

Land-use analysis of eco fishery tourism using a low-cost drone, the case of Lumpur Island, Sidoarjo District

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Abstract. Lumpur Island in Sidoarjo, East Java, is an island formed by mud sedimentation. This island emerged after the Lapindo mud disaster. This study is aimed at mapping the distribution and the extent of mangrove ecosystem as well as potentially, to analyze land use for Eco Fishery Tourism. This research uses technical analysis of aerial photographs using a low-cost drone and satellite images through the process of scattered aerial images and satellite imagery. It shows that Lumpur Island has an area of 85.37 ha, where 70.38 ha of the island was covered by mangrove ecosystem. This island is potentially managed as Eco Fishery Tourism by Land use management based on area mangrove ecosystem, puddle area and pond.

Keyword : *Eco fishery tourism, aerial photograph, drone.*

1. Introduction

The Sidoarjo Lumpur Island is a new land formed from dredge material disposal of Porong River estuary due to high sedimentation. Lumpur Island has unique characteristics, considering the dredged sediment is that originated from the Sidoarjo mud volcano which may contain dangerous chemicals.

Since 2010, Lumpur Island has been utilized as both additional land for mangrove ecosystem area at Porong river estuary and as a fishery cultivation area with the wanamina (sylvofishery) system. Marine Research and Observation Agency, Ministry of Marine Affairs and Fisheries (BPOL) study results had showed that *Avicennia* (api-api) and *Rhizophora* (mangrove) are able to grow well as media on the Sidoarjo mud. It had been supported by laboratory analysis of the mud content, water quality conditions and marine biota, in which no the values of the analyzed parameters are at hazardous levels for both coastal environments and Porong river estuary [1].

The mangrove ecosystem is that of any main coastal and small islands which play a large role in the availability of fish resources in those areas and surrounding [2]. The mangrove ecosystem has a dual function and as an important link in maintaining the balance of biological cycle in a water system. The ecological function of mangroves is provider of nutrients for aquatic biota, spawning and care sites of various kinds of biota [3]. Physically, its function either to resist erosion, hurricanes and tsunamis, also as waste and sea water intrusion absorber. Mangrove ecosystems function economically as providers of



wood and its leaves as raw materials for medicines, and others [4]. The commercial functions of mangroves are as aquaculture (such as *wanamina* ponds), recreational (tourism) and timber producers and as salt pools [5].

Location of Sidoarjo Lumpur Island is bordered by Surabaya and Gresik regencies in the northern, Madura Strait in the eastern, Pasuruan regency in the southern, and Mojokerto regency in the western. Lumpur Island close to Tlocor hamlet, Kedung Pandan village, Jabon district, Sidoarjo regency. As one of the central economic and industrial growth areas of East Java, Sidoarjo regency continues to experience rapid growth. Some of the major indications of rapid economic development in the region are the increasing industrial and residential areas numbers [6]. The increasing of industries and settlements numbers it requires the opening of new lands. In order to meet these needs, mangrove forest areas on the coast began to be converted into residential and industrial areas.

Lumpur Island with an area of ± 94 Ha potentially, it has biological resources contained in its mangrove ecosystem. Utilization of mangrove ecosystem as *wanamina* area is one of the development efforts that have been done by the government, in order to avoid land conversion into industrial estate and infrastructure development, considering the location close to settlement and in the suburbs.

According to Lawley, et al. [7], helpfully, remote sensing can calculate area, species abundance and diversity changes of vegetation cover, as well as monitoring of vegetation conditions and changes, especially on mangroves in this study. The analysis used for vegetation on remote sensing used different characteristic extraction techniques, plant indices and spectral classification [7].

The results of research conducted by Hidayah and Wijayanto [6] had showed that from Landsat analysis of 2002 and 2010 images, mangrove ecosystem in Sidoarjo regency experienced a reduction from total area of 1,236.42 ha to be 1,203.35 ha. The area which had that experienced the largest decrease of mangrove ecosystem in Sidoarjo Regency is Jabon district, i.e. 55.94 ha [6]. The damage of mangrove ecosystem in Sidoarjo regency is mostly caused by illegal logging activity and the conversion of mangrove ecosystem into ponds by local community.

Changes of land use on small islands trend to grow along coastline lines, ports, public services, rural centers, commercial areas, residential areas, tourism accommodation, tourist center areas, and tourist attractions as well as away from landfills [8]. To avoid land use change due to rapid population growth and limited land in urban areas, it is necessary to plan the development of Lumpur Island as an eco-tourism area.

This development carried out as an effort to develop natural resources in Sidoarjo regency which must be optimally and sustainably based on the concept of natural resources development. The development of Lumpur Island area as an eco-tourism area is one of the alternatives in increasing economic growth around the area.

Tourism and fishery activities basically have different spatial allocations, so it will be a challenge if both designations can be done in an integrated ways for tourism development [9], and turns out eco-tourism as a solution. Ekominawisata (eco fishery tourism) is a tourism activity to enjoy the natural atmosphere of mangrove ecosystem and fish resources in it responsibly by participating in maintaining its sustainability [10].

The initial step of success of land use is the selection of the appropriate location as well as in line with the type or concentration of land exploration, thus potentially, it requires a study of land mapping. Mapping activities undertaken in a wide scope of territory such as mangrove ecosystems of Lumpur Island requires considerable time and cost, making them less effective. Along with technological developments, the existence of mangrove ecosystem of Lumpur Island can be mapped easily. Remote sensing system and aerial photography used by using drones. The advantages of this technology are the effectiveness and efficiency in terms of space and time and low cost.

Researchers agree with Rokhmana [11] to add some interesting characteristics in the use of multi-rotor drones DJI Phantom 3 Professional in general, namely (1) the relatively cheap cost, because the current market price is Rp. 17,000,000.- with 2 spare batteries; (2) to operate easily and more stably; (3) in accordance with geometric accuracy (sub-meter) (4) long travel, or around 20 minutes for one battery and can reach distance of 1 km; (5) has been widely supported both paid and free applications for

mapping so that it can fly automatically on the desired mapping area, and (6) there is a 'back to starting point' flight feature if signal is lost between the drone and remote control.

Meanwhile, the multi-rotor drone DJI Phantom 3 Professional also has some disadvantages such as (1) if it used to map large areas (> 5000 ha), resulting in too much aerial photographs and battery usage; (2) It still needs some Ground Control Points (GCP) for accurate georeferencing; and (3) frequent loss of signal if done at too far distances and many covered locations of vegetation.

This study is aimed to 1) map the distribution and extent of mangrove ecosystems, 2) to analyze land use of Sidoarjo Lumpur Island as a reference in sustainable development of mud islands. A low-cost and human independent census technique developed by Rokhmana [11] and Ventura, et al [12] partially combining the use of an unmanned aerial vehicle platform (a small and low cost quadcopter) and specific human interventions to identify areas of interest in unexplored regions. We build the method to provide a way to acquire very fine spatial resolution imagery to map land use eco fishery tourism.

2. Methods

2.1 Research Time and Location

The research having been conducted in Tlocor Hamlet, Kedung Pandan Village, Jabon District, Sidoarjo Regency, East Java. Dusun Tlocor chosen as location of this research, because it is the closest settlement to Lumpur Island. The study was conducted from April 2016 to February 2017.

2.2 Materials and Research Tools

We used a prefabricated quadcopter provided with an integrated camera and gimbal (DJI Phantom 3 Professional) drone for shooting the existing condition of Lumpur Island area and stationeries. For field data validation, equipment used are GPS Garmin Oregon 650, Arcgis software version 7, Arcgis version 10.2, and Microsoft Excel 2007 is used for calculation, processing, and data interpretation.

3. Data collection

3.1 Planning

The first step to take aerial photographs is planning. During planning, a discussion was conducted on the location where the aerial photography will be taken in Lumpur Island, the type of aircraft used was the multi-rotor drone type, the flight height of 120 m. Although the camera specifications make this combination less suitable for the creation of ortho photos (especially the DJI Phantom Vision+) [13], however the added value (DJI Phantom 3 Professional) is in the possibility to make orthophotos and oblique photographs.

3.2 Preparation

The next step is the preparation that include the aerial camera system, availability of drone batteries, as well as the planned flight path to be traversed. The detailed preparations made on the aerial camera include:

1. Installation of programming and settings on the drone camera system, so that the camera can take photos of the earth's surface automatically when the camera is flown.
2. Integration of compass system and IMU (Inertial Measurement Unit) and GPS (Global Positioning System) on drone rides needs to be calibrated.

The next stage is to prepare a plan for the flight path to be photographed. In areas designated as flight paths, observations had been made to establish the points of the aerial photographic location by using a reference to Google Earth or other reference map at that location. Subsequently, ground truth is generated along the flight path according to the specified airspace location points.

3.3 Ground Test

After all the preparations had been completed, then the testing of the camera system on the ground

(ground test) is intended to determine the overall performance of the camera system, such as the camera's resistance to shocks, the suitability of the camera image position, the accuracy of the coordinates in the image of ground test results.

3.4 Camera calibration

Results obtained from the ground test are then used to re-calibrate the camera system, both internally and externally. Internally, it is to re-adjust the internal camera, such as focal length, camera shutter speed, and exposure time; while externally re-adjusting the layout of the camera or camera holder on the rides. According to Purwanto [14] Ground Control Points (GCPs) which in this case use DJI Phantom 3 Professional drone type has been through post processing process so that its accuracy can reach 0.03 to 0.1 cm.

3.5 Aerial photo taking

Next step is taking aerial photography. Additionally, to ensure aerial cameras work properly, it must also ensure the weather conditions when shooting. Cloudy sky or a very hot sun, of course, will affect the results of aerial photographs.

3.6 Aerial image results processing

In order that the aerial photographs images to be utilized by remote sensing image data users, the data of the aerial photograph should be processed (corrected) first. Thus, the image data of the aerial photograph is in accordance with the satellite remote sensing standard image, i.e., geometrically corrected image [15].

The data used include primary data and secondary data. Primary data were obtained by field measurement, direct observation and documentation; while secondary data were obtained from the literature study. Satellite data used is satellite image of Landsat in 2005 and 2015 (Figure 1 and 2).



Figure 1. Porong river estuary condition in 2005 **Figure 2.** Porong river estuary condition in 2015

4. Data analysis

Data analysis was done by using remote sensing integration (aerial photography overlay) and Geographic Information System (GIS) to know the land utilization at research location. Analysis of aerial photographs using elements of interpretation of colors, shapes, patterns and sizes.

Color interpretation consider dark and bright colors of the shooting object. The brightness of the color indicates the density level of mangrove vegetation, the darker the brightness level indicates the higher density and height of mangrove vegetation cover [11]. Vice versa, the brighter the color, the more distant the distance between vegetation mangrove and the low level of vegetation cover is low.

The roughest scale for mangrove zone detail mapping is 1: 15,000 (although 1 mm wide zone depiction would be less accurate) and the roughest spatial resolution is around 2.5-4 m [16]. Aerial

photos of Lumpur Island are photographed using Phantom 3 Pro drone rides at a height of 120 meters. Mangrove mapping on Lumpur Island is done on a 1: 2,000 scale so that it can be concluded that this mapping is very accurate.

Aerial photograph analysis used is according to Van Gils et al (1990) in Danoedoro [16] that is the photo key approach, in which photomorphic appearance in the image is used as the main foundation in the differentiation of various object appearances. According to Danoedoro [16] key photo approach specifically for vegetation, textural coverage of canopy cover combined with hue/color and elevation impression are the main elements of the introduction of vegetation types.

5. Result and Discussion

5.1 Mapping of mangrove vegetation

According to Ventura, et al [12] ecologically, point of view this low-cost drone results shown how ultra-high resolution imagery acquired by small unmanned aerial vehicles can be valuable in identifying and characterizing coastal area. Based on the results of topographic measurements and aerial photographs with drone rides (Figure 3) the following data are known:

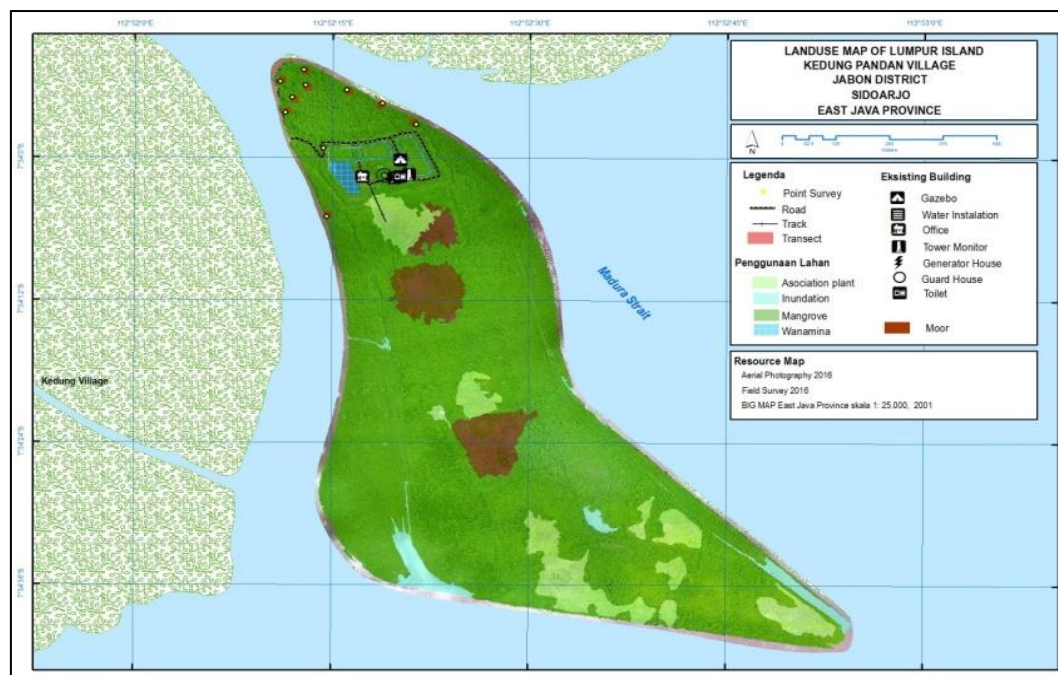


Figure 3. Measurement location map at Lumpur Island

1. The total aerial photographs of 708 images displaying the shape of Lumpur Island like the letter L with an area of about 85.37 ha. The final report from BPLS and BPOL [1] shows Sidoarjo Lumpur Island has an area of about 94 ha. This wide difference is result of the analysis of aerial photographs conducted by researchers at the tide of sea water.
2. The highest elevation of the island is +2,367 above sea level, located in the existing hall building area included in the tidal zone of sea water. In this zone mangrove plants can grow well.
3. existence of mangrove ecosystems spread throughout the island with varying heights, ranging from 50 cm to 7 m. The total area of this mangrove ecosystem is 70.38 ha.

Mangrove ecosystem on Lumpur Island has high density. From the analysis with plot samples measuring 10 m x 10 m of 9 plots, each transect contains more than 15 mangrove trees per 100 m². The

high level of mangrove vegetation density shows the regeneration of mangrove vegetation found in Pulau Lumpur is high.

The results also had shown a good level of mangrove vegetation thickness, which means that the mangrove vegetation damage level of Lumpur Island is very small. Mangrove cultivation on Lumpur Island is done by replanting, i.e. if there is a dead mangrove that will be replanted with the same species.

With good density and thickness, mangrove ecosystems are able to supply the surrounding waters with leaf litter and nutrients, so as to sustain and maintain the continuity of fishery activities and other biota.

5.2. Analysis of Land Utilization

Land cover types in urban areas have characteristic temporal profiles in several spectral regions, and particularly, conversion from agriculture to urban lands leads to a reduction in year-to-year greenness [17, 18]. If this situation is unable to be properly managed, deforestation rate will increased over the period of time [18]. The management of the eco-tourism will be a solution to suppress deforestation rate land utilization of Lumpur Island. Land utilization of Lumpur Island is adjusted to surface characteristics of the area inside which is divided into 4 types:

5.3. Dry and Open (Mooring) Area

The total of this area is about 4.9 ha. It is located in the middle of the island, unevenly distributed. This area has a dry soil contour, so it can be utilized as a land for the construction of permanent and semi-permanent building facilities to support tourism activities, such as exhibition space of mangrove processing, restoration, toilets, diesel-powered electric generator building, mushola (praying house), children playground and health service room. Some of this area's land has been used for building guard houses (security offices) and halls.

5.4. Half Dry and Open Area

Located in the central part of the island, and a small part of the south of the island. The condition of the soil is still muddy but walkable. Most of these areas are still open only overgrown vegetation mangroves relatives and shrubs. This area has an area of about 7.51 ha. With the condition of the soil is still muddy, the utilization is more directed to build tourism support facilities, such as mangrove tracking zone, tower view, gazebo and mangrove nursery area.

5.5. Mangrove ecosystem area

This area is scattered throughout the island and has overgrown mangrove vegetation with an area of about 70.38 ha. The mangrove ecosystem area will not be used for pavement or building cover, so this area is specially designated as green area.

5.6. Inundated area and ponds

This area covers 2.58 ha. This area is located in the southern and northern parts of the island. This area is always inundated by sea water. 0.58 ha of land in some parts of the northern part of the island has been used as a pond with a wanamina (silvofishery) system built by the Marine Research and Observation Agency (BPOL), Ministry of Marine Affairs and Fisheries (KKP) in 2011.

From the results of aerial photographs, facilities and infrastructure that has been built by the BPLS in the dock of Tlocor hamlet, among other thing dock mooring boats, roads, parking areas, stage and the heart-shaped 'I Love the Environment' monument. Furthermore, the community also independently built other facilities such as islamic prayer room (musholla), stand and means of water bike pool (Figure 4).



Figure 4. Facilities and infrastructure at Tlocor hamlet and Lumpur Island.

Potentially, mangrove and pond in Sidoarjo Lumpur Island which has an area of about 70.38 ha and 2.58 ha respectively, is appropriate to be an eco-tourism area. Through land use that is adapted to the surface characteristics of the area, conservation of mangrove both will remain preserved and provide economic benefits for the community continuously. The people of Sidoarjo and the City of Surabaya can make the municipality of Lumpur Island as one of its tourist destinations. The mangrove potential is not only found at Lumpur Island but also in areas in Sidoarjo regency, highly potential to make Sidoarjo regency as a model city of eco-tourism.

This study revealed the requirement to consider seasonality when attempting to discern urban change. Sidoarjo Regency as a buffer of Surabaya city can surely contribute to improve the economic life of the community in that city, if Sidoarjo Lumpur Island becomes a national-scale eco-tourism area and Sidoarjo Regency becomes the model city of eco-tourism.

6. Conclusion

Potentially, Sidoarjo Lumpur Island may be developed into an eco-tourism area, especially the mangrove area covering 70.38 ha from total and area of 85.37 ha. Based on map overlay result, the area is divided into space utilization based on specification of area, that is open area (mooring), semi-dry area, mangrove ecosystem, pond and inundated area. Government intervention related the control of Land use change are expected to have an impact on improving the socio-economic conditions of the peri-urban population.

7. References

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