Primeval Forest in the Period of Human Cultural History on Gunungsewu Karst Indonesia

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Abstract

This research was carried out to seek evidence of the presence of karst forest during the human cultural history in Gunungsewu in the past. The human cultural history approach and pollen deposit analysis were used for finding the relationship between human cultures with the condition of the forest in the past. The lawuniformity was used as a basis for analysis, which explains that the keyto the past. The ancient karst forest was identified from pollen deposition and the age of deposit was carried out by radiocarbon analysis. This research contributes to reach forest resources sustainability with respect to recent increasing forest depression due to anthropogenic factors. Research indicates that at prehistoric human occupations in the Gunungsewu karst area did not affect the condition of flora. Cultural traits on prehistoric and territorial subsistence can explain that it is not anthropogenic factors that caused changes in the types of flora. Since there was no culture of exploitation, the extraction of natural resources was just performed to meet their subsistence. Changes in the type of flora can be influenced by palaeo-climate change on Gunungsewu Karst area. The beginning of forest karst destruction occurs in the periods of Islamic empire and colonialism, which are known as tenure systems of migration and exploitation of teak by Colonizers. Results of the forest reconstruction along the human prehistory indicated that the lower mountain-rain-forest occurred on Keplek period, then the mixed type of lower mountain rain-forest and tropical rain-forest occurred on the period of Ngrijangan. In the period of Klepu, the forest type turned into the type of tropical rainforest. Monsoon is the last forest type of residents in the human history since the Hinduism and Buddhism period up to the present.

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1. Background

Forests are one of the constitutional elements of karst area. The physical condition of the remaining karst is a proof that the past history of the Gunungsewu karst has been supported by the presence of a dense forest. Research of the paleoethnoforestry is an attempt to find native plants identify that characterizes the karst forest type. The result of the paleoethnoforestry can be a reference for karst forest conservation.

In this research, paleoethnoforestry was compiled from human history period (early Holocene) until the period of history. Data information was identified from (1) history of the flora that inhabit the karst areas, identified under the laws of uniformity and analogy [1, 2], (2) change of the type of flora as bio-indicators of paleoclimate and history of human exploitation. Verstappen [3] and Bellwood [4] explain that the vegetation on the island of Java in prehistoric times indicates that the climate during this period was very different from now, and (3) historical evidences on human occupation in the area from pre-historic human equipments findings such as bifacial and axes from Paleolithic era [5, 6]. The study is based on physical, biotic, and socio-cultural approach and characterizes the environmental science study [7].

Historical evidence states that once dense forest was located in Gunungsewu karst area [8, 5, 6], whilst the dense forest is now no longer available. Based on this explanation, the research issues organized such as follows:

- How was the flora occupation history in the Gunungsewu karst area?
- Do anthropogenic factors contribute to the flora types shifting in the area?

In line with the research problem as formulated before, this study has two research objectives as follows:

- To find historical flora which was occupied in Gunungsewu karst area, and
- To investigate the anthropogenic factors that influence changes in the type of flora in the area.

2. Literature Study

Reconstruction is a state of art for predictions in the past based on data, information, and evidence obtained in the present time. Reconstruction can provide a real picture of the condition which has occurred somewhere. Identical to the definition, the reconstruction of the forest is an attempt to describe the condition of forests in the past, with the use of evidence obtained in the present. The evidence comes from material that once lived in the past, and at present stored in the layer deposition (may include pollen, wood, leaf, and bones). The age of deposition identified by radiocarbon dating and expressed as unit of BP (Before the Present). BP units are commonly used in studying the history of the earth and was internationally adopted in 1950 as a starting point/point zero. To learn the history of human culture, scale BC-AD (Before Christ – Anno Domini) was used, which is based on the birth of Christ as a starting point or zero point in the Gregorian calendar.

Paleoecobotany approach is needed to perform the reconstruction of forest. Paleoecobotany discusses the reconstruction of ancient ecology and organisms, related to the autecology and synecology [1]. The interpretation of paleoecobotanical data requires the support of biological science and involves the use of uniformitarianism concept and analogy. Uniformitarianism is based on the understanding that the material’s conditions and rate of processes have remained relatively constant through time. This concept can be applied to study the strata deposited. Analogy involves the application of modern organism features to ancient organisms. This principle may be applied to individuals, community structure (species diversity, organizational and structure) and structure dynamics (response to time-independent environmental factors) [2].

The paleoethnoforestry requires biogeography applied science, which is the study on flora fauna distribution in recent times or in the past. Each flora and fauna has its own geographical distinctness and has high numbers only in its habitat [9]. This characteristic could be used to differentiate species types which are able to occupy specific geographical conditions with specific physical characteristics. Geographical units with specific physical characteristics are alandform, which is characterized by relief, rocks, geomorphic process, earth outer layer structures, and its time development [10].

Landscape relief of the Gunungsewu karst area is hilly on Miocene limestone, which consists of coral reef limestone. Geological structure of the Gunungsewu karst area is a fault block on the Southern Zone of Java Island when uplifted since the Late Pliocene. The geomorphic process, which dominated in this region, is a solution process. Development of the Gunungsewu karst area consists of three stages. The first stage (Inception karst) was started on the Late Pliocene until the Early Pleistocene; the second stage (Young Karst) developed on the Middle Pleistocene;
and third stage developed during the Late Pleistocene until the Holocene [11]. The physical characteristic of the landforms determines the variation in the flora and fauna occupying specific geographical units and could be related to endemic aspect [12].

Tropical forest covers 50% from total forest area in the world, which is distributed in South Africa, Middle America, South-East Asia and Australia. Tropical forest ecosystem is sensitive to annual rainfall. Thus, humidity factors and temperature could be used to classify climatic regions in the tropics [9]. Tropical forest occupies heterogeneous edaphically and climatic areas. According to Montagnini and Jordan [13], at micro scale, the effect of wind direction affected the forest types in tropical areas, which are distributed from coastal to mountains areas. Tropical forest in karst area is affected by air humidity and total rainfalls [14]. The ideal condition for the development of karst area is in tropical areas and in mid latitude with medium to high rainfall and covered by thick forest.

The vegetation description on Java Island during the pre-historic era indicated climate condition within the periods of 17,000 – 10,000 years BP which is highly different from current climate conditions [4]. Verstappen [3] predicted that within a period of 30,000 to 10,000 years BP, the climatic conditions in Southeast Asia were drier than current situations. The wet and medium wet climatic conditions occurred at the end of ice age (10,000 years BP). However, according to Bellwood [4], during Pleistocene time at the top of ice age, Indonesia had climatic variations. Some parts of the area were wet tropical zones with heavy rainfall (within equator zones: Sumatra, western part of Java, Borneo, Mid Sulawesi, and some parts of Moluccas); and some parts were mid tropical zones with distinct dry and wet seasons (Malacca peninsula, South Sulawesi, Lesser Sundas Islands from Central Java to eastern part). Dry seasons affect the gap within the forest due to deciduous trees. The climatic history is very important for reconstructing the pre historical flora types.

Environmental geomorphology helps to find the relation between the objects and its environmental condition play an important role in the forest reconstruction process. Environmental geomorphology is the study of the relation between landforms and the process affecting its formations. The landscape components are: rocks, vegetation, and land use [15]. Therefore anthropogenic factor is important in environmental geomorphology.

Human history in the Gunungsewu karst area is divided into two, namely the prehistoric and historical times. Prehistoric identifications are done by finding sites and artifacts of prehistoric human culture, the life are not familiar with its religious order and government/kingdom. Thus in this period, it is not known the status of land tenure, since tenure is required for survival beyond (territorial based). Sites that characterized the prehistoric period in this study referred to the finding of Simanjuntak, et al. [6], namely Keplek Period (10050 - 2050 BC, or 12,000 - 4,000 years BP), Ngrijangan Period (2050 BC - 950 AD, or 4,000 - 1,000 years BP), and Klepu Period (950 - 1350 AD, or 1,000-600 years BP). Forestier [5] says that from archeological studies in the tropics, there is variability in the composition of equipment that consists of herbs, bones, and stone. From ethnographic research it is known that the region of Southeast Asia in prehistoric times can be described as an area of vegetation civilization.

The history of human culture in Indonesia took a place when the arrival of Indians, who brought the influence Hinduism and Buddhism in 1350 AD. Thus, the influence of Hindu and Buddhist in Indonesia is delivered into the era of history, which took a place between 1350-1500 AD or 600-450 years BP. The influence of Hinduism and Buddhism became the symbol of the end of Indonesian prehistory [16, 17]. The implication of this influence is arising kingship and royal government, also emergence of new religious [16, 17]. In the beginning, there was the status of land tenure, although just only tend to be communal/customary, until eventually become tenure in the next period. The next period is the period of Islam Kingdom and Colonialism, which lasted from 450 years BP until the beginning of the impendence of Indonesia (1500-1950 AD), and the post-colonial period from 1950 to the present.

There were six periods of human history in the research area, namely the Period Keplek with Preneolithic and Neolithic cultural. In this period the human life has begun to require the landscape, especially the forest to hunt animals and seeds. The next are the period of Ngrijangan with Neolithic cultural traits, the period of Klepu with cultural traits Palaeomethalic, Hinduism and Buddhist period with Neomethalic cultural traits, the Islamic Kingdom and Colonialism period to modern cultural traits, and Post Colonialism with postmodern culture [6, 18].

Anthropogenic factors in a karst area could accelerate geomorphologic process, and disturb the natural law, which is gradually and slow [19]. Paleoethnoforestry needs to trace the cultural history of humans, to understand the development of environmental ethics [5, 6, 8, 16, 17]. Those cultural values, together with ethno-forestry of community in karst area are highly relevant for deductive approach during forest profile reconstruction in the Gunungsewu karst area.
3. Theoretical Framework

Paleoethnobotany was carried out through the paleoecobotanical approach, based on the concept of uniformitarianism and analogy. Uniformitarianism is based on the law of original horizontally, to study the strata deposited. Analogy involves the application of modern organism features to ancient organisms.

Tracking the flora tracks is carried out by pollen deposit analyses. The pollens were collected from alluvial karst (exokarst) and also from caves (endokarst). The living evidences in the past were well preserved in the rocks layers. Cave’s sediment also could preserve organisms, fauna (mollusk and vertebrate) and flora (spores, pollen).

Tracking the human history in the karst area is divided into two periods, i.e. periods of prehistory and history. Prehistoric periods are broken down into three, namely Keplek, Ngrijangan, and Klepu. Historical periods are also broken down into three, namely Hind-Buddhist, the Kingdom of Islam and Colonialism, and Post Colonialism (Indonesian period). The explanation of the periodization of human history is presented in Table 1.

| Time (BP and BC/AD)     | Periodization          | Culture                |
|-------------------------|------------------------|------------------------|
| 12000 – 4000 BP(10050–2050 BC) | Keplek                  | Preneolithic and Neolithic |
| 4000 – 1000 BP(2050 SM-950 BC) | Ngrijangan             | The end of the Neolithic |
| 1000 – 600 BP(950-1350 AD)   | Klepu                  | Palaeomethalic         |
| 600 – 450BP(1350-1500 AD)   | Hinduism and Buddhism  | Neomethalic            |
| 450 BP – 0 BP(1500-1950AD)  | Islam and Colonialism | Modern                 |
| 0 BP to Present (1950 to Present) | Indonesia             | Postmodern             |

Explanation: BP (Before the Present), BC (Before Christ), AD (Anno Domini)

Sources: Department of Forestry [20], Featherstone [18], Forestier [5], Samodra [8], Septariska and Rini Andini [21], Simanjuntak [6], Soekmono [16, 17, 22].

Radiocarbon dating can be used to describe the environmental characteristics of the sedimentation and to reconstruct past environmental conditions, which are related to geomorphic formations and process. The paleoethnobotany periods started from Preneolithic culture periods (Keplek period). Human began to require landscape, in particular forest geo-ecosystem for hunting and seed gathering (subsistence). The next period is Neolithic culture (Keplek and Ngrijangan period), Paleomethalic (Klepu period), Neomethalic (Hinduism and Buddhism period), Modern (Islam and Colonialism period), and postmodern (Indonesian period) which changed the subsistence culture to natural resource exploitation culture.

Analogical flora type distribution approach can be used as foundation to deduct climatic history from Preneolithic until now. Furthermore, the adaptation and succession theories could be used to explain the effect of physical and anthropogenic on the spatio-temporal dynamics of flora types. Soil textures analysis could be used to deduct and explain geomorphic process, which is related to rock sedimentations in spatio-temporal processes.

The variation type of flora that was founded in the age range of deposition, and the human culture history periodization prepares spatio-temporal forest profile reconstruction. Ethnoforestry conducted to determine the prospects for forest conservation with the exploring of public knowledge about the usefulness of forest, and the motivation to preserve it.

4. Results and Discussions

Gunungsewu karst area was selected for research identification from Geological Map Sheet Surakarta-Giritontro, Java [23], overlaying with the RBI map scale 1: 25,000 [24]. This overlay provides information of the parent rock units that characterize karst landforms, which then becomes the scope of the study area. Research sites that represent in the karst area is divided into two, namely the outside of karst (exokarst) with sample points of karst alluvial valley in Kanigoro, Drini, and Sumur Krakal; and caves representing endokarst with sample points in the Cave of Nguyahan, Jrebeng, and Greweng.

Ten native flora family were found in the study area, which consisted of small part of tropical flora (Myrtaceae and Rubiaceae), and Monsoon flora (Euphorbiaceae, Palmae, Leguminosae, Moraceae, Verbenaceae, Anacardiaceae, Anonaceae, and Meliaceae). Euphorbiaceae is the oldest family which occupied karst area (was found since 17,000 years ago), and presently only be found in Greweng.
This study also found flora types were to be bio-indicators of palaeo-climate, which are (1) the lower montane rainforest in 16,894±440 –6,615±140 years BP; (2) tropical rainforest in 6,615±140 –1,960±95 years BP; and (3) monsoon in 1,960±95 years BP – modern. A large relic area of monsoon flora indicated that this type does not demand specific niche in the study area. Mountainous and tropical flora in Nguyahanand Jrebeng indicated that these sites during 16,894±440 - 1,960±95 years BP had climatic type A to B (Schmidt and Ferguson category). These flora types have been shifted to monsoon flora, which is distributed in the medium wet climate (C to D climatic types).

Therefore, medium wet climatic types are characterized Gunungsewukarst area now, which was begun since 1,960±95 years BP. The fact that monsoon flora existence was from pollen deposits in Kanigoro, SumurKracal and Drini. The climatic shifting to more dry started from western part (Kanigoro) and followed by eastern part of it. Those floristic types can be used to determine relic area of flora in the Gunungsewu karst area. Several groups of monsoon flora (Palmae, Leguminosae, Podocarpaceae, and Euphorbiaceae) have always been a part of community members from various types of flora. In contrast to the flora of tropical and lower mountain as Pinaceae, Fagaceae, Dypterocarpaceae, Bombacaceae, and Ulmaceae, which can no longer adapt to the changing environment that become more dry and disappear from the karst area. Identification of flora from pollen analysis along the human prehistoric and human historical periods explained the history of primeval forest is presented in Table 2.

| No. | Findings Pollen | Species/Genus-Family | Image of Plants | Flora Types |
|-----|-----------------|----------------------|-----------------|-------------|
| 1   | Chenopodium sp. | Chenopodiaceae       | Lowland tropical rainforest |
| 2   | Pinus sp.       | Pinaceae             | Lowland tropical rainforest |
| 3   | Altingia excelsa | Hamamelidaceae       | Lowland tropical rainforest |
| 4   | Mimosopselengi | Sapotaceae           | Tropical rainforest |
| 5   | Duriosp.        | Bombacaceae          | Tropical rainforest |
| 6   | Syzygium sp.    | Myrtaceae            | Tropical rainforest |

Table 2. Flora identification based on pollen analysis.
| No. | Image | Species                  | Family              | Season             |
|-----|-------|--------------------------|---------------------|--------------------|
| 7   | ![Image](image7) | *Dipterocarpus sp.* | *Dipterocarpaceae* | Tropical rainforest |
| 8   | ![Image](image8) | *Celtis sp.* | *Ulmaceae* | Tropical rainforest |
|     |       | **Pollen findings from Klepu to the present** |                     |                    |
| 9   | ![Image](image9) | *Podocarpus sp.* | *Podocarpaceae* | Monsoon            |
| 10  | ![Image](image10) | *Morinda sp.* | *Rubiaceae* | Monsoon            |
| 11  | ![Image](image11) | *Arenga pinnata* | *Palmae* | Monsoon            |
| 12  | ![Image](image12) | *Glochidion sp.* | *Euphorbiaceae* | Monsoon         |
| 13  | ![Image](image13) | *Macaranga sp.* | *Euphorbiaceae* | Monsoon        |
| 14  | ![Image](image14) | *Acacia sp.* | *Leguminosae* | Monsoon            |
| 15  | ![Image](image15) | *Tamarindus indica* | *Leguminosae* | Monsoon            |
| 16  | ![Image](image16) | *Ficus sp.* | *Moraceae* | Monsoon            |
| 17  | ![Image](image17) | *Anonasquamosa* | *Anonaceae* | Monsoon            |
| 18  | ![Image](image18) | *Elaeocarpus sp.* | *Elaeocarpaceae* | Monsoon            |
The migration in the Islamic Kingdom to avoid tax [21] led to the clearing of forests in the karst area for settlements and cultivation activities. The lowest of flora diversity findings from the analysis of pollen in the Drini and Krakal, relevant to the reason for the selection of places to migrate most flat compared to other area of this research. The implications from the migration were the lower numbers of flora occupation during Islamic Kingdom and Colonialism periods than other periods. The relative younger sediment age also indicated an intensive sedimentation process during those periods from anthropogenic activities. Flora succession was occurred during post colonialism to 1960’s. The succession process were indicated by more various pollen deposits which is similar to periods before Islamic and colonialism periods. The family Verbenaceae, Leguminosae, and Meliaceae occupation, which are dominant at present time, were the results from replanting programs from the president of Indonesia for critical land rehabilitation in 1976. Thus, the forest damage has been occurred for 15 years.

5. Conclusions and Recommendations

5.1. Conclusions

The results from this study explain the history of flora occupation in forest in Gunungsewu karst area in Gunungkidul district as follow.
1. The occupations of human prehistoric in the Gunungsewu karst area not affect the condition of flora. Cultural traits on prehistoric subsistence and territorial can explain that it is not anthropogenic factors that cause change in the types of flora, because there was on culture of exploitation. Extraction of natural resources just to meet their subsistence. Changes in the type of flora occur in the periods of Islamic empire and colonialism, which have known tenure systems even of migration and exploitation of teak by Colonizers.
2. The primeval forest reconstruction along the human prehistoric indicated that the lower mountain rain-forest occurred on Keplek period, and then the mixed type of lower mountain rain forest and tropical rain forest occurred on the period of Ngrijangan. In the period of Klepu, the forest type turn into the type of tropical rain forest. Monsoon is the last forest type were residents at the human history since the Hinduism and Buddhism period up to the present.

5.2. Recommendations
1. Sustainability of forest karst was needed to ensure human welfare on Gunungsewu karst area, and especially to conserve karst species native. Exploration efforts required of native species for reintroduction and ecosystem restoration.

2. Public support is very important to fill the gap of biodiversity conservation. Economically, the preservation of biodiversity can guarantee sustainable use. Implementation of the management of protected areas can take the form of private forests indigenous/communal forest (mainly for conservation), forest to non-timber forest products, the hunting parks, and ecotourism.

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