

Vegetation cover analysis for sustainable coastal forest management in Pesanggrahan, Bantur District, Malang Regency

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Abstract. Pesanggrahan Coastal Forest has potential in the ecotourism and education sector because it has biodiversity and stunning landscapes. However, this condition does not rule out the possibility of changes due to the degradation of protected forest ecosystem functions. The instability of this ecosystem function can lead to reduced types of biodiversity in the Pesanggrahan Coastal Forest. Keeping the Pesanggrahan Coastal Forest intact needs to be addressed to reduce the threat of forest ecosystem function degradation. Management for the education and ecotourism sectors is useful when involving the community and other relevant stakeholders as a protection for achieving sustainable forest management. This study aims to analyze vegetation density using NDVI analysis of biogeodiversity and analyze eco-edutourism model planning for sustainable forest management in Pesanggrahan Coastal Forest, Srignonco Village, Bantur District, Malang Regency. Based on research data, it is known that the distribution of NDVI values in Pesanggrahan Coastal Forest in 2022 is in the vicinity of 0.63 - 0.85 which is included in the classification of dense vegetation or high density. High vegetation density can affect the high level of biogeodiversity as well. Based on the survey results, the number of plant species was 444 species belonging to 94 families. Thus, the diversity or composition of the plant taxon making up the vegetation in the Pesanggrahan Coastal Forest area is still high. The eco-edutourism model of the Pesanggrahan Coastal Forest Area adapts the best practice model for forest management which is always related to social, economic, and environmental aspects.

1. Introduction

Forest is an area that is a habitat for a variety of biota. Forest is an environment with biologically based resources formed by the dominance of trees in their natural surroundings that are inextricably linked to one another [1]. The forest area is divided into protection, production, and conservation forest [2]. According to the Forestry Law of the Republic of Indonesia Number 41 of 1999 [3], a protected forest is an area that



has the main function as a protector for the life support system that regulates the water system, prevents flooding, controls the land erosion, prevents seawater intrusion into land area, and maintains the fertility of soil. Meanwhile, the production forest is an area that has the primary function as the production of forest products. Pesanggrahan Coastal Forest has two types of forest, namely protection forest and production forest.

Forests that can still carry out their essential functions can be said to be healthy forests or have good conditions [4], so that the state of the forest, both physical and biological, can be known [5]. The Pesanggrahan Coastal Forest is observed to be in good and tight condition. However, this condition does not rule out the possibility of changes due to increasing pressure from human activities and can accelerate the degradation of protected forest ecosystem functions [6]. The instability of this ecosystem function can lead to reduced types of biodiversity in the Pesanggrahan Coastal Forest.

Monitoring forest density using remote sensing technology and various satellite imagery to generate vegetation coverage is essential [7,8]. Monitoring forest density can be an option in supporting the achievement of sustainable forest management. Assessment of forest density can determine the status, changes, and trends experienced by a forest [4]. Remote sensing technology is very effective and accurate in providing information about the density of vegetation in the Pesanggrahan Coastal Forest related to the diversity of vegetation in the Pesanggrahan Coastal Forest. In order to monitor an ecosystem's dynamics and develop habitat and ecosystem management plans, it is possible by measure the vegetation density [9].

Vegetation index is widely used as a gauge to assess how green the vegetation is using remote sensing data and satellite imagery [10]. The vegetation index is modified for various purposes such as the effect of soil background used in vegetation analysis [11]. The method used in assessing the vegetation index is the Normalized Difference Vegetation Index (NDVI) analysis [12]. NDVI analysis is widely used for various scientific purposes in analyzing land cover changes in watersheds and in urban areas [7,9], and how human activity affects vegetation [13]. NDVI contributes to mapping the ecosystem condition of a vegetation by using remote sensing technology that utilizes satellite image data [14]. NDVI data is useful as a resource for knowledge regarding the geological environment's status, as well as the intensity of tree and shrub vegetation [15].

Pesanggrahan Coastal Forest has potential in the ecotourism and education sector because it has biodiversity and stunning landscapes. The potential of the Pesanggrahan Coastal Forest has not been developed optimally. This is because the understanding of the eco-edutourism model is still very minimal. The eco-edutourism model is used to combine the idea that ecotourism with education with two of geodiversity's and biodiversity's primary components [16].

The conservation of the Pesanggrahan Coastal Forest needs to be addressed to reduce the threat of forest ecosystem function degradation. A safeguard for achieving community-based sustainable forest management is to manage the education and ecotourism sectors and related stakeholders. Therefore, this study aims to analyze vegetation density using NDVI analysis of biogeodiversity and analyze eco-edutourism model planning for sustainable forest management in Pesanggrahan Coastal Forest, Srignonco Village, Bantur District, Malang Regency.

2. Materials and methods

2.1. Research location

This research was conducted in the eastern part of Pesanggrahan Coastal Forest Area, located in Srignonco Village, Bantur District, Malang Regency. Astronomically, the Pesanggrahan Coastal Forest Area is at 8°23'34'' S - 8°24'15'' S dan 112°32'58'' E - 112°33'42'' E. This area has an area of 92.28 ha which is divided into two types of forest, namely protection forest with an area of 45.61 ha and production forest with an area of 49.68 ha.



Figure 1. Research site map.

2.2. Methods

2.2.1 *Vegetation density analysis.* Vegetation density analysis using the NDVI vegetation index analysis method. Vegetation is a land cover that has various types which will produce different vegetation densities [17]. Analysis of vegetation density is very important because vegetation produces oxygen needed by living things and is the habitat of several animals. NDVI analysis can be performed using remote sensing technology with data in the form of satellite images such as Landsat 8 obtained from the USGS. NDVI is a formula to calculate the value of the vegetation index based on the reflectance of the red and near infrared bands received by an image [9]. NDVI can be calculated using the formula below:

$$\text{NDVI} = (\text{NIR} - \text{RED}) / (\text{NIR} + \text{RED})$$

Where NIR and Red are obtained from Red-Ray which refers to visible light and reflected light from vegetation cover, respectively. The extracted value between the values of -1 is used to describe the area without vegetation cover and the value of 1 to indicate the area with high density vegetation. [10,12]. This study classifies NDVI values into 5 classes referring to [18], the following table of vegetation density classification.

Table 1. Vegetation density classification.

Vegetation Density Classification	NDVI value
Clouds and Water	-2,00 – 0,00
Non-vegetation	0,00 – 0,21
Not Dense Vegetation	0,21 – 0,42
Quite Dense Vegetation	0,42 – 0,63
Dense Vegetation	0,63 – 0,85

Source: Sunaryo & Iqmi (2015) [18]

2.2.2 *Qualitative analysis of vegetation diversity.* Vegetation diversity analysis was collected through field surveys and observations. The results of the observations will be used to investigate the status of vegetation diversity and types of forest threats to forest management in the Pesanggrahan Coastal Forest.

2.2.3 Eco-edutourism model planning. The analysis of eco-edutourism planning model is carried out in a quantitative descriptive manner to produce information that will be used as the basis for making eco-edutourism planning models. This model is designed according to the factual conditions in the Pesanggrahan Coastal Forest Area so that it can be applied effectively.

3. Results and discussion

3.1. Vegetation cover in Pesanggrahan coastal forest

Remote sensing technology can help in providing information about vegetation dynamics easily, cheaply, and quickly which is obtained based on analysis of satellite imagery. Vegetation index can help in decision making such as steps for reforestation [19]. This study uses the Normalized Difference Vegetation Index (NDVI) in measuring vegetation density using satellite imagery data. Vegetation dynamics of the Pesanggrahan Coastal Forest using Landsat 8 imagery in 2020 and 2022, NDVI calculations on Landsat 8 using bands 4 and 5 channels.

Based on the analysis of satellite image data that has been carried out, the results of the vegetation density value using the NDVI method in Pesanggrahan Coastal Forest consist of 5 classifications, namely cloud and water, non-vegetation, vegetation not dense, vegetation quite dense, and vegetation dense. The classification of vegetation density levels in the research area in 2020 and 2022 can be seen in Figure 2.

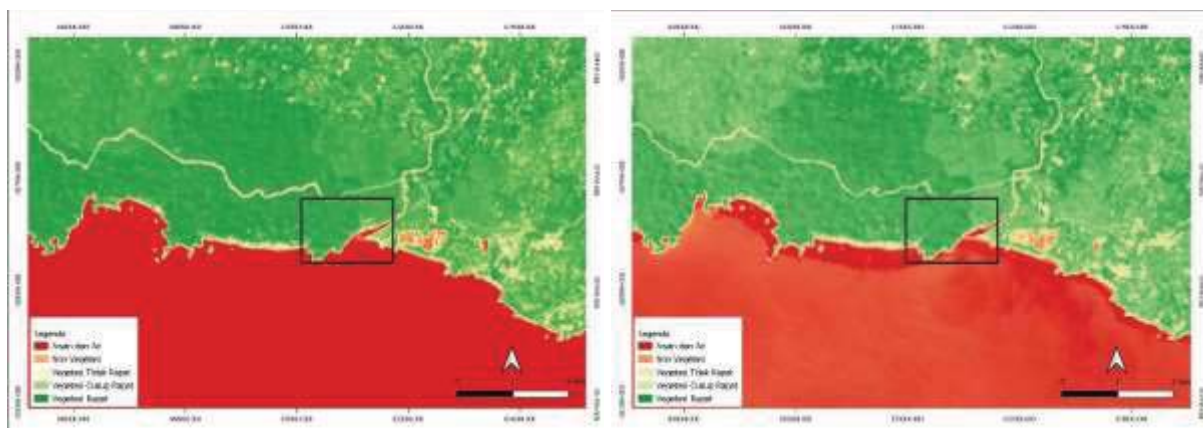


Figure 2. 2020 vegetation density (left), 2022 vegetation density (right).

Based on Figure 2, it can be shown that the Pesanggrahan Coastal Forest is included in the classification of dense or high density vegetation which has a range value of 0.63 – 0.85. This high vegetation density is dominated by tropical forest stands associated with shrubs, shrubs, and cover crops underneath. The high vegetation density in the Pesanggrahan Coastal Forest indicates that the dynamics of the vegetation has not changed significantly. This is because the Pesanggrahan Coastal Forest is still well preserved. In line with the statement Jayanthi & Arico [20] that the density of a stand of vegetation can occur because the types of vegetation are found in large numbers, evenly distributed throughout the forest area, and the influence of the diameter level on the growth of poles and trees. So that these factors can affect the high and low density of a vegetation. The percentage area of vegetation density can be seen in Table 2 below.

Table 2. Vegetation density percentage in 2022.

Vegetation Density Classification	Percentage
Clouds and Water	-
Non-vegetation	-
Not Dense Vegetation	0,5
Quite Dense Vegetation	2,5
Dense Vegetation	97

Based on Table 2 of vegetation density in 2022, the highest percentage is in the classification with dense vegetation with a percentage of 97%. This is also proven on the vegetation density map that the Pesanggrahan Coastal Forest Area is dominated by green with a high density classification. Vegetation density with fairly dense classification has a percentage of 2.5% and vegetation with a less dense classification of 0.5%. In the classification of clouds and water, as well as non-vegetation, there is no percentage value because in both classifications the spectral reflection pattern decreases in infrared and red light [21].

3.2. Biodiversity in the coastal forest of Pesanggrahan

Physiognomy observations in the Pesanggrahan Coastal Forest have a complete vertical forest structure. The vertical structure is still found in four layers, namely the understorey layer/forest floor, the shrub layer, the shrub layer, and the tree-shaped plant layer. In tree-shaped plants, various epiphytic plants were also observed attached to various types of trees. In addition, there are still many lianas attached to the trees. The condition of the vertical structure of the forest which is still complete illustrates the main characteristics included in the tropical forest. Based on the survey results, the number of plant species was 444 species belonging to 94 families. Thus, the diversity or composition of the plant taxon making up the vegetation in the Pesanggrahan Coastal Forest area is still high.

Table 3. List of plant types in Pesanggrahan coastal forest.

Local Name	Species	Family	Tree Height (m)	Group
Sapen	<i>Biancaea sappan</i>	<i>Fabaceae</i>	4 – 10 m	Protected forest
Gondang	<i>Ficus variegata</i>	<i>Moraceae</i>	15 – 30 m	Protected forest
Ipik	<i>Ficus retusa</i>	<i>Moraceae</i>	3 – 4 m	Protected forest
Beringin	<i>Ficus benjamina</i>	<i>Moraceae</i>	18 – 30 m	Protected forest
Munung	<i>Pterocymbium</i>	<i>Malvaceae</i>	40 – 50 m	Protected forest
Timoho	<i>Kleinhovia hospita</i>	<i>Malvaceae</i>	5 – 20 m	Protected forest
Jati	<i>Tectona grandis</i>	<i>Lamiaceae</i>	9 – 11 m	Production forest
Kosambi	<i>Schleichera oleosa</i>	<i>Sapindaceae</i>	15 – 40 cm	Production forest
Mahoni	<i>Swietenia macrophylla</i>	<i>Meliaceae</i>	10 – 25 m	Production forest
Pisang	<i>Musa sp.</i>	<i>Musaceae</i>	2 – 5 m	Production forest

Sources: POWO, 2022 & ITIS, 2022[22,23]

On the basis of Table 3, it is clear that there are 6 plant species belonging to 3 families in Protection Forest and 4 plant species belonging to 4 families in Production Forest. Vegetation types of Protected Forests are composed of mixed forest vegetation types with plants that are often found as constituents of vegetation, including Sapen, Gondang, Ipik, and Banyan. Vegetation height in the Protected Forest ranges from 3 – 50 m. While the vegetation type of Production Forest is dominated by 86% of the type of Teak vegetation with a vegetation height of 9 – 11 m. The dominance of vegetation in the Production Forest is in accordance with the function of the forest area as a production forest area that is managed in a monoculture manner as indicated by the vegetation which is the main plant that makes up the stand. [24].

Findings from an examination of each forest ecosystem's vegetation show that the composition and structure of the vegetation varies in each species. This is because there are differences in the character possessed by a tree [24]. In general, the existence of various plants in the Pesanggrahan Coastal Forest has 6 potential benefits as medicinal plants, plants for household needs, plants for food sources, plants for industrial purposes, plants for ritual purposes, and plants for ecological conservation purposes.

Biodiversity is related as a whole to form an ecosystem with non-living elements around it. These elements are interrelated with each other, so that they will affect each other if one of the elements is damaged and extinct. This can result in the balance of the ecosystem being disturbed as a whole [25].

Biodiversity is an important asset in keeping species populations from becoming extinct. However, biodiversity has 2 types of threats in practice, namely major (general) and minor (specific) threats. The main threats are destruction/conversion, whether intentional or not, for example land conversion for settlements, plantations, agriculture, and natural disasters. While the minor threats that occur are harvesting for food and horticultural purposes [26].

3.3. Eco-edutourism model planning adapting best practice models for sustainable Forest management

Eco-edutourism model for the Pesangrahan Coastal Forest area adapts the best practice model for forest management [27]. The development of eco-education is always related to social, economic, and environmental aspects. Eco-educational area planning is the boundary of ecosystem areas and other functional areas such as coastal areas, watersheds (DAS), and ecosystems [28]. Ecological and social factors underlie various management uses and values. This means that these two factors can be positioned as management resources. Social and ecological factors must be in an optimally stable condition to support the management of eco-educational services, while still trying to maintain social and environmental factors. Therefore, management best practices need to be placed above local characteristics, so that these characteristics can be self-controlled or can be called homeostasis in response to threats, risks, and uncertainties [27].

The management approach does not absolutely prioritize growth in an economic sense, but produces a quality that is in synergy with the growth of social and natural capital (sustainable growth). So as an ecotourism destination, it is important to generate economic benefits and quality of life [27]. The planning of an eco-educational area (figure 3) also needs to be developed with the protection of the value of local wisdom in the area. Facilities and infrastructure such as accommodation, accessibility, services and products produced are developed by adopting and collaborating with indigenous values and local products. So in this case, proactive institutional management is needed so that it is carried out properly. The protected value order will create a source of inspiration and best practice in institutions and community participation [27].

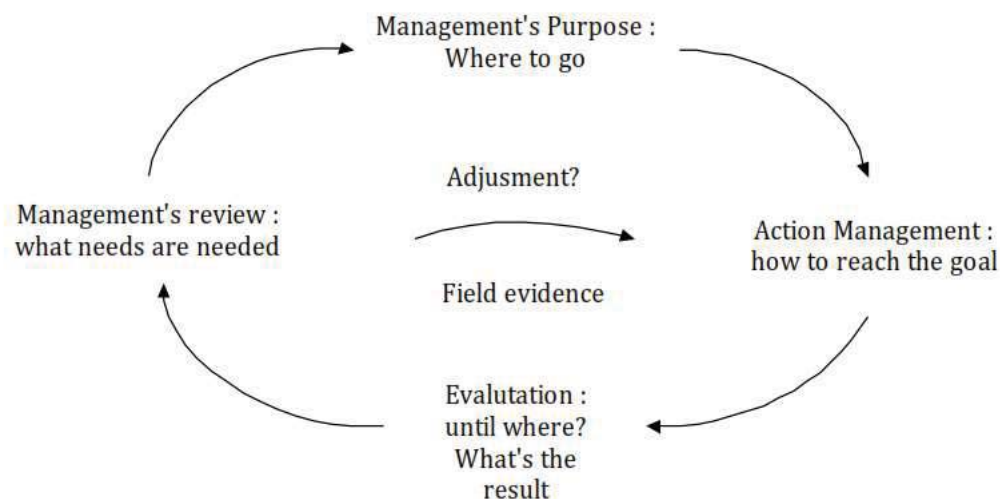


Figure 3 Eco-educational Management Planning Cycle

Sources: Nugroho, 2011[27]

Eco-educational services or products have different characteristics from other tourism. This is because eco-edutourism refers to the philosophy and principles of conservation and education. Eco-edutourism visitors may demand many interesting programs but this is not fully fulfilled in eco-edutourism if the program violates conservation rules [27].

4. Conclusions

According to the research findings, it can be said that the distribution of NDVI values in the Pesanggrahan Coastal Forest in 2022 is in the range of 0.63 - 0.85 which is included in the classification of dense vegetation or high density. The density of a stand of vegetation can occur because the types of vegetation are found in large numbers and spread evenly throughout the forest area. High vegetation density can affect the high level of biogeodiversity as well. The denser a forest, the higher the level of biogeodiversity. Based on the survey results, the number of plant species was 444 species belonging to 94 families. Thus, the diversity or composition of the plant taxon making up the vegetation in the Pesanggrahan Coastal Forest area is still high. The eco-edutourism model for the Pesanggrahan Coastal Forest area adapts the best practice model for forest management which is always related to social, economic, and environmental aspects.

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