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Orchid conservation development at Mudal river by using remote sensing

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ABSTRACT

Daerah Istimewa Yogyakarta (DIY) is a district in Yogyakarta that contains various tourist attractions (ODTW) such as the Mudal river, attracting many local and international visitors each year. However, this region must be developed by identifying the best conservation position. Technology is required to explore the geographical aspects in establishing ecotourism in order to complete this process. This study sought to determine the most appropriate new development for the Mudal river, taking into account environmental variables, site area, orchid growing demands, ease of access, and commercialization. This is accomplished by employing a remote sensing technique based on the overlay technique. As a consequence of the investigation, three sites have been identified as the most plausible candidates. The analysis identified three areas that are most likely to be used as conservation sites: an orchid cultivation house, an orchid garden area that may be used as a photo location, and an orchid education garden.

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1. INTRODUCTION

Indonesia as a country with a tropical climate has many flora and fauna biodiversity. However, the existence of these several species has been threatened with extinction. Previous research showed that the rate of extinction for some plants was 350 times quicker than the historical average [1]. One of the solutions to this problem is conservation, which entails the protection of plants, animals, and natural areas. According to the International Union for Conservation for Nature (IUCN) in 1994, a conservation area is a portion of land or water that is designated and legally managed for the protection and preservation of biological diversity and related natural and cultural resources [2].

Indonesia also has the largest number of orchid species in the world [3], however, the attention given to ensure its further existence is still very low, specifically in term of preservation. Consequently, several species of this plant are classified as being extinct. Therefore, orchid conservation needs to be carried out in order to preserve this plant. Moreover, the challenges in maintaining orchids compared to other plant groups are quite large, because the plant growth depends on other organisms and is also influenced by habitat and climate change [4]. Gale *et al.* [5] explained that the presence of orchids is an indicator to assess the health of an ecosystem because the plant often grows in a conducive environment.

Orchid plants are often used as medicine and food, thereby leading to many illegal smugglings that causes this species to be threatened with extinction [4]. In addition, this plant is often taken as horticulture or

garden plants because of its beauty. Orchid plants have a high aesthetic value which makes it to be highly demanded in the market. Based on the declining population of this plant due to the reasons explained, there is a need to practice conservation in order to ensure the availability of the plant amidst the demand.

This research was conducted in Mudal river ecotourism in the hilly area of Mount Menoreh, Banyunganti Hamlet, which is located in Jatimulyo Village, Girimulyo Sub-District, Kulonprogo District, Province of Yogyakarta. The plants are able to grow well in this highland because the area has a fairly good temperature for the growth of orchids [6]. In addition, Mudal river also has natural water tourism and an environment that is beautiful and very conducive for the growth of orchids. According to MacKinnon and Phillips, the characteristics of conservation areas that serves as an attraction for nature-based tourism and ecotourism activities include the uniqueness of the ecosystems, the presence of fauna resources that are threatened with extinction, diversity of species both flora and fauna, panoramas or geophysical characteristics that have aesthetic value, the hydrological function of the area for water regulation, erosion, and soil fertility [7]. In this research, the kernel density method is used to determine the orchids' distribution in the ecotourism of Mudal river, while the overlay technique is used to determine the best location for the plant. This conservation is expected to increase the sustainability of orchids and become objects of tourist attractions (ODTW) in Mudal river.

2. METHOD

2.1. Basic concepts of aerial photographs

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object [8]. One of the applications of remote sensing is photography. This involves recording of objects through the use of a camera which serves as a sensor, and film functioning as a detector with electromagnetic energy in the form of the visible spectrum. The result obtained is the aerial photographs which is in accordance to the following researches [9]–[13].

In capturing objects using aerial shooting techniques known as aerial mapping, the principles of photogrammetry need to be considered. Photogrammetry is a method of mapping objects on the surface of the earth by using aerial photographs as a medium. Furthermore, object interpretation and geometric measurements are conducted to produce line, digital, and photomaps [14], [15]. According to [13], photogrammetry is a geoinformation technology that is carried out by using geospatial data obtained through aerial photography. Photogrammetric mapping activities, such as using aerial photographs that have been conducted for decades, have led to the development of equipment and techniques in mapping, as well as the development of photogrammetry that is accurate, efficient, and very profitable in the field of mapping. Furthermore, this method is used for mapping activities that require high accuracy, such as the development of topographic and parcel mapping [16], [17].

2.2. Aerial photo data acquisition

Aerial photography is one of the media used to describe the Earth's surface in two dimensions. It allows users to obtain a spatial description of the state of the Earth [18]. The results of aerial photographs often serve as a basis for map making and spatial analysis. The first aerial photograph was taken in 1919 [19], starting with shooting through airplane and interpreting aerial photographs.

One of the data sources used for analysis in this research is spatial data. In addition, an unmanned aerial vehicle (UAV) was used in the inventory of spatial data, and then acquisition steps of aerial photo data with UAV are divided into two stages, namely pre-field and post-field. The preparation of equipment and flight mission design are outlined in the pre-field activities, while data processing is contained in the post-field. These steps are completed through the previously determined SOPs, hence, the process of taking and acquiring aerial photo data is shown in Figure 1 [20].

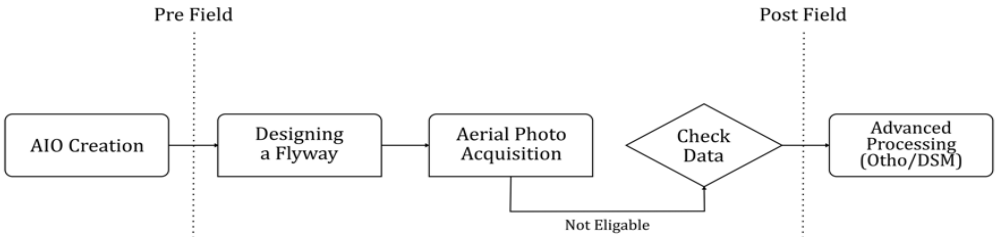


Figure 1. Aerial photo data acquisition and acquisition process

2.3. Orthophoto technique

An orthophoto is an aerial photograph that presents an image in the correct orthographic position. Furthermore, it is geometrically equivalent to a conventional line and a planimetric symbol map that correctly represents the position of the orthographic object. The advantage of orthophoto overline maps is that it has the pictorial quality of aerial photographs that makes it to be recognized and identified properly, after going through a process called differential rectification [17], [21]. This process of incorporating aerial photographs in Figure 2 using an orthomosaic technique is shown in Figure 2(a) and orthophoto technique in Figure 2(b).

(a) (b)

Figure 2. Incorporating aerial photographs using (a) orthomosaic and (b) orthophoto

In the processing of aerial photographs, orthophoto and height data were obtained. The height data was further processed through interpolation in order to form a surface model, namely digital surface model (DSM). The DSM data is very useful when it is reduced to digital elevation model (DEM) and digital terrain model data [19], [22].

The formation of DEM entails the digital and mathematical representation of a real or virtual object, along with its surroundings as shown in Figure 3. In a situation whereby the digital terrain model undulates a certain area, DEM forms a general representation of the ground surface's height, along with the several layers above it. However, objects namely buildings, trees, and everything on it are included in DSM [23], [24]. The results of the orthophoto in the (.tif) format are visualized into a map to make it easier for users to read. Subsequently, ArcMap software is used to map out processes from the ArcGIS platform provider as shown in Figure 3.

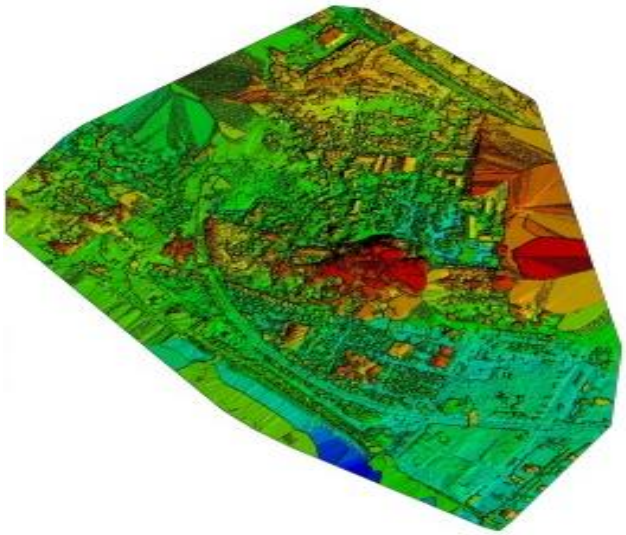


Figure 3. Digital elevation model (DEM)

2.4. Kernel density

Kernel density estimation (KDE) is a geostatistical analysis that uses the estimated point density distribution to perform spatial interpolation [25], [26]. KDE is used in a variety of natural and social sciences, including economics, physics, astronomy, agriculture, public health, geography, epidemiology, criminology, demography, and hydrology. The QGIS software was used to determine the value of KDE and the orchid distribution in Mudal river. According to [27], the (1) is used in the KDE analysis.

$$K = \frac{3}{4}(1-p)^2, p = \frac{d}{h} \leq 1 \; or \; K = 0, p = \frac{d}{h} \quad (1)$$

Where K represents the extrapolation or prediction value, p represents the density value, d represents the distance between points in the spatial dataset, and h represents the bandwidth. The bandwidth values in QGIS are calculated by using the data's standard deviation.

2.5. Overlay technique

Overlay analysis is an operation in the GIS technique used for integrating spatial data with attribute data. Tiede [28] explained that this process merges multiple layers of different themes in order to analyze or identify the relationship of each layer. Raghuvanshi *et al.* [29] stated that overlay analysis represents a composite map with different combinations of attributes and geometries of data sets or entities. In this research, an operation was used to compare the distribution variables of Mudal river ecotourism facilities, the orchids' distribution, and the average temperature at the orchids' distribution place [30], [31].

2.6. Ecotourism planning

One of the tours that becomes a reference in ecotourism planning in Mudal river is Orchid Forest. This is a pine forest whose function has been partially converted into a natural tourist destination in Lembang, and it is known as the largest orchid garden in Indonesia. This place has a land area of 12 hectares, which is 6% of the forest in Lembang, with more than 157 types of cultivated orchids. The facilities in this forest are quite complete and some of them are owned by the people of Mudal river such as counters, food courts, flying house rides, and photo spots rides [32].

The result of remote sensing in the form of a map describes the process of planning Mudal river tourism area in order to meet the place's needs. When a new area is identified as potential ecotourism, it is necessary to conduct an assessment, both in terms of products and markets, in order to determine the ecotourism business development and management plan. Meanwhile, when the area has developed but still facing the threat of being damaged, the cause needs to be diagnosed before determining the next development plan. Drum and Moore [33], explained that three ecotourism development objectives must be considered in this plan, namely (1) avoiding threats to conservation targets, (2) allocating revenue for conservation, and (3) optimizing benefits for local communities. The development of Mudal river ecotourism is able to improve the experience of the tourists by focusing on their level of interest in the environment. Also, the knowledge of the exact experience needed by the tourists helps in meeting their needs, ensuring maximum management of the area, and determining the tour packages that need to be created.

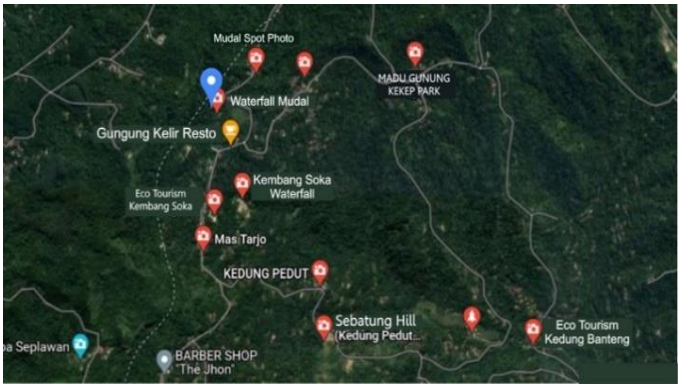
One of the importance in developing the ecotourism is that it serve as a means of education and recreation for visitors. During the celebration two centuries of bogor botanical gardens in 2017, the Indonesian Institute of Science (LIPI) states that most of the orchids found from natural forests in the country are threatened with extinction. Therefore, an orchid storage centre is needed in order to re-create a sense of love for the place, as well as to make the visitors aware of the importance on preserving and cultivating orchids [34].

3. RESULTS AND DISCUSSION

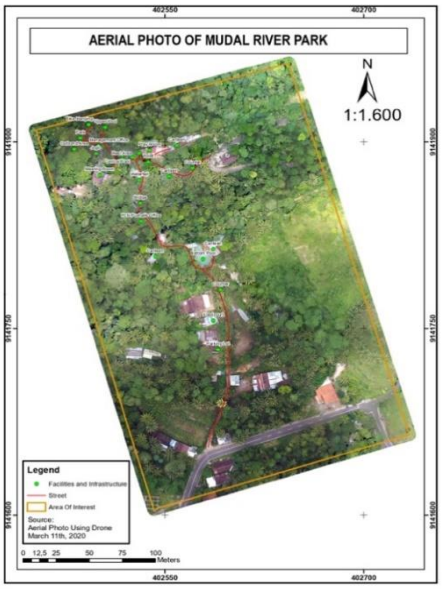
3.1. Research area

Mudal river ecotourism is close to two big cities, namely Purworejo, with a distance of 21 Km and 44 minutes drive on the road, and Yogyakarta City with a distance of 1 hour 14 minutes with a distance of 39.2 Km and 1 hour 14 minutes drive through an uphill. Mudal river is in a strategic place because there are several inns and restaurant around it and also many other tourist attractions with a nature theme. The portrait of Mudal river Figure 4 ecotourism is seen in Figures 4(a) and (b). Meanwhile, the locations of the planted orchids and distribution of facilities from Mudal river ecotourism are displayed in Figure 4(c). The result showed that the existing facilities are not evenly distributed, such as the absence of a prayer room and joglo in the area under the river.

(a)



(b)



(c)

Figure 4. Mudal river ecotourism portrait in: (a) Makro Map, (b) Miso Map, and (c) Mikro Map

3.2. Data extraction

Data extraction is a stage where more values are provided compared to the products that have been made. This extraction produces some data from the orthophoto derivatives, such as the area and length data of an object, which makes the aerial photo to be viewed in real-time or current conditions. Aerial shooting data are used to carry out detailed mapping of Mudal Kulonprogo river conservation zone area because detailed information on objects is required for decision-making [35]. Table 1 shows the number of ecotourism facilities in Mudal river was 22 which are scattered in the tourism area. Furthermore, the place has three main pools as well as other supporting facilities, namely buoy rental, prayer room, canteen, and toilet.

The area of each existing facility is obtained through the tool in ArcGIS software, namely Calculate Geometry. This software's functionality makes it easier to estimate the exact area at a specific time. Table 2 shows the area of each facility that has been identified by aerial photo including land with an area of 309.44 m, wood with an area of 119.61 m, and cement with an area of 42.13 m.

Table 1. Number of facilities in Mudal river ecotourism

No	Facility Name	Amount	No	Facility Name	Amount
1	Canteen	4	9	Prayer Room	1
2	Foodcourt	1	10	Buoy Counters	1
3	Parking Area	2	11	Management Office	1
4	Ticket Window	2	12	Outbound	1
5	Pool	3	13	Toilet	1
6	PLN Pusharlis	1	14	Rest area	1
7	Joglo	1	15	Park	1
8	Meeting Room	1	**Total**	**22**	

Source: Aerial Photo Interpretation, 2020

Table 2. The extent of facility area in Mudal river ecotourism

No	Area	Large (m^2)	No	Area	Large (m^2)
1	Nether Pool	259.45	12	Canteen	170.77
2	Canteen	173.87	13	Prayer Room	131.18
3	Foodcourt	1601.25	14	Buoy Counters	16.63
4	Parking Area	998.82	15	Management Office	20.68
5	Ticket Window	13.72	16	Outbond	213.17
6	Canteen	118.58	17	Upper pool	39.68
7	PLN Pusharlis	33.25	18	Center pool	37.82
8	Ticket Window	15.54	19	Toilet	9.07
9	Canteen	33.89	20	Rest Area	97.77
10	Joglo	46.39	21	Park	83.16
11	Meeting Room	174.00			

Source: Aerial Photo Interpretation, 2020

By using the kernel density method, a distribution pattern of orchids was formed. According to Figure 5, there are three parts of color that represent the density of plant distribution, namely the cream color, which depicts the ferns' distribution, the green color, which depicts the orchids' distribution in the area, and the dark color, which described the density of plant. The interesting thing found from the aerial photos is that the distribution of ferns is more dominant than the distribution of orchids.

Fern is one of the good growing media for orchids because it has good moisture and water absorption capacity. Based on the distribution visualization in the Figure 5, the tendency for orchid growth in Mudal River area is quite high. Potentially, the average orchid plant grows and has a density level around a dense area of ferns.

Figure 5. Patterns distribution of ferns and orchids

3.3. Ecotourism planning with overlay technique

Overlay is one of the design techniques in landscape architecture, where the images that are stacked in layers are used to determine the most ideal site location. In this research, 3 locations already have open areas that were reprocessed based on the distribution of orchid plants, the distribution of facilities, and the average temperature in the layer. The result of the overlay technique is determined by stacking all the layers above into one, then the pile at the most strategic place indicates the location of orchid ecotourism as shown in Figure 6.

Figure 6. Overlay technique of ecotourism planning

To determine a Mudal River ecotourism site, several parameters are used as recommendations for the suitable areas including environmental conditions, commercialization, ease of access in order to look at the proximity of the relationship between facilities/spaces to improve the maintenance, site area which helps in simplifying the design process, and also make it easier to meet the needs of the existing space to overshadow the activities of the user, Orchid crowing needs such as sunlight, water sources, humidity, and altitude. This parameter has a temperature range of 18-24 °C, while the wind direction needs to be considered for conditioning the place. The parameter of each site plan are shown in Table 3, while the fertility and ideal place for orchid growth is seen from the orchid distribution map. From the results obtained, three sites are most likely to be used as locations of orchid conservation, namely Site A which is recommended for an orchid cultivation house, Site B which is recommended for photo spots or garden areas, and Site C which is used for orchid education garden.

Table 3. Parameter of site

Parameter	Site A	Site B	Site C
Environmental conditions	Not surrounded by many buildings and facilities	Surrounded by many buildings and facilities	Not surrounded by many buildings and facilities
Site area	666,111 m^2	187,226 m^2	170,076 m^2
Orchid growing needs	Being in an area where there is a lot of orchid growth	Located in a moderate orchid growing area	Being in an area of little orchid growth
Ease of reach or access	Difficult to reach and access	Easy to reach and access	Being in an area of little orchid growth
Commercialization	Not commercial	Commercial	Less Commercial

4. CONCLUSION

This ecotourism is an excellent location for orchid conservation because the population of ferns is evenly distributed in Mudal river ecotourism area. In the aspect of developing new areas, several factors need to be considered, namely environmental conditions, site area, orchid growing requirements, ease of access, and commercialization. These factors help to consider the economic values of nature to the local community. The purpose of this research is to determine the most suitable new development area by using remote sensing based on overlay techniques. The results of the analysis yielded three sites that are most likely to be used as orchid conservation sites, namely an orchid cultivation house, an orchid garden area that is useful for a photo spot, and an orchid education garden.

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