August the intensity of low rainfall, generally farmers grow chili and beans. Both of these plants do not like high rainfall. It inhibits the growth or often found fallen flowers and fruits [13]. Another thing that needs to be understood at the time of high rainfall intensity is water in this monoculture farming system is not able to optimally absorbed by the soil [14], then the water will run off on the soil surface. Therefore, it is important to implement the agroforestry systems for water to be absorbed by the soil through the roots of trees [15].

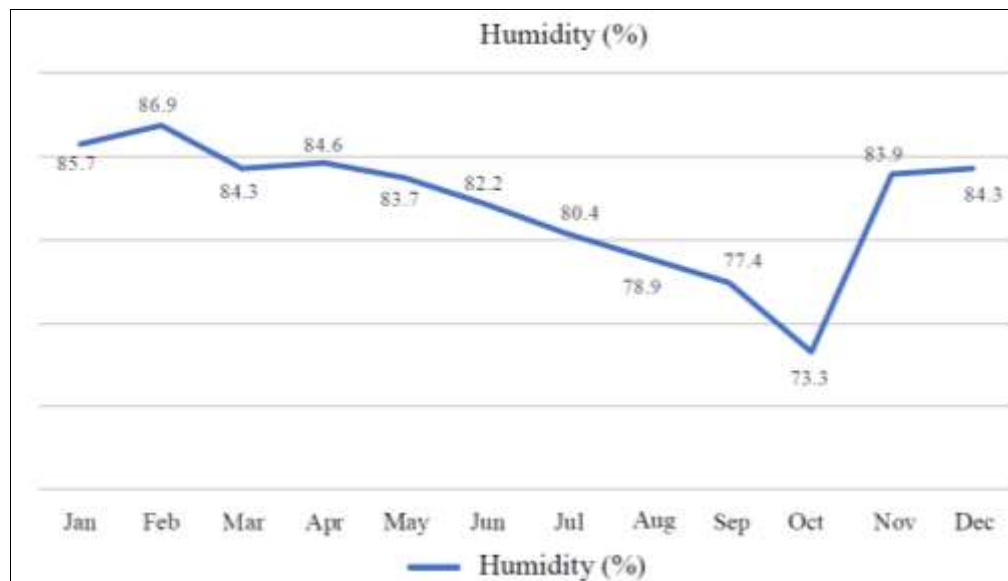


Source: BMKG Bogor, 2018 (processed)

Figure 2. The average of monthly temperature at the study site based on time series data from 2008 to 2018.

Temperature fluctuated in the study site, it ranged between 25-26°C. The temperature proportional to the intensity of rainfall, which at the end until the beginning of the year, there was observed low temperature due to high rainfall. While in the mid-year, temperature increased in line with the dry season. The temperature is basically no significant impact on agricultural commodities [16]. Various types of the commodity at these locations have compatibility with temperature throughout the year. Fundamentally this temperature is closely related to vegetation cover. The higher the vegetation cover, then the temperature decreases because the sunshine does not reach the soil surface [17]. The sunshine will reach the existing plant canopy, so that the soil temperature can be maintained in a stable condition.

Air humidity in the study site showed a fluctuated trend. It can be said the air humidity tends to be stable throughout the year, except in September and October which decreased significantly. In September and October normally are entering the beginning of the rainy season, but sometimes there is a delay and the rain will fall then in November. Therefore, in October, soil water content usually is very low, so the soil humidity dropped quite dramatically. It is also influenced by the cultivation of monoculture crops that result in low uptake of water due to seasonal plant root systems do not have the optimal ability to absorb water from soil [18]. As a result of high rainfall intensity during the rainy season, water only run off through the soil surface and not infiltrate to the lower surface. These conditions are not ideal, and not occurred in the area of natural ecosystems, as should the rainwater can be optimally absorbed by the root system of the plant.



Source: BMKG Bogor, 2018 (processed)

Figure 3. The average of monthly humidity at the site based on time series data from 2008 to 2018

It is thus necessary to evaluate agricultural systems of monoculture into agroforestry. Implementation of agroforestry provides a greater benefit to the farmer for agricultural productivity as well as for the ecological benefit [19]. Through agroforestry, soil has a better ability to absorb water during the rainy season, so in the dry season, ground water reserves can be exploited by an ecosystem to maintain its stability. Environmental services through agroforestry systems are also given the greater good for the habitat function [20], such as water storage, carbon dioxide absorbing, producing oxygen, as well as soil conservation [21]. The roles must be able to be given by the North Tugu Village area as the upstream watershed (DAS). The annual flooding events that occurred allegedly due to the inability of the water body to accommodate the water flow of the river is very large. If reviewed in depth there were two main factors that lead to such things happen: (1) loss of- or not optimal as the upstream area as the water absorbent and (2) of silting and the narrowing of water bodies including rivers.

Therefore, it is important to be mainstreamed agroforestry systems to realize the upstream area as the optimal water absorbent so that the flow of water flowing in the water bodies including rivers in the middle does not overflow and exceed its capacity [22,23]. The application of agro-based farming that man was not against nature but trying to adjust oneself with nature. This happens because basically the upstream is a natural forest area and/or primary [24]. However, due to the increase in population, the need for food also increased, so that agricultural land continues to be opened, including to upstream area [25]. It is not entirely wrong for humans to conform to the rules of ecology. Therefore, agricultural systems that are applied to accommodate the presence of woody plants and chronic illness that has the function of habitat, water absorbent, and a good root system to bind the soil structure [26,27]. If this can be realized the occurrence of natural disasters such as floods and landslides can be avoided or at least minimized.

4. Conclusion

Agriculture area in Tugu Utara village dominated by vegetable crops over the year. There are only one species of perennials planted in agricultural areas namely *Camelia cinensis*. Various types of agricultural commodities grown in this region have compatibility with the microclimates. However, the agroforestry systems need to be implemented to optimize the stability of ecosystems and environmental services as the watershed upstream region.

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