Value of vegetation diversity for indigenous (Adat) community of Kasepuhan Karang

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Abstract. The indigenous community of Kasepuhan Karang has legal authority to manage a 486 ha forest area in Gunung Halimun Salak National Park (GHSNP) as a customary forest. As 95% of the customary forest is located in the conservation area of the GHSNP, the Kasepuhan Karang community is responsible for conserving and utilizing forest resources sustainably. Due to the diverse landscape, biodiversity, and their ecological function of the area as well as the necessity to increase community welfare, managing customary forest is challenging. The scientific information on vegetation diversity, proportion, and its compatibility to the landscape characteristic and function will assist the customary leader(s) to apply proper strategies based on ecological and economic benefits. This study was aimed to calculate the economic benefits of the forest for the community and identify the compatible commercial crops that meet with the ecology of the customary forest. The research was conducted in Jagaraksa village of Lebak District, Banten Province, during the period from April to November 2018. The data analysis used was descriptive analysis and market prices. The highest value of economic benefits was obtained from plantation crops, with a benefit value per unit of above IDR 10 million/unit, namely petai (Parkia speciosa), jengkol (Archidendron pauciflorum), coffee (Coffea sp) and sugar palm (Arenga pinnata). Thus, these four species are highly recommended to be cultivated by the Kasepuhan Karang community.

1. Introduction
The roles of the local community and indigenous people to biodiversity conservation of protected areas have been appropriately acknowledged at the international level [1]. Several studies related to forest conservation in Brazil, Namibia, and Australia showed that the conservation by indigenous people and community is much better for some biodiversity measures, the benefits of diversity, high-quality governance and its role in effective, representative and equitable protected areas across the world than isolation of protected areas [1]. The studies concluded that the adat community implementation needs to be further reviewed in order to protect biodiversity in socially sustainable ways. A study on community governance in three Indonesian protected forests shows that the social capital (adat norms, local wisdom, belief and leadership) have a positive correlation with forest preservation, while forest economic benefit has a negative correlation [2]. How the forest economic utilization synergizes with the conserved forest protection, including biodiversity, remains essential to study.
Kasepuhan Karang is the indigenous people who live in the customary forest of Gunung Halimun Salak National Park (GHSNP). The customary forest area is located in the Jagaraksa Village of Muncang Sub-district of Lebak District, Banten Province (Figure 1). Based on the Indonesian government regulation, the Kasepuhan Karang community has a legal authority to manage a total area of 485 hectares, in which 462 hectares of this is located in conservation areas of the GHSNP, and 24 hectares in other land uses.

A majority of Kasepuhan Karang land is in the conservation area of the GHSNP. The indigenous community has rights and obligations to conserve, protect, and enhance the forest function, as well as to utilize the forest resources for improving community welfare in sustainable ways [3]. In the implementation level, applying sustainable forest management in customary forest utilization is challenging. For example, in order to utilize vegetation resources, the community should consider the ecological function as well as the economic potential of the plants. Proportionally considering these two aspects will ensure the social- and environmental- benefits through applying proper local conservation approaches.

Vegetation plays an essential role in maintaining the function of protected forests [4] and also has significant impacts on water and soil conservation [5]. There are two types of natural vegetation in the customary forest of Kasepuhan Karang, i.e., commercial (which has an economic value in the trading market) and non-commercial vegetations. Excessive use of commercial vegetation can cause negative impacts on the ecosystems, which may lead to the change of forest function. The indigenous community usually has a traditional knowledge system (local wisdom) in managing forest resources to support their livelihood sustainably. However, to ensure this wisdom applied correctly, the leadership of the indigenous community plays a significant role to monitor and evaluate the application of their traditional forest management strategies. This system ensures that the ecosystem balances are well-maintained, and forest biodiversity is well conserved for the sake of future generations.

Based on its economic value, biodiversity has been classified into two categories, i.e. (a) direct extractive uses, such as the collection of wood products, non-timber forest products, and animals and (b) direct non-extractive uses, such as the use of forests biodiversity for recreation and cultural activities [6]. Besides, in terms of biodiversity assessment, three approaches of economic, socio-cultural, and ecological approaches need to be considered [7]. In the concern of sustainable biodiversity management, biodiversity utilization is required to meet the economic needs of the
indigenous people. While from the socio-cultural aspect, the choice of biodiversity that will be utilized should refer to the customary rules or not against the local customs. In addition, finding the compromising point which accommodates the need for sustainable biodiversity utilization and ecological conservation is essential. Wise decisions considering these multiple aspects are necessary to ensure sustainable use of biodiversity and other forest resources.

In order to encourage the local community to cultivate certain species of vegetation, which is in line with the conservation efforts, it is necessary to identify the economic, socio-cultural, and ecological values of the vegetation for the indigenous community of Kasepuhan Karang. The vegetation assessment is very important for designing customary forest management. In addition to the responsibilities of indigenous stakeholders, the central government, regional governments, non-governmental organizations, and other stakeholders must play a role in assisting and empowering indigenous peoples. Mentoring of forest development activities by the respected parties through fostering forest farmer groups (FFG) as a unit of forestry business management at the local level is expected to enhance participation of the local community. Assessment of the values of vegetation benefits is expected to have a significant contribution to the conservation planning of regional management and FFG business management.

Thus, the study aims to identify the tree species cultivated by the indigenous community of Kasepuhan Karang and its availability (abundance) in each customary forest zone. Concerning the people's income, this study assesses the economic benefits of the vegetation and identifies its socio-cultural and ecological benefits.

2. Material and Methods
This research was conducted from April to November 2018. Primary data were taken by purposive sampling of 30 respondents who cultivated their land in the Kasepuhan Karang customary forest area. Data and information obtained from the local people who associated with plant biodiversity, land management and roles of traditional knowledge system (local wisdom) were the subjects to be analyzed from three different aspects, i.e., analysis of vegetation and assessments of economic, socio-cultural and ecological benefits.

2.1. Analysis of vegetation
Initial information on vegetation diversity was collected from interviewing the local community. A field survey to confirm the initial information was also conducted, and the actual vegetation diversity was analyzed descriptively.

2.2. Assessment of economic benefits
The economic benefits of the vegetation for the community can be calculated based on either market value, relative value, or procurement value methods [8]. The economic potential of vegetation biodiversity was analyzed based on the market value method using the following formula:

\[ N_t = JV_t \cdot P_t \]

where:
\[ N_t \] = the economic value of forest products (Rp/unit volume)
\[ PV_t \] = market prices of forest products (Rp)
\[ JV_t \] = the amount of volume of forest products taken (unit)

2.3. Assessment of socio-cultural and ecological benefits
The socio-cultural benefits of vegetation yield, harvesting process and local wisdom associated with these issues were assessed using descriptive analysis. While ecological benefits of the vegetation were determined by referring to the relevant works of literature.
3. Result and Discussion
Kasepuhan Karang adat society is the people who live in the Halimun conservation forest area since 1677 [9]. The society is headed by the adat leader, called kokolot or abah. From generation to generation, there is adat institutions regulating the adat social norms and traditional rituals. Even more, there is adat law which controls the natural resources and utilization area. It is unwritten and verbally disseminated; however, it is obeyed by society so as not to get disastrous for any violation.

In Kasepuhan Karang customary forest, there is a local wisdom to divide the area into several parts, namely: leuweung titipan, leuweung tutupan, and leuweung garapan [9]. Leuweung titipan is a prohibited forest that must not be entered and is usually close to a spring. Leuweung tutupan is a forest that can be used with the permission of the customary leader and generally, there are types of woodworking plants. Leuweung garapan is a forest managed by the community in the form of rice fields, gardens and fields. In the management of each of these areas, there are customary rules that must be obeyed so that forests remain sustainable.

From biodiversity owned by Kasepuhan Karang customary forest, indigenous people tend to utilize and cultivate various types of plants (vegetation). This can be seen from the livelihoods of adat peoples who generally farm at 87% (Figure 2) while the rest are private employees (4%), traders (3%), and laborers (3%). Most farmers own agricultural, forestry and plantation crops. Most farmers have crops in the form of rice and crops (vegetables, corn, etc.). Rice is an agricultural crop that becomes a staple crop for adat farmers because it is the staple food for the community. Generally, rice is not sold but is stored in a granary called a leuit. While the results of the secondary crops are used for their own needs, therefore, the study will calculate the value of the benefits of forestry and plantation crops in each customary zone.

![Figure 2. Main livelihood of the indigenous people – ‘Kasepuhan Karang’](image)

3.1. Leuweung Titipan
In the Kasepuhan customary forest of Karang, there is a forest area that must not be entered and is highly preserved [9]. Indigenous peoples believe that the area needs to be preserved so that the spring is maintained. There are verbal rules as well as no written rules for sanctions if any violation made. Adat peoples are prohibited from cutting down the trees near water sources. If the ban is violated, the majority of respondents believe that it will be unlucky. While a small proportion of respondents (13%) said they had to replace it with three tree seedlings planted, but the intended tree species were not determined [9].

3.1.1. Vegetation analysis. Despite the interview results, it can be concluded that the biodiversity in this entrusted forest is still classified as good, but some things need to be considered by both adat
peoples and the government. First, the rules and sanctions for violations of *adat* related to the management of entrusted forests need to be emphasized. The socialization of the regulation needs to be carried out, so all elements of indigenous people know about it. Besides, it is necessary to avoid planting fast-growing tree species for sanctions of felling trees in Leuweung. These types of species include *Acacia mangium*, sengon (*Paraserianthes falcataria*) and *leda* (*Eucalyptus deglupta*), which took up a lot of nutrients [10]. Related to this, according to [11], the changes in forest vegetation types to fast-growing species in areas near the springs, can reduce springs discharge and water catchment quality. In addition, it is necessary to socialize the clarity of entrusted forest boundary and customary forest as a whole. This is possible because one of the requirements for the submission of *adat* forests is participatory mapping.

The recommended types of vegetation to be planted around springs are *Moraceae* group. Based on Ridwan and Pamungkas's research [12], the dominant plant species mostly found around springs are *Moraceae* groups such as *Ficus microcarpa*, *F. elastica*, *F. retusa*, *F. racemosa*, *F. annulata* and *F. benjamina*. In order to protect the springs, vegetation design is needed that can improve the quality and quantity of water, such as *Ficus* sp. [13].

### 3.1.2. Assessment of economic benefits.

Economic benefit from forest plantation does not exist since the *adat* society is not allowed to harvest the woods from forest plantation within the zone. Despite the non-wood forest benefit from fruit plantation or multipurpose tree species, the *adat* law prohibiting the exploitation, as well as the limited access from entering the Leuweung titipan discouraged the society from utilizing them. From the interview, there are many people who took benefit from forest honey with an uncertain amount and volume.

The significant economic benefit of Leuweung titipan is water resources. The water springs remain to be naturally clear and abundant in volume. The water is distributed to the *adat* villagers through water piping. The water flowing daily both in the rainy season and the dry season is utilized for drinking, bathing, cleaning, and watering. Around 37% of respondents stated to have monthly fixed volume utilization. The other 13% had increasing water consumption monthly, while the rest 50% had no answer (Figure 3). The respondents with no answer had no certainty on their water consumption as a result of having daily free-flow water regardless of being utilized or not. They consume around 5-20 liter of water per day. Being aware of the importance of the water resource, they have the same conclusion that the forest should be protected to keep the water naturally conserved for the next generation.

![Figure 3. Springs consumption of Adat community.](image)

### 3.1.3. Assessment of socio-cultural and ecological benefits.

The existence of *leuweung* deposited is in line with the division of zones in the National Park. However, identification of the core zones according to indigenous peoples and the government is different. The determinations of the core zones
in GHSNP is considered based on the land slope, altitude, biodiversity and other technical aspects. In customary forests, there are only limited sources of springs and the layout of the boundaries, so most indigenous people do not know it as there is no clear benchmark. As many as 57% of respondents did not know the boundaries of the Kasepuhan Karang traditional forest. Based on spatial analysis of land use in the MHSNP area, it is proven that there is an increase in land use for mixed gardens, fields, paddy fields and shrubs in the core, jungle and rehabilitation zones [14]. So, it is necessary to clarify the boundary structure of the conservation forest to maintain sustainable use of the springs.

3.2. Leuweung Tutupan

Generally, people of Kasepuhan Karang grow forestry plants on the land cover as savings and inheritance for posterity. The average period after planting until it can be cut down is about ± 5 years. To grow forestry plants does not need many costs as people generally do not buy seeds. They look for plant seeds from the forest. When this research was conducted, there were no nursery business activities for forestry plants or MPTS plants in Kasepuhan Karang.

3.2.1. Vegetation analysis. Most of the leuweung cover is planted with woody trees and a small portion of plants that produce sap, fruit, fiber (multipurpose tree species/MPTS). The collection of timber forest products is only permitted if it is needed for house construction. Due to the absence of nursery businesses, the species of plants are mostly sengon or albasia or jeunjing (P. falcataria) and African wood (Meisopsis eminii). The other small part is karet (Hevea brasiliensis), meranti (Shorea spp.) and mahogany (Swietenia mahagoni). People rarely use rubber plants because they are few, and there is a marketing constraint on the sap product. Likewise, meranti and mahogany are also less planted, and the seeds are increasingly rarely found.

3.2.2. Assessment of economic benefits. Most farmers plant albasia or sengon wood for several reasons. First, seeds are available, and there is no need to buy because they can be easily obtained in the forest. Also, farmers do not need to take intensive care of these plants. In 2010, the price of sengon wood was auspicious at IDR 500,000 - IDR 1,100,000 per m³[15]. Many Bedouin farmers plant albasia trees to expect profits for the next five years [16]. Sengon wood is also perfect for home building materials. This has encouraged the indigenous Kasepuhan Karang farmers to prefer planting sengon as savings for the future.

Besides being beneficial, in terms of ecological aspects, sengon plants are perfect for conservation and can grow in any type of mineral soils, including regosol, alluvial, and latosol [17]. In agroforestry planting patterns, sengon trees are proven to be able to fertilize the soil so that it can help the growth of cardamom buds better when compared with manglids and gmelina [18]. In sloping land agroforestry, the diversity index of macrofauna in sengon agroforestry is 0.86, which is not much different from mixed agroforestry with the diversity index of 0.88 [19]. The study also revealed that the macrofauna diversity index was shown to correlate with environmental factors on sloping land. So it can be concluded that planting sengon trees in agroforestry is proven to be suitable for conservation.

| Wood Types                  | Plant Cycle | The Average of Economic Value unit ¹ |
|-----------------------------|-------------|-------------------------------------|
| Paraserianthes falcataria (sengon) | 6           | 100,000                             |
| Meisopsis eminii (African wood)   | 4           | 30,000                              |

Source: primary data

From Table 1, it can be seen that the economic value of sengon over six years was only IDR 100,000, while African wood was only IDR 30,000 for four years. These timber prices are lower than the expected ones. This is possible because of the wholesale harvest system used by adat farmers. The
intermediaries value of the price of sengon and African wood is using the unit of the stem, not cubic meters. The interesting thing is that farmers do not need to spend energy and costs to harvest even though the benefits received are less. Moreover, there is no coordination about harvest time so that it can be dangerous for conservation. Therefore, kokolot or adat leaders should establish some rules related to this matter.

3.2.3. Assessment of socio-cultural and ecological benefits. On the ecological aspect, African woods can grow well on the agroforestry system. As a protector plant,, it can grow better on hallway gardening (one type of agroforestry) mixed with chickpeas, peanuts, and coffee as the main plantation [20]. The advantages of M. eminii are that it can grow on soil without humus, withstand shade and breed vegetatively and generatively [21]. Although known as a pioneer or invasive plant, M. eminii plants that are in the conservation area do not need to be eradicated because the more important thing is to close the canopy gap [22]. Unfortunately, these plant species are considered to have the ability to degrade the quality of water catchment capacity, so it needs to be controlled by planting native species [23]. However, in the intercropping system, M. eminii has the potential to store very high soil organic carbon [24]. Therefore, African intercropping wood is permitted in conservation areas, but planting around water sources should be avoided.

3.3. Leuweung Garapan

3.3.1. Vegetation analysis. The leuweung garapan land is planted with crops, plantation crops, and forestry plants with intercropping systems. To meet daily food needs, 50% percent of respondents plant rice (Oryza sativa), and 30% of respondents grow other crops such as cassava, maize, taro, lemongrass, galangal, long beans, cucumber, pumpkin, chili, and vegetables for own needs. While forestry and plantation are used to meet the periodic needs where the results are sold at a certain time. The commodities are African wood, jeunjing, kadu or durian, mangosteen, petai, jengkol, rubber, coffee, duku, meranti, mahogany, sengon, rambutan and banana (Table 2). Besides, some people do fish farming, including carp and mujaer ponds, to meet family needs. Furthermore, if the family's needs are met, excess crop yields from plantation and forestry are sold to intermediaries who come to the village.

| Agriculture Crops   | Plantation Crops                           |
|---------------------|--------------------------------------------|
| Rice (Oryza sativa) | Durian (Durio zibethinus)                  |
| Cassava (Manihot utilissima) | Mangosten (Garcinia mangostana)       |
| Corn (Zea mays)    | Petai (Parkia speciosa)                   |
| Taro (Colocasia esculenta) | Jengkol (Archidendron pauciflorum)      |
| Lemongrass (Cymbopogon citratus) | Coffee (Coffea sp.)                        |
| Galangal (Alpinia galangal) | Duku (Lansium domesticum)                |
| Long bean (Arachis hypogaea) | Rambutan (Nephelium lappaceum)          |
| Cucumber (Cucumis sativus) | Banana (Musa spp.)                        |
| Chili (Capsicum frutescens) | Rubber trees (Havea brasiliensis)        |
| Pumpkin (Cucurbit sp.) | Aren (Arenga pinnata)                     |

3.3.2. Assessment of economic benefits. Additionally, the community also plants fruit trees as a deposit for posterity and as a source of income each year. The average harvest period for estate crops is once a year. In general, the community does not conduct intensive cultivation by fertilizing these plantations. The relatively fertile natural and soil conditions strongly support the growth of these MPTS plants. What is more, the community planted MPTS plants in intercropping with woody plants. The average
age of a plant to become unproductive reaches 20 years. The value of benefits per unit can be seen in Table 3.

### Table 3. Economic value of the MPTS per unit in Kasepuhan Karang.

| Types of Plantation Crops | First Harvest Period (years) | Productive Period (years) | Benefit Value year⁻¹ | Benefit Value of Timber | Economic Value year⁻¹ |
|---------------------------|-----------------------------|---------------------------|----------------------|-------------------------|----------------------|
| Durio zibethinus (durian) | 8                           | 8                         | 250,000              | 100,000                 | 2,100,000            |
| Garcinia mangostana (manggis) | 5                           | 10                        | 150,000              | 100,000                 | 1,600,000            |
| Lansium domesticum (duku) | 8                           | 10                        | 300,000              | 100,000                 | 3,100,000            |
| Havea brasiliensis (karet) | 5                           | 10                        | 180,000              | 150,000                 | 1,950,000            |
| Arenga pinnata (aren)      | 4                           | 6                         | 2,100,000            | 100,000                 | 12,700,000           |
| Coffea (kopi)              | 4                           | 16                        | 900,000              | 100,000                 | 14,500,000           |
| Archidendron pauciflorum (jengkol) | 5                           | 20                        | 2,000,000            | 60,000                  | 40,060,000           |
| Parkia speciosa (petai)    | 4                           | 16                        | 4,000,000            | 60,000                  | 64,060,000           |

From the benefit value calculation of forestry and plantation crops, overall, it can be concluded that the plantation crops have a higher benefit value than the timber plant’s value. This result is in line with [25] research, where generally, society prefers MPTS plants over timber because more profitable. Plantation plants that have the highest benefit value are petai trees. Specifically, plantation crops that also have a value of benefits per unit above 10 million unit⁻¹ are jengkol, coffee, sugar palm/aren and petai. Economically, Parkia speciosa (petai), Archidendron pauciflorum (jengkol), Coffea (kopi), Arenga pinnata (aren) are recommended as commercial commodities that are feasible to increase the adat farmer’s income.

### 3.3.3. Assessment of socio-cultural and ecological benefits

For conservation purposes on slopes above 15%, it is suitable for agroforestry between annual crops [26]. Besides being easy to adapt to various types of land, the annual sugar palm plant is a reasonably large biomass producer and is very good for water and soil conservation [27]. Coffee cultivation with a mixed or shaded system is better than a monoculture system because it has a conservation function and can suppress erosion [28]. Petai, jengkol, coffee and palm sugar plants are strongly recommended to be cultivated by the Kasepuhan Karang community to increase the income of adat farmers and conservation purposes.

### 4. Conclusion

Kasepuhan Karang customary forest is divided into three types of utilization, i.e., leuweung titipan, leuweung tutupan and leuweung garapan. Even though there is already an adat prohibition related to the vegetation utilization of leuweung titipan, it is necessary to conduct comprehensive socialization to ensure the compliance of the adat law community. In addition, planting fast-growing species near water sources should be avoided so that the springs remain conserved. The most recommended trees for planting around the springs are the Moracea group. In leuweung tutupan, most of the crops cultivated are forestry plants. Based on calculations using market values, forestry plant values are lower than multipurpose tree species (MPTS) crops. Therefore, intercropping between forestry plants and MPTS is well recommended. Whereas in the leuweung garapan, the types of vegetation cultivated on agroforestry patterns are more diverse even though most of them are staple food plants.

Based on the above research, the most ecologically valuable and profitable MPTS yields (more than 10 million/unit) for the surrounding community are petai, jengkol, coffee and palm sugar plants. A collaboration between various parties, especially with the local government, is needed. The
economic benefits of several other types of vegetation also need to be considered as an initial step in efforts to develop vegetation types that are both economical and ecologically sound.

Further research needs to continue in terms of developing products derived from these plants. Adat institutions need to be brought together with investors or other supply chain managers. It includes research related to business feasibility studies on the development of these products, processed products, supply chain management, and other business development efforts.

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