Landscape planning for geodiversity conservation of Ciletuh geo area in Ciletuh Geopark using bioregional approach

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Abstract. Indonesia has 15 National Geoparks, and four of them have been recognized by UNESCO as the Global Geopark Network (GGN). The Ciletuh Geopark is one of the geo-parks in Indonesia that UNESCO has recognized. With the status of GGN, the management of the Ciletuh Geopark area must be directed according to the area development criteria set by UNESCO. The form of designated area development is related to efforts to increase cooperation, increase local communities’ welfare, develop infrastructure, and establish sustainable geopark areas. This Area’s result must pay attention to the Area’s sensitivity with geological uniqueness so as not to damage the geological diversity (geodiversity) in it. Therefore it is necessary to arrange the area with the direction of area development under the stipulations outlined. This research aims to develop a landscape plan to conserve the Ciletuh Geo Area geodiversity as part of Ciletuh Geopark using a bioregion approach. This process starts from inventory, literature study to analysis and synthesis, and planning. The research is carried out with a bioregion approach to determine the bioregion unit, landscape unit, and place the unit. Biophysical and geological characteristics are used in the preparation of bioregion classes. The synthesis was carried out by compiling the place units with significance values at 18 geological sites, making each place unit's intrinsic value. The landscape plan prepared by referring to the rules of conservation of nature reserves can be considered in the development and management of the Ciletuh Geo Area in particular and Ciletuh Geopark area in general.

Keywords: bioregion approach, Ciletuh geo area, geodiversity

1. Introduction
With its diversity of natural resources, Indonesia has 4 (four) National Geoparks, which UNESCO has recognized as the Global Geopark Network (GGN). Geopark is an area that has outstanding geology, which includes geological, ecological, and cultural values. Efforts to protect and enhance natural heritage function are carried out by involving community participation [1]. The development of the Geopark area is carried out to empower 3 (three) elements of diversity, namely geological diversity (geodiversity), biodiversity (biodiversity), and cultural diversity (cultural-diversity) so that in this Area must take Place at least 3 (three) functions, namely conservation, education, and community development. One of the Geoparks in Indonesia that UNESCO has recognized is the Ciletuh Geopark, Palabuhanratu, Sukabumi, West Java.

The Ciletuh Geopark area has a unique geological diversity and the oldest age in West Java. This Area was formed as a result of activities in the subduction zone, namely: the Eurasian Plate, which is composed of granite (acid), and the Indo Australian Plate, which is composed of basalt (alkaline), then produces deep troughs where deep-sea sedimentary rocks, metamorphic rocks, and igneous rocks alkaline to ultra-alkaline [2]. This geology's
uniqueness means that the Ciletuh area must be developed comprehensively as an area with conservation, education, and sustainable development functions with comparative and competitive advantages. These three functions are aspirations in the Geopark development, as mentioned by [3] and [4].

The Ciletuh Geopark status, which UNESCO has recognized as GGN, must be maintained. Efforts to maintain this status are by fulfilling the recommendations set by UNESCO. One of the 13 recommendations given by UNESCO to the Sukabumi regional government that must be completed to maintain its status as UNESCO GGN is the development of infrastructure and empowerment of local communities in the Ciletuh Geopark. One of the efforts that can be done in developing a total area focused on preserving the geodiversity function of the Geopark area. The resulting conservation is aimed at maintaining the geological quality contained in it. The geological quality should be maintained that have impacts to sustainability of area are the uniqueness of geodiversity (special geological phenomena, landform features), significance in occurrence and distribution special ecological function, and suitable for both educational and research purposes [7]. The maintained those geological quality will have an impact on the sustainable use of the Area. The Geopark concept is focused on and considered a balance between the conservation of geological heritage, geo-tourism, and local communities’ welfare. To ensure the preservation of the geopark area in a balanced manner, landscape planning is needed to maintain the Ciletuh Palabuhanratu Geopark Area’s sustainability.

Bioregion, which comes from the words bio (living) and region (territorial), is a place to live (life place), which is a unique environment where the boundaries are more determined by the natural order, which can support uniqueness. The activities of the biotic community therein [5]. The limits set by the government are administrative boundaries that are not necessarily following natural boundaries, which the bioregion approach can determine. In this study, a method was made between the Area’s natural characteristics with the geological distribution and the above sites’ presence. By planning to conserve bioregion-based areas, it is hoped that the geodiversity of the Ciletuh Geopark area will be conserved.

2. Methods

2.1. Location and Time of Research
The research location was conducted at the Ciletuh Geo Area, which is part of the Ciletuh Geopark with an area of 128,000 Ha (1,280 km²). Administratively, the Area is located in Sukabumi Regency, West Java Province, Indonesia (Figure 1). The research was carried out for six months, starting in February 2020, which was continued with data processing and compilation of study results until July 2020.

2.2. Preparation
At this stage, the activities include setting planning objectives, gathering initial information, drafting research proposals, and arranging permits for research. This stage is carried out before the field survey.

2.3. Inventory
Inventory is carried out by collecting data/information required in spatial analysis in the form of secondary data. The data and information required include biophysical and geological aspects. A thematic map/data was compiled based on the data and information predefined classification criteria.
2.4. Bioregional Analysis
Geodiversity analysis of the Ciletuh Geo Area was carried out based on the bioregion approach. The classification of bioregion units is arranged hierarchically based on the biophysical data and geological data of the Ciletuh Geopark with modifications to [6]. The data are classified hierarchically into three units: bioregion unit, landscape unit, and place unit.

2.4.1. Bioregion Unit
The Ciletuh Geopark bioregion unit classification is based on topographic characteristics outlined in a watershed to obtain watershed classification data. The bioregion unit is the highest level or the widest in the division of areas defined on the similarity of natural characteristics within which form the Ciletuh Geo Area.

2.4.2. Landscape Unit
The landscape unit is a subdivision of the bioregion unit, which is aggregative has homogenous characteristics in it. This unit can be identified by classifying the bioregion unit into sub-unit based on the sub-watershed, soil type, slope of the land, and the Ciletuh Geo Area’s geological unit area.

2.4.3. Place Unit
The Place Unit is the lowest level unit in the bioregion subdivision, based on land cover in the landscape unit and evaluation of the characteristics of the geodiversity significance value based on the modification of [7].

2.5. Synthesis
At this stage, directives for the preservation of the Ciletuh Geo Area were drawn up. The preservation direction is based on evaluating the bioregional analysis results that form the unit of Place. Based on the bioregion analysis, each unit of Place’s development’s direction can be determined based on its geodiversity significance. The geodiversity significance of each unit of space forms the basis for the formulation of landscape planning.
2.5.1. Landscape Planning

2.5.1.2. Basic Concept of Landscape Planning

The concept of planning for the Ciletuh Geo Area is to make the area preserved based on the uniqueness of geodiversity. The uniqueness of geodiversity as a system guides the development of landscape layout based on the bioregion approach.

2.5.1.2. Landscape Plan Development Concept

The main development concept plan is outlined in the form of a spatial zoning concept. The spatial concept is based on the Ciletuh Geo Area system according to the significance of geological formations’ distribution and formation. The idea of zoning refers to [8]. The Ciletuh Geopark area’s space is divided into 3 (three) spaces: protection blocks, rehabilitation blocks, and special blocks. Meanwhile, the concept of supporting development was developed in the form of a conservation supporting infrastructure system in the form of access (circulation) connecting the sub-systems of the Ciletuh Geo Area. Besides, the concept of land designation that supports the conservation of the Area is developed.

The landscape plan is the final result for the geodiversity conservation area of Ciletuh Geo area with a bioregion approach. The program is equipped with a schematic plan drawing.

3. Result And Discussion

3.1. General Condition

The research was conducted at Ciletuh Geo area, Sukabumi Regency, West Java. Ciletuh Geo area covers four districts, namely Ciemas District, Ciracap District, Surade District, and Waluran District, with approximately 568.53 km². Ciletuh Geopark or Ciletuh Earth Park is one of the areas that has the oldest rocks on the island of Java. These rocks have an age of about 50–65 million years ago. The process of the occurrence of these rocks is predicted to result from the collision of the Eurasian Plate (Continental Plate), which is composed of granite (acid), and the Indo-Australian Plate (Ocean Plate), which is composed of basalt (alkaline) then appears to the surface of the earth.

3.2. Ciletuh Geo Area Bioregion Characteristic

The Ciletuh Geo Area's bioregion characteristics, which consist of four districts, namely Ciemas District, Ciracap District, Surade District, and Waluran District, are the basis for the classification of bioregional space units. These characteristics consist of bio-physical and geological characteristics.

3.2.1. Topography and Land Slope

The slope of the land in the Ciletuh Geo Area is very diverse, divided into five classes of steepness, i.e., flat (about 39% or an area of 223.41 km²), gently sloping (by 32% or covering an area of 180.39 km²), moderate steep (by 20% or an area of 114.13 km²), steep (by 7% or an area of 39.09 km²), and very steep (by 2% or an area of 11.41 km²). The very steep slope classes are dominating the fault around the Ciletuh Bay Amphitheatre.

3.2.2. Soil

Ciletuh Geo Area is composed of 7 (seven) types of soil, namely alluvial, laterite, latosol, lithosol, podzolic, Mediterranean, and regosol. Ciletuh Geo area consists of eight groups of soil types, namely alluvial gray-brown, alluvial hydro morph, yellowish red and podsolic lateritic complexes, reddish-brown and lithosol latosol complexes, yellowish red and brown latosol complexes, yellowish-red latosol brown latosol complexes and yellowish red podsolic complexes, mediteran reddish-brown, and lithosol, and regosol gray.

The results of data processing on soil types in Ciletuh Geo area show that the dominant soil types are lateritic complexes of yellowish red and podsolic with a percentage value of 53%
or an area of 299.19 km² and a complex of yellowish red and brown latosol with a percentage of 18% or an area of 100.9 km². This type of yellowish-red lateric soil has an in-depth soil profile, quickly absorbs water, has a moderate organic matter with a neutral to acidic pH, and contains lots of iron and aluminum, so it is good to be used as a building foundation. The red soil texture is relatively dense and sturdy to support the buildings on it and can be used for plantations for maize, oil palm, rubber, cloves, cocoa, and coffee. Brown-gray alluvial soil types have the smallest percentage, namely 1% or an area of 3.84 km². This type of soil contains a lot of sand and clay, does not contain many nutrient elements, and has a high organic matter content. The pH content in this soil is low (5.3 - 5.8), and the dissolved aluminum content is very high.

3.2.3. Climate
The climatic data of Sukabumi Regency for ten years from 2006-2015 was used average annual rainfall in Ciletuh Geo Area uses in. There are two classes of rainfall dept in Ciletuh Geo Area, i.e. 2000-2500 mm / year and 2500-3000 mm / year.

3.2.4. Hydrology
The Ciletuh Geo Area’s hydrological conditions include groundwater in the form of springs and surface water in rivers and tributaries. Surface water primarily consists of rivers and tributaries that form 5 (five) watersheds (DAS), namely the Cikaso River Basin (922 km²), the Cikarang Watershed (309.44 km²), the Cimarinjung Watershed (133.89 km²), Ciletuh Watershed (279.88 km²), and Cipamaranga Watershed (81.24 km²). The Ciletuh watershed is a distinctive and unique area because there are rocks that are the oldest (pre-tertiary) in West Java. The river in Ciletuh Geo Area consists of the main river, namely the Ciletuh River with a length of 230.72 km, Cikarang River (259.62 km length), and several tributaries.

3.2.5. Land Cover
Based on satellite imagery's visual interpretation, the land cover class of the Ciletuh Geo Area consists of water bodies (lake and ponds), natural forest, plantations, settlements, rice fields, shrubland, bare land, and upland cultivated land. Land cover is one factor that influences the preservation of the geodiversity area in the Ciletuh Geo Area.

3.2.6. Geological Formation Process
The Ciletuh area has unique structural characteristics. In general, it cannot be separated from the activities of the West Java regional tectonic processes, which are tectonic fossils (subduction during the Cretaceous era). So that makes the geological outcrop in the Ciletuh area very unique and rare. The formation of the geological structure of West Java coincided under the influence of the Indian-Australian plate collision activity with the Eurasian plate that has lasted since the Cretaceous Period until now. The position of the subduction zone during this period has changed several times.

In the Late Eocene, the Java subduction route's position shifted to the south for the first time. The Ciletuh area, including its Massive Area, has experienced several tectonic activities, the first time in Pre-Tertiary tectonic activity, the second after the Eocene, maybe even the Oligocene, the third at the end of the Middle Miocene, and the last rapture in the Pliocene era. Tectonic activities after Eocene (Oligocene) affect massive rocks and Eocene rocks, during which time massive rocks experience shifts to form fractures. The Massive Ciletuh includes the western end of the Southern Mountain Range or the Southern Mountain Line, with approximately 50 km in West Java. In the east, this line narrows down to several kilometers, ends near Cilacap, and appears again south of Jogyakarta. Morphologically Massive Ciletuh is located outside Plateau-Jampang, which is bordered by the surrounding escarpment.
3.2.7. Geological Distribution Pattern
Based on the data obtained, [7] has assessed 25 geological sites found in the Ciletuh Geopark. There are differences between the geological sites at the Ciletuh Geopark that have been determined by UNESCO and the sites that have been assessed due to the absence of data related to the assessment of the 61 sites found in the Ciletuh Geopark. However, based on the results obtained, an assessment has been carried out on the entire geological site but has not been published. Among the 25 sites, 18 geological sites were selected in the Ciletuh Geo Area. The 18 sites have moderate to prominent geological heritage values based on scientific records and unique geological phenomena for educational and research purposes [7].

3.2.8. Bioregional Classification
The bioregional classification is arranged hierarchically based on the biophysical characteristics of the Area. There are 3 (three) classes of biophysical and geological characteristics, namely: Bioregion Unit, Landscape Unit, and Place Unit.

3.2.8.1. Bioregion Unit
The bioregion unit classification is prepared by initiating the existing watershed boundaries in the Ciletuh Geo Area. The natural characteristics contained within a watershed boundary have similarities but differ from one watershed to another. The Ciletuh Geo Area is divided into 5 (five) watersheds, namely Cikarang Watershed, Cikaso Watershed, Ciletuh Watershed, Cimarinjung Watershed, and Cimaparangan Watershed. The five watersheds are the basis for determining the bioregion unit in the Ciletuh Geo Area.

3.2.8.2. Landscape Unit
The biophysical characteristics used are sub-watershed, soil type, climate, and land slope. Overlay the four parameters, resulting in 294 landscape units within the Ciletuh Geo Area.

3.2.8.3. Place Unit
The Place Unit is the lowest unit in the bioregion classification. The type of geological formation is used as the basis for determining the unit of Place in this study. The analysis of 294 landscape units with geological formations found in the Ciletuh Geo Area resulted in 711 Place Units. Each class of Place Units is a homogeneous area distinguished from other classes of Place Units.

4. Synthesis
Ciletuh Geopark is a National Geopark area that UNESCO has recognized as a Global Geopark Network (GGN). The uniqueness of geodiversity, which is formed through a process that lasts hundreds to millions of years, is a resource that must be conserved. In the synthesis stage, the compilation is carried out at each place unit with a significance value for 18 geological sites, making each place unit's intrinsic value. Based on the 18 selected geological heritage sites, there are 6 (six) geological sites classified as aquatic units, and 12 sites are terrestrial place unit (Figure 2). The locations of the 18 sites are in different Place Units and landscape units. After that, 12 sites located in terrestrial areas will become objects in the Ciletuh Geo Area landscape's conservation planning. Based on these 12 sites, there are 2 (two) geological sites are in the same Place and landscape unit, namely the Puncakmanik Curug and the Middle Curug. Besides, there are 2 (two) geological sites in the same landscape unit but different Place Units, namely Batununggul Beach and Batu Batik.
5. Concept And Development

5.1. Planning Concept
Based on the bioregion approach, Ciletuh Geo Area consists of 711 Place Units with homogeneous characteristics in each unit class and can be distinguished from other class unit units. The Place Units are then overlaid with geological heritage sites and selected as many as 18 Place Units with geological heritage sites. The 18 units consist of 12 units in the terrestrial Area, and the other six are in the water unit. Based on 18 geological sites that have been identified, they have a low to leading geological value heritage. The basic concept of planning applied in the Ciletuh Geo Area is to create a conservation area for the Ciletuh Geo Area’s geological diversity. The determination of the conservation area is based on 711 Place Units in the Ciletuh Geo Area.

5.2. Concept Devevopement Plan

5.2.1. Block Plan Concept
Based on [8] management blocks in the nature reserve area consist of protection blocks and other blocks. The other block in question includes the rehabilitation block, religion, culture, history, and special block. The protection block is a core part that has a geological object on it. Rehabilitation blocks are blocks that have been damaged and need a rehabilitation process. The rehabilitation block also acts as a buffer for the protection block, a core part of conservation. A particular block is located outside the rehabilitation block and does not directly access the protection block. This conservation area spatial planning is also supported by [9] and [10]. This regulation explains the zoning regulations for areas of the uniqueness of rocks and fossils. In this regulation, it is defined that an area of the uniqueness of rocks and fossils included in a nature reserve area needs to pay attention to several regulations, namely, the construction of buildings is limited to research, education, and nature tourism. The construction of buildings and activities other than the three things mentioned is strictly prohibited and may be subject to sanctions. However, in the regulations regarding the management block of nature reserves, areas in conservation areas with buildings are categorized into special blocks.

5.2.2. Circulation Concept
The circulation concept used to preserve the Ciletuh Geo Area is based on determining blocks and limiting each block’s activities. There are 3 (three) circulation concepts applied: primary circulation, secondary circulation, and tertiary circulation. The primary circulation is the main circulation route in the Ciletuh Geo Area. Secondary circulation is a circulation that connects between special blocks with each rehabilitation block in the Area. Tertiary circulation is circulation that is in the core area of the protection and at the same time
connects the protection block with the rehabilitation block. Besides, access to the rehabilitation block also needs to be limited because the rehabilitation block activities are ecosystem restoration activities. Meanwhile, for special blocks, circulation is a little loose because the activities in this block are more general. Some settlements existed before the designation of the Ciletuh geological diversity area as a Geopark area.

5.2.3. Vegetation Concept
The concept of vegetation in geodiversity conservation landscape planning is based on vegetation's function on the existing land cover of Ciletuh Geo area. The idea of vegetation is arranged based on its functions, including its conservation and cultivation function. Vegetation with a conservation function is used to protect the ecosystem's richness above it and is found in forest land cover. The cultivation function is found in the agricultural land cover, consisting of rice fields, fields, and plantations. Vegetation with the cultivation function is applied to the entire Ciletuh Geo Area in accordance with existing conditions. Vegetation with a cultivation function can be applied to protection blocks, rehabilitation blocks, and special blocks. In protection blocks, cultivated vegetation can be applied because it allows the use of germplasm for the protection block's cultivation functions.

6. Landscape Planning

6.1. Block Plan
Spatial plans are made based on references from the concept of space. The spatial plan for preserving the geodiversity of Ciletuh Geo Area is divided into three blocks. The three blocks are protection block, rehabilitation block, and special block. Each block has its criteria according to the concept of space. These criteria affect the land cover in each block.

6.1.1. Protection Block
The protection block is a space that is the core of conservation. Protection blocks are based on the presence of a geological site in a Place Unit. The Place Units used as protection blocks are Place Units 53, 222, 248, 253, 258, 309, 589, 672, 561, 601, and 693. In the protection block, the activities carried out are very limited, which affects the land cover. The existing land cover is maintained, including forest land cover, shrubs, open land, and water bodies. Besides, land cover in the form of agricultural lands such as paddy fields, plantations, and fields is also maintained due to the permissibility of utilizing nuftah plasma in the protection block. However, the existence of buildings is prohibited above the protection block. Therefore, the protection block has an existing land cover in the form of a building used as an activity area or a settlement where the location is moved out of the protection block. Palampang beach is located in the protection block in unit 53, where part of the existing land cover is in the form of a newly built lodging building. The building is then moved out of the protection block to preserve the geological site inside.

6.1.2. Rehabilitation block
A rehabilitation block is an area around a protection block that has been damaged, so it needs to be repaired. The general activities that can be carried out in this block are the same as in the protection block but are given additional area restoration activities. The rehabilitation block also functions to maintain the protection block from interference from outside the block.

6.1.3. Special Block
The Special Block is an area in the Ciletuh Geo Area conservation area, which has a building above it, but this building existed before the Ciletuh Bay area was designated as a Geopark area. One Area that becomes a special block is in unit 54 around the Palampang
Beach protection block. In this Area, a building is a center for fish auction activities and a pier for fishing boats fishing in Ciletuh Bay. The building is located downstream on the shore of Ciletuh Bay. The building is inevitable because it is one of the activity centers for fishers in Ciletuh Bay.

6.1.4. Landscape Plan
At the landscape planning stage, the final result is a landscape plan image (Figure 3). Landscape planning is prepared based on spatial plans, circulation plans, and vegetation plans prepared based on planning concepts. In-Place Units with a geological site significance class above them, planning is carried out with the consideration of determining blocks based on [8]. The planning is then outlined in the Ciletuh Geo Area's spatial planning. This geodiversity conservation landscape plan is expected to maintain the geological diversity in this Area in line with the Ciletuh Geo Area's development as a sustainable area.

![Figure 3 Landscape plan](image)

6.1.5. Circulation Plan
The circulation plan is divided into 3 (three), namely primary circulation, secondary circulation, and tertiary circulation. The primary circulation is only located in special blocks and is a public road traversed by motorized vehicles. This circulation is the main circulation within the Area and a connecting circulation outside the Ciletuh Geo Area. Secondary circulation is located at geological site points. The secondary circulation connects the Area to and from the rehabilitation block of the special block. This secondary circulation is in the form of access that can only be passed by humans and non-motorized vehicles such as bicycles. The third is the tertiary circulation, the circulation within the protection block and the circulation connecting the protection block and the rehabilitation block. The tertiary circulation in this conservation plan cannot be accessed freely due to the limited activities that can be carried out in the Area.
6.1.6. Vegetation Plan
The vegetation plan developed follows the development of the draft vegetation concept. The vegetation used in each space is in accordance with the existing and existing characteristics of the unit. The use of greenery is adjusted to the land cover in the existing Place Units.

7. Conclusions And Suggestions

7.1. Conclusion
The Ciletuh Geo Area has landscape characteristics in biophysics and geology, which form the bioregion units. Based on the analysis results, the Ciletuh Geo Area is included in the five watersheds bioregion unit of 5 watersheds, namely Cikarang watershed, Cikaso watershed, Ciletuh, Cimarinjung watershed, and Cimaparangan watershed. These five bioregion units can be divided into 294 landscape units based on their intrinsic physical value (sub-watershed, soil type, rainfall, and slope). Furthermore, based on the intrinsic value of the geological site significance, there are 711 Place Units.

Landscape planning for geodiversity conservation in the Ciletuh Geo Area can be prepared based on the bioregion approach. Based on the intrinsic value in the form of geological significance in each class of units, a block plan unit can be developed by referring to [8]. Landscape plans are outlined in the form of spatial plans, circulation plans, and vegetation plans.

7.2. Suggestion
Landscape planning for the preservation of geodiversity in the Ciletuh Geo Area with the bioregion approach is expected to be a source of information in developing a sustainable Geopark so that preserving geodiversity in this Area, it can always be maintained. In the future, it is also hoped that based on this landscape plan, regulation can be made by the Sukabumi Regency government related to the preservation of geodiversity in the Ciletuh Geo Area. Besides, to perfect this research, further and more comprehensive research is needed on the properties of the properties so that a protection program can be carried out at each geological site.

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