The pattern of agricultural plant types based on cultivated land region and soil types in the Mount Patuha area

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Abstract. Indonesia is an agrarian country with agrarian society producing and maintaining crops and farmland. Most of the agrarian society in Indonesia is concentrated in the Java island. The Mount Patuha Area in West Java is considered to be a suitable area for agriculture. In May 2017, there has been erosion and major flood lately due to annual crop changed to seasonal crops in the Mount Patuha Area. This study aims to analyze spatially the suitability of agricultural plant types based on the WTU concept and soil types to prevent environmental damage from happening again and maintaining the sustainability of the agricultural sector. The Cultivated Land Region concept is also known as “Wilayah Tanah Usaha” (WTU) in Indonesia is an approach to manage agricultural land properly and sustainably based on the land elevation and slope as limiting factor from soil damage. Soil type also determines the plant suitability. This study is utilizing Geographic Information System (GIS) to overlay spatial data in the form of a DEM, soil types, and land use. The results show that WTU category in Patuha Mount Area is dominated by Second Main Area and Second Restricted Area, with soil type dominated by cambisol and the dominant plant type is tea plantation. This study concluded that there are still many agricultural plant types that are not in line with the WTU concept. The WTU concept is suitable to be applied in the Mount Patuha area as long as the farmers can adapt their land management by balancing with soil conservation technique such as make terracing on steep slopes and maintaining the second restricted area in permanent vegetation conditions.

Keywords: Agriculture, patuha, plant types, soil, WTU

1. Introduction
Sustainable agriculture is a way of farming that integrates environmental, economic and social aspects of the agricultural community [1]. However, in reality, there are still many farmers who insufficiently manage their land because their main goal is to achieve maximum profit, thus resulting in an environmental damage [2]. Other than economic purposes, other aspects, such as the ecological and social aspects, have to be considered to prevent environmental damage. The ideal agricultural land should be able to bring optimal benefits without damaging the nature [3]. Therefore, it is necessary to cultivate a sustainable farming system.

Conceptually and historically, food security is an essential part of sustainable agriculture because it is one of the main objectives of the sustainable agriculture programs [4]. Food security depends on agricultural resources and environmental preservation, so ecology-based sustainable agriculture is needed to minimize negative impacts on the environment [5]. Increasing the food production must also
be carried out in a sustainable manner such as not reducing and damaging soil fertility, not increasing erosion, and minimizing the use of non-renewable natural resources [6]. One of the sustainable land management models in Indonesia is the concept of the Cultivated Land Region (Wilayah Tanah Usaha/WTU) introduced by I Made Sandy in 1977 [7].

The WTU concept uses the pattern of land use for villages with elevation, slope, and soil [7]. There are four WTU classifications based on land elevation and slope: First Restricted Area, First Main Area, Second Main Area, and Second Restricted Area [7]. In WTU theory, the slope becomes the limiting factor of the plants from soil damage, because surface water runoff will be higher on the steep slopes [8]. This WTU concept explicitly made for agriculture land use where land with a slope of more than 35 % should not be used as agricultural land because in general the land is categorized as prone to land movement [7]. For slope more than 35 %, special treatment is needed to prevent erosion and damage to the land. Landscape variations can also affect types of agriculture because each region has different physical characteristics for certain types of plants, including the soil type and existing land use in the region. [8].

The type of plant and crops in the agriculture land is also influenced by the planting medium, which is soil [9]. Each type of soil has different characteristics that affect what plants are above it [10]. On the fertile soil types, plants will grow well. Each type of soil has different physical characteristics of the soil so that soil fertility for agriculture also has different levels in each type of soil. 92.4 % of the total area of Mount Patuha Area is agricultural land [11]. Based on the Digital Elevation Model (DEM) data, Mount Patuha area has an altitude of 800–2,400 meters above sea level. So, Mount Patuha Area has optimal temperatures for the agricultural sector and has various types of crops in the region [11]. The types of plants in Mount Patuha area consist of horticulture, paddy or secondary crop, plantations, and forestry plants or agroforestry.

In May 2017 there has been a major flood disaster in Mount Patuha Area caused by the condition of a bare river upstream. Before the flood happened, tea plantations and forestry plants that can function as a barrier to water discharge in some upstream areas, have turned into seasonal crops such as potatoes [12]. To prevent environmental damage from happening again and to maintain the sustainability of the agricultural sector in Mount Patuha area, it is necessary to review whether the existing types of plants are by the physical characteristics of the region. Therefore, this study analyzes the spatially on the pattern of agricultural plants based on WTU concept and soil types.

2. Methodology
The research area located in the Mount Patuha area which covers three districts, namely Pasirjambu, Ciwidey, and Rancabali, Bandung Regency, West Java. The variables of this study are elevation, slope, soil types, and agricultural plant types: the elevation and slope data derived from Digital Elevation Model (DEM). Soil types of the research area were collected from the Soil Research Institute (Balittanah) with a scale of 1: 50,000. Land use data for the analysis was from the Indonesia Geospatial Information Agency (BIG) on a scale of 1: 25,000. Plant types of the research area were combined from the Unit of Implementation of Technical Control Managing of Agricultural Ciwidey (UPT PPP) with interviews and verification during the field survey.

Data processing carried out in this study was utilizing the Geographic Information System (GIS) by overlaying the elevation map and slope map (figure 1), resulting map of the Cultivated Land Region based on WTU classification [7] (table 1). Afterward, created the soil types map from soil types data and used the classification of national soil types. Furthermore, making agricultural plant types map by classifying land use map based on observation of field result, farmers interview, and tabular data of plant types in each subdistrict from UPT PPP Ciwidey. All this data was used to distinguish the agricultural plants into different classifications, such as forestry plants, plantations, secondary crops, and horticulture.
3. Results

3.1. Distribution of plants type, WTU and soil type in Mount Patuha area

Types of agricultural plants in Mount Patuha area consist of paddy / secondary crops, horticulture, plantations, and forestry plants. Paddy / secondary crops cover planting area of 6,194 ha in the Patuha Mount Area [11]. Paddy /secondary crops and horticulture plants are the dominant agricultural crop in the Northeast of Patuha Mount area which includes Ciwidey and Pasirjambu districts, in the Rancabali District only in the Southwest, namely Cipelah Village (figure 2) while those included in the type of cropped
horticulture plant in Mount Patuha area are leeks, strawberries, oranges, cabbage, tomatoes, chili, mustard greens, and beans [11].

In plantations, there are plantations of tea, coffee, cloves, and tobacco. The Mount Patuha area is dominant with tea plantations which have an area of 4,196.74 ha located in the Districts of Rancabali and Pasirjambu [11]. In addition there are also forestry plants in the form of Eucalyptus alba (kayu putih), Litsea angulata (kalangkala), pine, and based on the interview with the Chairperson of the Forest Village Community Institute (LMDH) Ciwidey, now many people have planted coffee in the gaps of trees, growing avocados, even tamarillo (terong Belanda) [12, 13]. Forest distribution is in the three sub-districts, but the highest forest area is in Pasirjambu District, which is in the East of Mount Patuha area.

There are only two classifications of the cultivated land region in Mount Patuha, namely the second main area and the second restricted area (figure 3) because Mount Patuha area has an altitude of 800–2400 masl. At an altitude of 500–1000 meters, the land can still be used for agriculture, but at an altitude of >1000 meters is not recommended because it will produce poor quality crops, especially tropical plants. Areas with elevation more than 1000 meters is better for plants that have a large canopy, such as annual crops and forestry. Otherwise, they will trigger erosion [14]. The second main area spread from Ciwidey District to Rancabali. In the second restricted area, the dominant areas are in Pasirjambu District, in other district. The second restricted area is spreading in the northern part of Ciwidey District to the northern part of Indragiri and Patengan Villages, Rancabali District.

Soil type in the study area was dominated by eutric cambisol and eutric andosol soil types. Eutric cambisol is distributed in all districts, the eutric andosol is dominant in Parijambu District (figure 4). In the cambisol district type, only in Cipelah Village, Rancabali District, and gleisol, eutric soil type is only found in the district border between Ciwidey District and Pasirjambu District. The type of andosol lithic soil is located in the Middle of Mount Patuha area, which is between the Pasirjambu and Rancabali Districts.

Figure 2. Type of agricultural plants in Mount Patuha area.
Figure 3. Cultivated land region in Mount Patuha area.

Figure 4. Soil type in Mount Patuha area.
3.2. Pattern of plants type based on WTU and soil type

The elevation of the area affects the temperature level so that the higher the elevation of the area the type of plant will decrease, especially with tropical plants. The slope is also a limiting factor for plants from land damage to prevent erosion. Besides, plants also get nutrients from the soil, and not all soil is suitable for plant growth so that each type of soil will affect the plants that grow on it.

The types of horticultural plants in Mount Patuha area are dominant in the second restricted area of the cultivated land region, covering an area of 9,973 ha and for the second main area covering 1,912 ha (table 2). Horticultural plants can grow on all types of soil in the Patuha Mountain Area except andosol lithic (table 2) because the area is a forest that has an elevation of > 000 masl and a steep slope of > 40 %. Therefore, in all types of andosol lithic soils, all land is a forest (forestry plants) to prevent erosion. The paddy / secondary crops were in the second main business area (table 2) in the area of cambisol soil and eutric gleysol, whereas in eutric cambisol soil types were in the second restricted area and second main area of WTU. Plantations in Mount Patuha area are only in the type of eutric andosol soil, covering an area of 6,170 ha and eutric cambisol covering an area of 6,166 ha. The types of plantation crops are in the second restricted area and second main area. Forestry plants are only in the type of andosol lithic soil, eutric andosol and eutric cambisol (table 2). The andosol lithic is only found in the second restricted area of WTU.

Cambisol soil types are classified as newly developed soils that have the potential for the development of crops because they include fertile soil [15]. Based on the results of the field survey, cambisol soil in Mount Patuha area is used for various types of agriculture, namely horticultural crops such as cabbage, chili, tomatoes, strawberries, oranges, mustard greens, leeks, and other highland vegetables. Also, it is also used for tea and coffee plantations as well as paddy / secondary crops. Furthermore, some andosols come from volcanic eruption material, so their distribution is concentrated in the highlands. Andosol soil is fertile soil and suitable for agriculture [9]. However, in the research area of andosol soil has a fairly steep slope, so it is only used for annual crops and forestry plants. In this type of soil, gleysol always formed in drainage which is always inundated [15]. This type of soil with stagnant condition has a high potential for the development of crops, mainly paddy fields if supported by proper irrigation and drainage facilities.

The overlay analysis produces a pattern of agricultural plant types based on the Cultivated Land Region concept and soil types in the Patuha Mountain Area. Agricultural cultivation in the highlands faces the biophysical limiting factors such as relatively steep slopes, soil sensitivity to erosion and landslides. Mismanagement and exploitation of land resources in the highlands can cause biophysical damage in the form of soil fertility degradation and water availability. The Patuha Mountain area is a hilly and mountainous plateau which causes in the two WTU categories only, which are the second main area and the second restricted area. WTU concept can be applied in the Patuha Mountain Area in land management to minimize environmental damage that occurs, but to support food security, the management of agricultural land must be adapted by balancing its land conservation activities.

The Patuha Mountain Area has various types of agricultural crops from plantations, forestry plants, horticulture, to paddy fields / secondary crops, which becomes the source of income of its populations. Despite having fertile soil types and opportunities for agricultural cultivation, mountainous land remains vulnerable to erosion and landslides due to the slopes and high rainfall. When the restricted area is planted with unsuitable crops, such as secondary crops, the area may be dangerous and causing environmental damage, just like the major flood disaster occurred in May 2017.

The classification of the WTU concept can be used as a reference for conducting agricultural land management with land conservation. Land with a steep slope of > 35 % indicates landslide-prone areas called "second restricted area". It is recommended to be maintained in permanent vegetation conditions, such as sanctuary reserve area (figure 5), conservation zone, and protected forest (figure 6). Erosion and landslide control can be planned and implemented through a mechanical (civil engineering) and vegetative approach or a combination of both. In several places, soil conservation systems have been implemented such as conducting terracing on the steep slope (figure 7) to prevent landslides and planting annual crops such as tea plantations (figure 8).
Table 2. The matrix of agricultural plant types pattern based on cultivated land region and soil types and area of plant types based on WTU.

| Agricultural plant types | Soil types | Area of plant types based on WTU (ha) |
|--------------------------|------------|--------------------------------------|
|                          | Andosol    | Kambisol | Gleisol |                                    |
|                          | Litik      | Eutrik   | Eutrik  | Eutrik | IIa  | IIb  |
| Horticulture             | none       | IIa, IIb | IIa, IIb| IIa, IIb| 1,912| 9,973|
| Paddy/secondary crop     | none       | none     | IIa     | IIa, IIb| 745 | 8,443|
| Plantations              | none       | IIa, IIb | none    | IIa, IIb| 1,334| 11,002|
| Agroforestry             | IIb        | IIa, IIb | none    | IIa, IIb| 380 | 13,725|

Figure 5. Nature preserve in Mount Patuha area.

Figure 6. Protected forest with coffee cultivation.

Figure 7. Terracing on a steep slope.

Figure 8. Tea plantations as annual crops.

The WTU concept or cultivated land area is the first form of soil conservation methods and management of sustainable agricultural land. With WTU, we can utilize the land by planting suitable plants with the characteristics of each area. Therefore, erosion, landslides, and damage on agricultural land can be minimized. In addition, food security can also be maintained using WTU concept.
4. Conclusion
In this study, it can be concluded that Mount Patuha area is dominated by forestry and plantation types, for land types dominated by eutric cambisol soil type, and the cultivated land region is dominated by second restricted area. The pattern of horticultural plants is in all types of soil and WTU, except in the type of andosol lithic soil. In paddy/secondary crops, it is only found in the cambisol types, gleysol soil types, and the eutricant cambisol with the second restricted area in WTU. For plantations, it is only found in eutric cambisol and eutric andosol soil types with the second main area and second restricted area WTU. Forestry plants are only found in the soil types of andosol lithic, eutric andosol, and eutricant cambisol, with second restricted area dominant.

There are still have horticultural and paddy/secondary crops in the second restricted area which indicates that agriculture in Mount Patuha area is still not managed by the WTU concept. For plantations and forestry crops, they are still suitable, namely in the second main area and second restricted area, because the plantations in Mount Patuha area are in the form of annual crops, namely tea and coffee plantations. Cultivated Land Region or WTU concept is suitable to be applied in the Mount Patuha area as long as the local farmers can adapt their land management by balancing with soil conservation techniques. The need to implement appropriate agricultural land management through the WTU concept as an initial form of conservation farming system, so that later it can provide economical benefits and protect the environment simultaneously. Therefore, agricultural and sustainable economical development can go hand-in-hand.

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