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Vegetation structure and composition in Ciletuh Geopark, Sukabumi, Indonesia

INDRI WULANDARI[1,3,♥], RANDI HENDRAWAN[1,3], TEGUH HUSODO[1,2,3], ERRI N. MEGANTARA[1,2,3]

[1]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran. Jl. Raya Bandung-Sumedang Km 21, Jatinangor, Sumedang 45363, West Java, Indonesia. Tel.: +62-22-7797712, ♥email: indri.wulandari@unpad.ac.id.

[2]Program in Environmental Science, School of Graduates, Universitas Padjadjaran. Jl. Sekeloa, Coblong, Bandung 40134, West Java, Indonesia

[3]Institute of Ecology, Directorate of Research, Community Services and Innovation, Universitas Padjadjaran. Jl. Sekeloa, Coblong, Bandung 40134, West Java, Indonesia

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Abstract. *Wulandari I, Hendrawan R, Husodo T, Megantara EN. 2018. Vegetation structure and composition in Ciletuh Geopark, Sukabumi, Indonesia. Asian J For 2: 54-61.* Ciletuh Geopark has unique geological and biological features which might provide benefits both to the environment and society. The sustainable management of the geopark requires information on biodiversity elements including the vegetation occurring around Ciletuh Geopark. This research was conducted to determine vegetation communities and plants diversity of the Ciletuh Geopark. The method used was a qualitative method through inventory of plant species and observation of the vegetation profile diagram, which represents a vertical structure of the vegetation community. In general, Ciletuh Geopark had four types of communities, namely natural forests, gardens, agroforest (*talun/kebon tatangkalan*), and beach and mangrove vegetation. In total, there were 179 plant species recorded from understorey to trees including plant species protected by the Indonesian government, namely *Rafflesia patma*. In the geopark, there had been changes in vegetation which is now dominated by crop plant species. This study highlights the importance of conserving the remaining natural vegetation in Ciletuh Geopark to enhance the biological values of the geopark.

Keywords: Ciletuh, geopark, composition, structure, vegetation

INTRODUCTION

In the last 15 years, there is an emerging interest of global community in the establishment and development of geopark. This is a new initiative promoted by UNESCO that aims to conserve areas with high importance not only on geological interests but also regarding biological diversity. So far, larger attention is highlighted on the geological aspects while the biodiversity issues are rather overlooked.

Ciletuh Geopark is located in Sukabumi, West Java, Indonesia. It was established in September 2016 through the Decree of the Governor of West Java No. 556/Kep. 941-Rek/2016. Administratively, Ciletuh Geopark encompasses eight sub-districts, namely Cisolok, Cikakak, Palabuhanratu, Simpenan, Ciemas, Ciracap, Waluran, and Surade. One of the aims of the establishment of this geopark is among others to support sustainable development, especially in Sukabumi and West Java Province.

Particular aspect in Ciletuh Geopark that can be explored to be utilized sustainably is the biodiversity elements. However, since the establishment of Ciletuh Geopark, not many efforts were carried out to reveal information regarding plant and animal diversity in the area. Previous study by Megantara (2016) in Ciletuh Geopark only focused on an inventory of REEPS (Rare, Endangered, Endemic, Protected Species) of animals species. As such, studies need to be expanded to reveal information regarding plants or vegetation of Ciletuh Geopark.

Gem (1996) states that vegetation is a collection of species of plants, each of which is incorporated in a population that lives in habitat and interacts with one another. Interaction in a community is reflected in the structure and composition of vegetation. Stratification in a community occurs because of competition between dominant species with other species or between tall trees in the uppermost layers controlling the trees below (Soerianegara and Indrawan 2005). The interaction between plants gives rise to a characteristic composition of vegetation. Mueller-Dombois and Ellenberg (1974) use the term composition to express the floristic wealth of forests. Soerianegara and Indrawan (2005) add that species composition is distinguished between population (one species) and community (some species). The composition of vegetation is defined as the variation in the plant species that arrange community. The composition of plant species is a floristic list in a community (Misra 1973).

The purpose of this research is to find out plant diversity and vegetation community occurring in Ciletuh Geopark. The results of this study are expected to serve as baseline information for the management of the geopark as well as for future studies looking at the dynamics of the vegetation over a certain period.

MATERIALS AND METHODS

Study area

This study was carried out in Ciletuh Geopark, Sukabumi, West Java, Indonesia. Data collection was concentrated in the horseshoe-shaped buffer area surrounding the Amphitheater (Figure 1). The Amphitheater has high importance since the government plans that this area would be projected as the center of Ciletuh's economic growth. In general, the Amphitheater is located in low elevation so that vegetation occurring in this area can be classified as lowland forest. A previous study by Megantara (2016) showed that the Amphitheater is the habitat animal species with REEPS status.

Methods

Data collection was carried out through an inventory of plant species as well as direct observation to capture the vegetation profiles. Stratification and vegetation profiles were drawn by profile diagram vertically (Mueller-Dombois and Ellenberg 1974). Profile diagram was aimed to understand the structure of vegetation and created based on transect with length of 200 m and plot with size of 10 x 10 m^2. The profile diagram represented vertical structure of vegetation at four types of communities, namely (i) natural forests (Selagedang Hulu, Curug Awang Bawah, Curug Tengah, Puncak Manik, Cipeucang Atas, Curug Dogdog, Curug Cimarinjing), (ii) gardens (Kebun Jati Selagedang, Kebun Kelapa Tamanjaya, Curug Awang Atas), (iii) agroforests (Cigembong, Cipeucang Bawah, Mandrajaya-Ciwaru, Pasir Muncang, Gunung Masigit), and (iv) coastal vegetation/mangroves (Mangrove Cikadal).

The profile diagram depiction was created on millimeter block paper with a scale of 1: 100. In the picture, it is added information such as research title, scale, species code, tree height scale, species name, and location map and study transect.

Data were analyzed using the qualitative-descriptive method to describe the condition of vegetation at the study location. Based on vegetation profile, the canopy strata were formed. The determination of the amount of strata is very dependent on the personal decision of the researcher.

RESULTS AND DISCUSSION

Vegetation community type

There were four vegetation community types found at the study sites in Ciletuh Geopark, namely natural forests, gardens, agroforest (*talun*/*kebon tatangkalan*), and beach and mangrove vegetation. Natural forest and agroforests dominated the landscape in Ciletuh Geopark. The description of each vegetation is as follows.

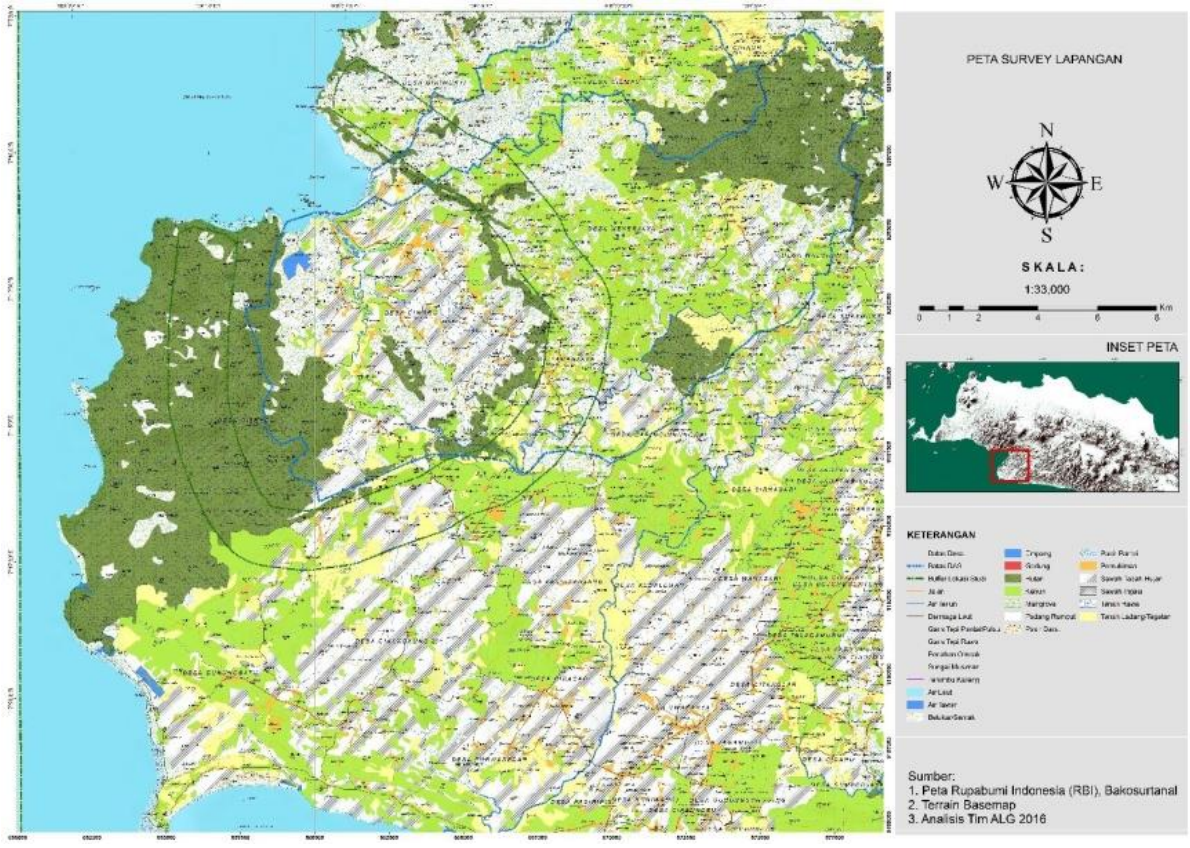

Figure 1. Map of the study location in Ciletuh Geopark, Sukabumi, West Java, Indonesia

Forests

Forest was arranged by natural vegetation. The surrounding area of the forest had undergone land-use change into agricultural land. The forest was located on steep slopes which were difficult to reach, such as around waterfalls and cliffs, thus saving it from encroachment for land clearing. The forest around waterfall had a slope of 50-90%, but the other forest around the Curug Dog-dog had slope between 20-30%, which tends to be flat. Meanwhile, the forest around the cliff has slope between 40-80%. In general, the canopy closure of forests around the cliff tended to be denser while the forest around waterfall was more open although in Curug Dog-dog it had a closed canopy closure (70-80%).

Garden

In general, gardens dominated the landscape in Ciletuh Geoparks. It is arranged by agricultural land consisting of cultivated vegetation, such as horticultural crops. Some gardens were cultivated by single crops (monoculture) while other gardens were planted with various crops to form intercropping vegetation (polyculture). Plant species that were often found in the garden included teak, coconut, rice, corn, and bananas. However, there were species being the main commodities of each garden, such as teak and coconut, which were the main commodities. The gardens had a relatively flat and wavy topography, with a slope of <50%. The canopy closure of the garden was relatively open, so sunlight can penetrate the ground.

Agroforest (Talun/kebon tatangkalan)

In Ciletuh Geopark, agroforest was generally located in a relatively flat area. Canopy closure was not too dense, around 50%. *Talun* which had slope of > 50% and a fairly close canopy closure can be found in Keusik Bodas area with slope of 50-70% and canopy cover of 75-95%.

Beach and mangrove vegetation

Beach and mangrove vegetation communities were located in coastal areas, so plant communities had adapted to high salinity. This area had a broad coastal vegetation formation because most of the land haf been turned into cattle grazing and residential areas. Coastal and mangrove vegetation were separated by village and river roads with relatively flat topography.

Figure 1. Vegetation communities of natural forest in Ciletuh Geopark, West Java, Indonesia

Figure 2. Vegetation communities of garden in Ciletuh Geopark, West Java, Indonesia

Figure 3. Vegetation communities of agroforest (*talun/kebon tatangkalan*) in Ciletuh Geopark, West Java, Indonesia

Figure 4. Vegetation communities of beach and mangrove in Ciletuh Geopark, West Java, Indonesia

Structure of vegetation community

Wyatt-Smith (1963) classify the structure of vegetation communities into four categories, namely trees, poles, saplings, and undergrowth. Tree is woody plants with diameter at breast height (DBH) > 35 cm, pole is a woody plant with a diameter of 10-35 cm, sapling is a woody plant with a diameter of <10 cm or has a height of >1.5 m and undergrowth is vegetation with a height of <1.5 m. Soerianegara and Indrawan (2005) classify vegetation structure based on the level of layers from top to bottom horizontally, namely strata A, B, C, D, and E. Strata A is plants that have a height > 30 m, strata B consists of plants with a height between 20-30 m, strata C consists of plants with a height between 4-20 m, and strata D and E each are plants with a height 1-4 m and < 1 m, respectively.

Generally, the vegetation in the Ciletuh Geopark had complex structures, starting from tree level to the sapling and also arranged by undergrowth vegetation. Based on its stratification, vegetation in the Ciletuh Geopark was dominated by strata B (height between 20-30 m) and C (height between 4-20 m).

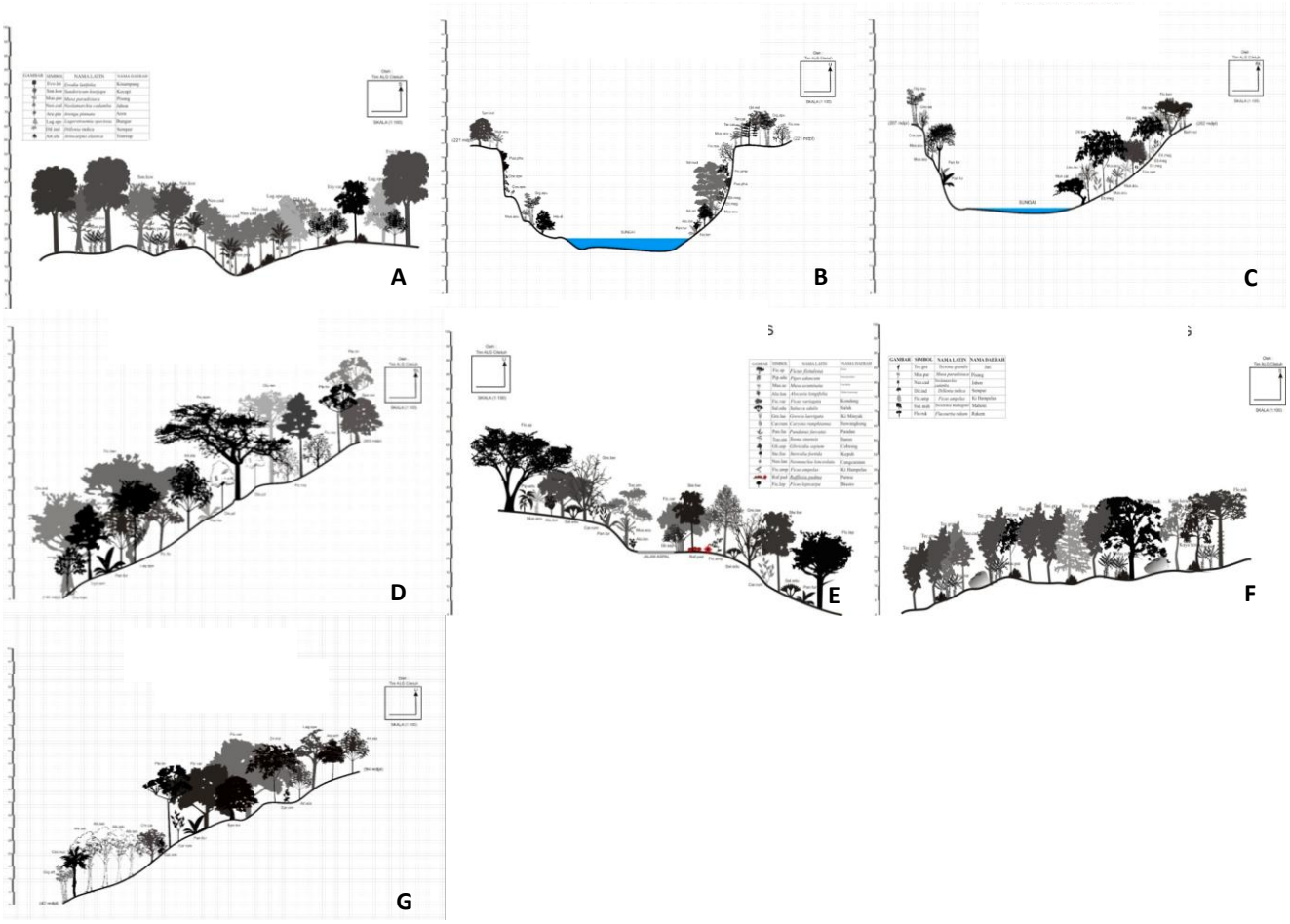

Figure 5. Vegetation profile diagram of natural forest in Ciletuh Geopark, West Java, Indonesia. A. Selagedang Hulu, B. Curug Awang Bawah, C. Curug Tengah, D. Puncak Manik, E. Cipeucang Atas, F. Curug Dogdog, G. Curug Cimarinjing

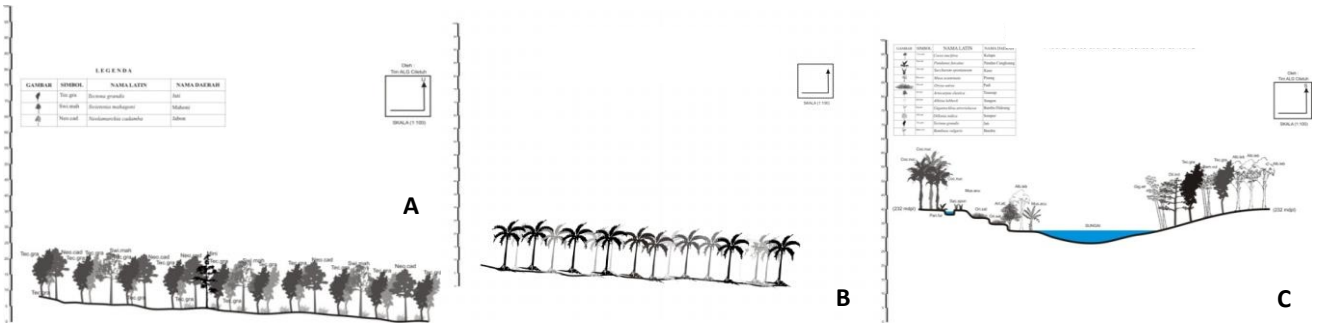

Figure 6. Vegetation profile diagram of garden in Ciletuh Geopark, West Java, Indonesia. A. Kebun Jati Selagedang, B. Kebun Kelapa Tamanjaya, C. Curug Awang Atas

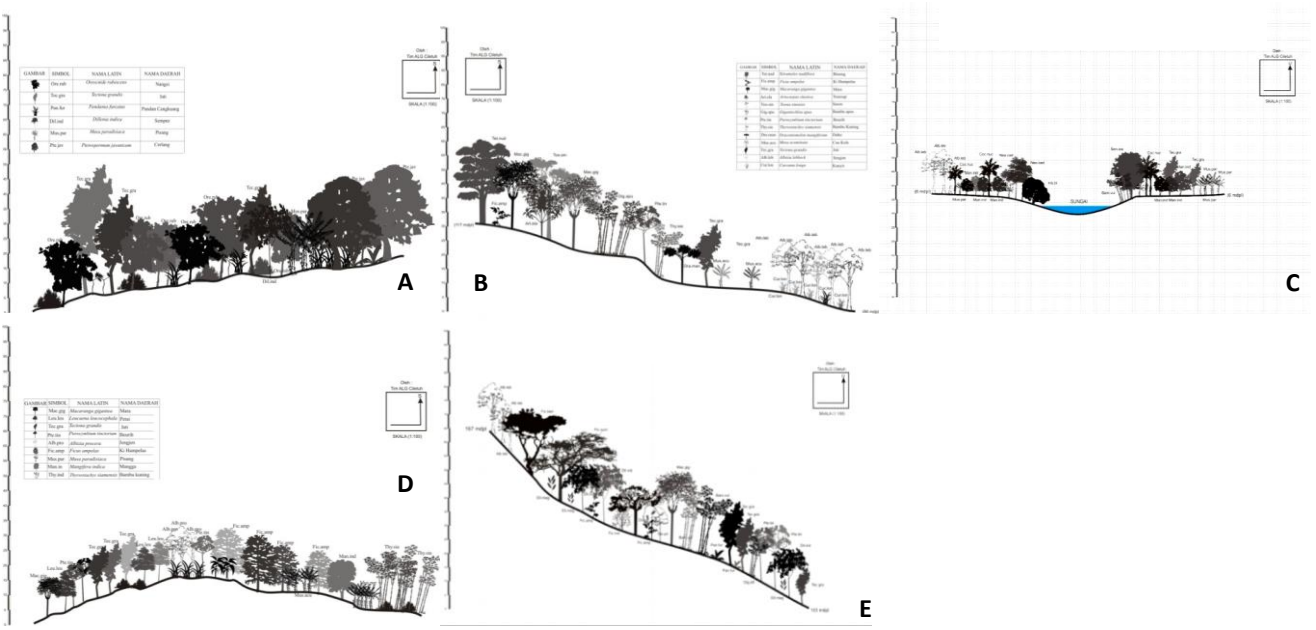

Figure 7. Vegetation profile diagram of agroforest (*talun/kebon tatangkalan*) in Ciletuh Geopark, West Java, Indonesia. A. Cigembong, B. Cipeucang Bawah, C. Mandrajaya-Ciwaru, D. Pasir Muncang, E. Gunung Masigit

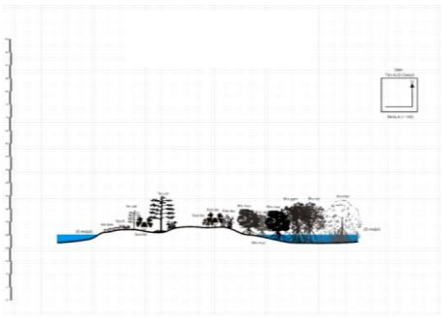

Figure 8. Vegetation profile diagram of mangrove in Ciletuh Geopark, West Java, Indonesia, i.e., Mangrove Cikadal.

Vegetation composition

Vegetation inventory recorded 179 species across all types of vegetations. Family with the highest number of species were Fabaceae and Moraceae with 13 species. The forests in Ciletuh Geopark had high species diversity compared to garden and agroforest. The most dominant species were from family Moraceae, such as *Ficus ampelas* Burm.f. and *Ficus rostrata* Thunb.

In contrast to forest and agroforest, the vegetation of garden and coastal and mangrove was different. In the garden, there were various agricultural crops species while vegetation on the beach included *Calophyllum inophyllum* and *Terminalia catappa*, whereas the dominant species were *Ipomoea pes-caprae*, and *Sesuvium portulacastrum*. Meanwhile, the dominant species of mangrove were *Avicennia marina*, *Rhizophora mucronata*, *Excoecaria agallocha*, and *Bruguiera gymnorrhiza*.

Table 1. List of species recorded in Ciletuh Geopark, West Java, Indonesia

Family	Species
Acanthaceae	*Acanthus ilicifolius* L.
Aizoaceae	*Sessuvium portulacastrum* (L.) L.
Amaryllidaceae	*Crinum asiaticum* L.
Anacardiaceae	*Anacardium occidentale* L.
Anacardiaceae	*Dracontomelon mangiferum* Blume
Anacardiaceae	*Gluta renghas* L.
Anacardiaceae	*Gluta wallichii* (Hook.f.) Ding Hou
Anacardiaceae	*Mangifera foetida* Blume
Anacardiaceae	*Mangifera indica* L.
Anacardiaceae	*Spondias dulcis* Forst.f.
Annonaceae	*Orophea hexandra* Blume
Apocynaceae	*Alstonia scholaris* (L.) R. Br.
Araceae	*Alocasia longifolia* Engl. & K. Krause
Araceae	*Colocasia esculenta* Schott
Arecaceae	*Aegle marmelos* (L.) Corrêa
Arecaceae	*Arenga obtusifolia* Mart.
Arecaceae	*Arenga pinnata* (Wurmb) Merr.
Arecaceae	*Calamus viminalis* Willd
Arecaceae	*Caryota rumphiana* Mart.
Arecaceae	*Cocos nucifera* Linn.
Arecaceae	*Daemonorops melanochaetes* Blume
Arecaceae	*Pinanga coronata* (Blume ex Martelli) Blume
Arecaceae	*Plectocomia elongata* L.
Asparagaceae	*Cordyline fruticosa* (L.) A.Chev.
Aspleniaceae	*Asplenium nidus* L.
Asteraceae	*Ageratum conyzoides* (L.) L.
Asteraceae	*Chromolaena odorata* (L.) R.M.King & H.Rob.
Asteraceae	*Crassocephalum crepidiodes* (Benth.) S. Moore
Asteraceae	*Erigeron sumatrensis* Retz.
Asteraceae	*Mickania cordata* (Burm.f.) B.L.Rob.
Asteraceae	*Sonchus arvensis* L.
Asteraceae	*Wedelia triloba* (L.) Hitchc.
Averrhoaceae	*Averrhoa bilimbi* L.
Avicenniaceae	*Avicennia marina* (Forssk.) Vierh.
Balsaminaceae	*Impatiens platypetala*
Bambusaceae	*Bambusa vulgaris* Schrad.
Bambusaceae	*Dendrocalamus asper* (Schult.) Backer
Bambusaceae	*Gigantochloa apus* (Schult.) Kurz
Bambusaceae	*Gigantochloa atroviolacea* Widjaja
Bambusaceae	*Gigantochloa atter* (Hassk.) Kurz
Bambusaceae	*Thyrsostachys siamensis* Gamble
Begoniaceae	*Begonia robusta* Blume
Bignoniaceae	*Oroxylum indicum* (L.) Kurz
Bombacaceae	*Durio zibethinus* Murr
Caricaceae	*Carica papaya* L.
Clusiaceae	*Calophyllum inophyllum* L.
Combretaceae	*Terminalia catappa* L.
Convolvulaceae	*Ipomoea pes-caprae* (L.) R. Br.
Cycadaceae	*Cycas rumphii* Miq.
Dilleniaceae	*Dillenia indica* L.
Dilleniaceae	*Tetracera scandens* (L.) Merr.
Dioscoreaceae	*Dioscorea hispida* Dennst.
Ebenaceae	*Diospyros pilosanthera* Blanco
Euphorbiaceae	*Acalypha lanceolata* Willd.
Euphorbiaceae	*Euphorbia hirta* L.
Euphorbiaceae	*Excoecaria agallocha* L.
Euphorbiaceae	*Macaranga gigantea* Rchb.f. & Zoll.) Müll.Arg.
Euphorbiaceae	*Manihot esculenta* Crantz
Fabaceae	*Acacia auriculiformis* Benth.
Fabaceae	*Acacia mangium* Willd.
Fabaceae	*Albizia lebbeck (*Osbeck). Merr.
Fabaceae	*Albizia procera* (Roxb.) Benth.
Fabaceae	*Albizzia lebbeck* L.
Fabaceae	*Archidendron pauciflorum* (Benth.) I.C.Nielsen
Fabaceae	*Calliandra calothyrsus* Meisn
Fabaceae	*Callotropis gigantea* (Hook.) G.Don
Fabaceae	*Cynometra ramiflora* L.
Fabaceae	*Erythrina variegata* L.
Fabaceae	*Gliricidia sepium* (Jacq.) Walp.
Fabaceae	*Gliricidia sepium* L.
Fabaceae	*Milletia elliptica* (Roxb.) Steud.
Fabaceae	*Mimosa pigra* L.
Fabaceae	*Mimosa pudica* L.
Fabaceae	*Parkia speciosa* Hassk.
Fabaceae	*Parkia speciosa* Hassk.
Fabaceae	*Pueraria phaseoloides* (Roxb.) Benth.
Fabaceae	*Senna siamea* (Lam.) H.S.Irwin & Barneby
Fabaceae	*Tamarindus indica* L.
Goodeniaceae	*Scaevola taccada* (Gaertn.) Roxb.
Hypoxidaceae	*Molineria capitulata* (Lour.) Herb.
Lamiaceae	*Clerodendrum laevifolium* Blume
Lamiaceae	*Tectona grandis* Linn.f.
Lythraceae	*Lagerstroemia speciosa* (L.) Pers.
Malvaceae	*Ceiba petandra* Gaertn.
Malvaceae	*Grewia laevigata* Vahl.
Malvaceae	*Heritiera* sp.
Malvaceae	*Hibiscus rosa-sinensis* L.
Malvaceae	*Hibiscus tiliaceus* L.
Malvaceae	*Melochia umbellata (*Houtt.) Stapf
Malvaceae	*Pterocymbium tinctorium* Merr.
Malvaceae	*Pterospermum javanicum* Jungh.
Malvaceae	*Thespesia populnea* (L.) Sol. ex Corrêa
Melastomataceae	*Clidemia hirta* (L.) D. Don
Melastomataceae	*Melastoma malabatrihcum* Jack.
Meliaceae	*Aglaia teysmanniana* (Miq.) Miq.
Meliaceae	*Dysoxylum alliaceum* (Blume) Blume
Meliaceae	*Dysoxylum caulostachium* (Blume) Blume
Meliaceae	*Lansium parasiticum* (Osbeck) K.C.Sahni & Bennet
Meliaceae	*Swietenia macrophylla* King
Meliaceae	*Swietenia mahagoni* (L.) Jacq.
Meliaceae	*Toona sinensis* R. Roem
Moraceae	*Artocarpus altilis* (Parkinson) Fosberg
Moraceae	*Artocarpus elastica* Roxb.
Moraceae	*Ficus ampelas* .Burm.f.
Moraceae	*Ficus ampelas* Burm.f.
Moraceae	*Ficus benjamina* L.
Moraceae	*Ficus fistulosa* Reinw. ex Blume
Moraceae	*Ficus grossularioides* Burm.f.

Moraceae	*Ficus lepicarpa* Blume
Moraceae	*Ficus rostrata* Thunb.
Moraceae	*Ficus septica* Burm.f.
Moraceae	*Ficus sumatrana* Miq.
Moraceae	*Ficus variegata Blume*
Moraceae	*Parartocarpus venenosa* Becc.
Moraceae	*Stelechocarpus burahol* (Blume) Hook.f. & Thomson
Muntingiaceae	*Muntingia calabura* L.
Musaceae	*Musa acuminata* Colla.
Musaceae	*Musa x paradisiaca* L.
Myrtaceae	*Psidium guajava* L.
Myrtaceae	*Syzygium aromaticum* (L.) Merr. & L.M.Perry
Myrtaceae	*Syzygium densiflorum* Wall. ex Wight & Arn.
Myrtaceae	*Syzygium jambos* (L.) Alston
Myrtaceae	*Syzygium lineatum* (DC.) Merr. & L.M.Perry
Pandanaceae	*Galearia filiformis* Boerl.
Pandanaceae	*Pandanus furcatus* Roxb.
Pandanaceae	*Pandanus tectorius* Parkinson ex Du Roi
Passifloraceae	*Passiflora foetida* L.
Phyllanthaceae	*Breynia racemosa* (Blume) Müll.Arg.
Phyllanthaceae	*Cleistanthus monoicus* (Lour.) Müll.Arg.
Phyllanthaceae	*Phyllanthus emblica* L.
Piperaceae	*Piper aduncum* L.
Piperaceae	*Piper betle* L.
Poaceae	*Spinifex littoreus* (Burm. f.) Merr.
Poaceae	*Brachiaria reptans* (L.) C.A.Gardner & C.E.Hubb.
Poaceae	*Cymbopogon citratus* (DC.) Stapf
Poaceae	*Imperata cylindrica* (L.) Raeusch.
Poaceae	*Oryza sativa* L.
Poaceae	*Oryza sativa* var. x
Poaceae	*Panicum maximum* Jacq.
Poaceae	*Pennisetum polystachion* (L.) Schult.
Poaceae	*Saccharum spontaneum* L.
Poaceae	*Zea mays* L.
Polygalaceae	*Xanthophyllum excelsum* (Blume) Miq.
Rafflesiaceae	*Rafflesia patma* Blume.
Rhizophoraceae	*Bruguiera cylindrica* (L.) Blume
Rhizophoraceae	*Bruguiera gymnorrhiza* (L.) Lamk
Rhizophoraceae	*Carallia brachiata* (Lour.) Merr.
Rhizophoraceae	*Rhizophora mucronata* Lam.
Rubiaceae	*Guettarda speciosa* L.
Rubiaceae	*Morinda citrifolia* L.
Rubiaceae	*Neolamarckia cadamba* (Roxb.) Bosser
Rubiaceae	*Neonauclea lanceolata* (Blume) Merr.
Rutaceae	*Acronychia pedunculata* (L.) Miq.
Rutaceae	*Citrus aurantiifolia* (Christm.) Swingle
Rutaceae	*Citrus hystrix* DC.
Rutaceae	*Melicope latifolia* (DC.) T.G. Hartley
Sapindaceae	*Filicium decipiens* (Wight & Arn.) Thwaites
Sapotaceae	*Chrysophyllum cainito* L.
Sapotaceae	*Manilkara zapota* (L.) P.Royen
Sapotaceae	*Palaquium rostratum* (Miq.) Burck
Sterculiaceae	*Sterculia foetida* L.
Tetramelaceae	*Tetrameles nudiflora* R.Br.
Urticaceae	*Oreocnide rubescens* Blume
Verbenaceae	*Lantana camara* L.
Verbenaceae	*Stachytarpheta jamaicensis* Gardn
Zingiberaceae	*Alpinia galanga* (L.) Willd.
Zingiberaceae	*Costus speciosus* (J.Konig) Sm.
Zingiberaceae	*Curcuma longa* L.
Zingiberaceae	*Etlingera megalocheilos* (Griff.) A.D.Poulsen
Zingiberaceae	*Hedychium roxburghii* Blume
Zingiberaceae	*Zingiber officinale* Roscoe

Note: 7 samples have not been identified yet

Discussion

In Ciletuh Geopark there has been changes in land use in which agricultural land was more dominant than forest. The existing forest vegetation was only remained in few areas, meaning that previously Ciletuh Geopark had experienced deforestation. Deforestation is the conversion of forest areas to non-forest land use (Gervet, 2007). Agriculture is one of the most significant causes of deforestation (Bennett, 2017). Effect deforestation includes the reduction or even loss of native species replaced by cultivated species. Deforestation can be caused by several factors including population pressures, commercial activities, and social and political conditions.

Currently, Ciletuh Geopark is dominated by *talun/ kebon tatangkalan*. *Talun* is an agroforestry system formed to increase overall productivity and serve various functions by combining agricultural crops with tree vegetation (Berkes 2012; Parikesit et al. 2005). *Kebon tatangkalan* has distinctive features and has developed under the influence of various biophysical and socio-economic factors (Parikesit et al. 2005).

Soerianegara and Indrawan (2005) state natural plant communities in tropical forests have at least three strata. Although the Ciletuh Geopark was dominated by trees from strata B and C, but the forest in the Puncak Manik area was still dominated by trees from strata A. Vegetation in Ciletuh Geopark were arranged of trees from strata A, B, and C, indicating the existence of old plants (Suci et al. 2017). The findings of this study highlight the importance of conserving the remaining natural vegetation in Ciletuh Geopark to enhance the biological values of the geopark.

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