

# Characterization of hydrological aspects in Kolong Enam Retention Basin, Kijang, Bintan Island, Indonesia

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**Abstract.** Bintan Island in the Riau Islands Province is classified as a small island ( $\pm 1170 \text{ km}^2$ ) with limited freshwater resources. The availability of raw water on Bintan Island will certainly be determined by the characteristics of hydrobiological aspects of Bintan Island. Fulfillment of freshwater needs is carried out through the creation of raw water shelters in the form of reservoirs, pond, retention basin, dams, or abandoned bauxite mining pits. One of the raw water sources on Bintan Island is Kolong Enam retention basin. This study aims to examine the hydrological aspects of Kolong Enam retention basin in Bintan Island. The main data used in this study is digital elevation model (DEM) to extract hydrobiological aspects on Bintan Island. In our study found that Bintan Island has nine sub-watersheds. Kolong Enam retention basin is located in the catchment area of Gunung Lengkuas, East Bintan District. The catchment area of Kolong Enam retention basin has an area of 1067,31 ha, which consists of 3 river orders. With regard to vegetation coverage from 2000-2018, it is indicated that there has been a decrease in vegetation coverage in the Kolong Enam retention basin water catchment area.

## 1. Introduction

Bintan Island is determined by the government as a National Strategic Industrial Estate based on Presidential Regulation No. 87 of 2011, will have implications for increasing the demand for raw water needs. Characteristics of Bintan Island are categorized as small islands where that island is a post-bauxite mining area, [1, 7, 9, 13, 14, 15] is expected to have dynamic hydrological characteristics of existing reservoirs or water reservoirs. A dam or retention basin is a basin used to regulate and accommodate the supply of rainwater and to improve water quality in related water bodies (rivers, lakes). The rainwater storage can be used during the dry season [8]. Small islands also have very limited water catchment capacity and have specific hydrological conditions [5].

Although Bintan Island is categorized as a small island, development on Bintan Island, especially in Kijang City, begins with the rapid development of the mining sector such as granite and bauxite. In early 2000 this sector was no longer a priority due to the diminishing economic potential of granite and bauxite resources. The abandoned bauxite mining pits on Bintan Island has changed the land cover pattern a lot and also left the post-mining tailings pond which is known by the local community as 'kolong'.

Kolong Enam retention basin is one of the sources of raw water in the City of Kijang, Bintan Island. At the

beginning of its existence, it was a holding basin originating from the Lengkuas Mountain water catchment area which was used for the operational needs of the Aneka Tambang (Antam) company. In line with the rapid population growth and regional expansion, Kolong Enam retention basin has become one of the providers of raw water in the City of Kijang, Bintan Island. The existence of Kolong Enam retention basin in Bintan Island is expected to have dynamic hydrological characteristics of the existing reservoir or water reservoir. This study aims to examine the hydrological characteristics of Kolong Enam retention basin on Bintan Island based on DEM (digital elevation model) analysis.

## 2. Material and Methods

The study was conducted from June to August 2021 at the location of Kolong Enam retention basin in Kijang, East Bintan District, Bintan Regency. Kolong Enam retention basin has a watershed area of 2.29 km<sup>2</sup>, an inundation area of 18.73 ha, an inundation volume of 370,000m<sup>3</sup> and a retention basin bottom elevation of +5.75. The main data used in this study is DEM (digital elevation model) to extract hydrobiological aspects on Bintan Island. The DEM data was obtained from the USGS website (<https://www.usgs.gov/>) which was accessed in July 2021. Changes in vegetation coverage were analyzed from the classification of Landsat 7 imagery in 2000 and Sentinel 2 image in 2018. The

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image classification process is carried out automatically. Based on spectral patterns that have been determined at the time of the selection of AOI (area of interest). The watershed parameters studied consist of watershed area, main retention basin length, watershed width, watershed length, flow density, flow length, average watershed slope, average slope, average river channel, river order, watershed circumference, total river length, and watershed shape coefficient. Field surveys were conducted to collect secondary data from relevant agencies.

Slope, elevation and catchment area delineation from dem data were conducted using Qgis version 3.20 [4] with the following steps:

1. Mosaicking dem tiles from downloaded dem to create a single raster dem
2. Reprojecting dem
3. Calculating the flow direction map
4. Fill sinks/remove spikes to make a hydrological correct dem by filling sinks and removing spikes from raw dem
5. Subsetting dem to area of interest
6. Calculating slope (percent) and elevation (meter), polygonizing the output to vector
7. Deriving streams from subsetting dem by calculating the flow direction for each cell
8. Defining outflow point
9. Deriving catchment area and polygonizing the output to vector to extract area extent

Change detection analysis of vegetation cover was carried out using caret package [3] in R programming language [10]. The flow of analysis is presented in Figure 1. Random forest classification method was used for each image (Landsat 7 and Sentinel 2).

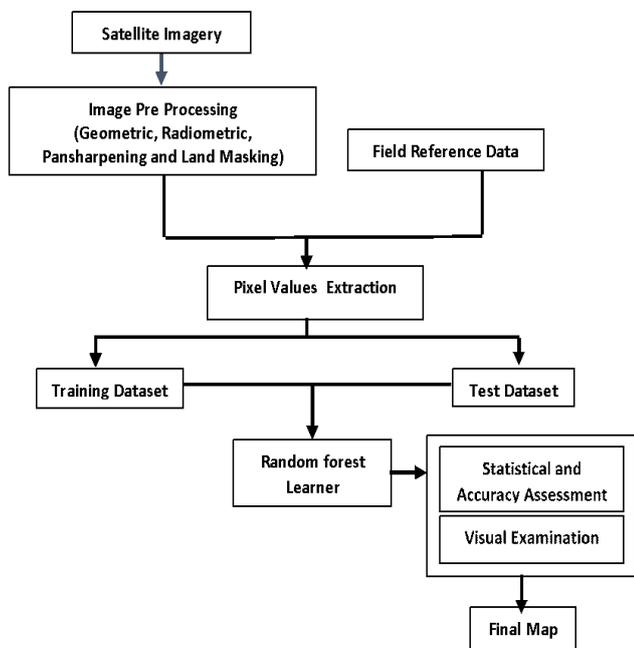


Fig 1. The flow of analysis

### 3. Result and Discussion

#### 3.1 Geomorphology of Watershed

Bintan Island has a topography which is generally an area with sloping plains on the coast. This island has a varied and undulating topography with slopes ranging from 0-3% to above 40% in mountainous areas. The altitude of the islands ranges from 0-50 m above sea level to a height of 400 m above sea level [2].

Digital elevation model (DEM) data processing is carried out to determine the water catchment path in a watershed. The results of the study from the extraction of DEM data showed that Bintan Island has 9 sub-watersheds (Figure 2). Kolong Enam retention basin as one of the raw water sources in this study is located in the Kalang Tua sub-watershed which is in the southernmost position of Bintan Island. The entire sub-watershed is included in the Bintan Regency area.

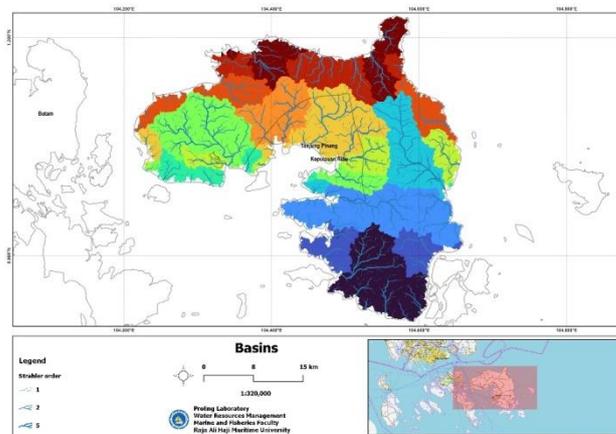


Fig 2. Map of Bintan Island watershed

Bintan Island is the largest island in the Riau Islands Province. In general, Bintan Island has an undulating hills geomorphology with a subtle elevation difference, namely with an altitude between 0 to 372 m above sea level [11]. The landscape of Bintan Island can be classified into several groups (Figure 3) as follows:

1. Lowland units are spread over most of the Bintan Regency area with an altitude of <25 m above sea level and the average slope is relatively flat and slightly sloping.
2. Units of wavy hills with low relief in areas has undulating hills with a height of <50 m above sea level and a rather steep slope.
3. The unit of wavy hills with moderate relief is in the form of a ridge with a height of > 50 m above sea level and a steep slope.

Based on the results of the morphological analysis presented in Figure 3, it is known that the Kolong Enam retention basin, holds water from a high hill area on Bintan Island, specifically in Gunung Lengkuas area. The geographical condition of the sub-watershed shows that the Kolong Enam retention basin catchment area consists of 3 river orders, the sub-watershed name is Kalang Tua, and the catchment area is Kolong Enam retention basin. The location of the retention basin that catches water from steep to flat areas will determine the

availability of raw water to meet of water needs by society, especially in the dry season with a catchment area of 1067.31 ha. The results of the morphometric

analysis presented in Figure 4 show that the steep upstream slope and the flat downstream slope have great potential to fill water reserves during the rainy season.

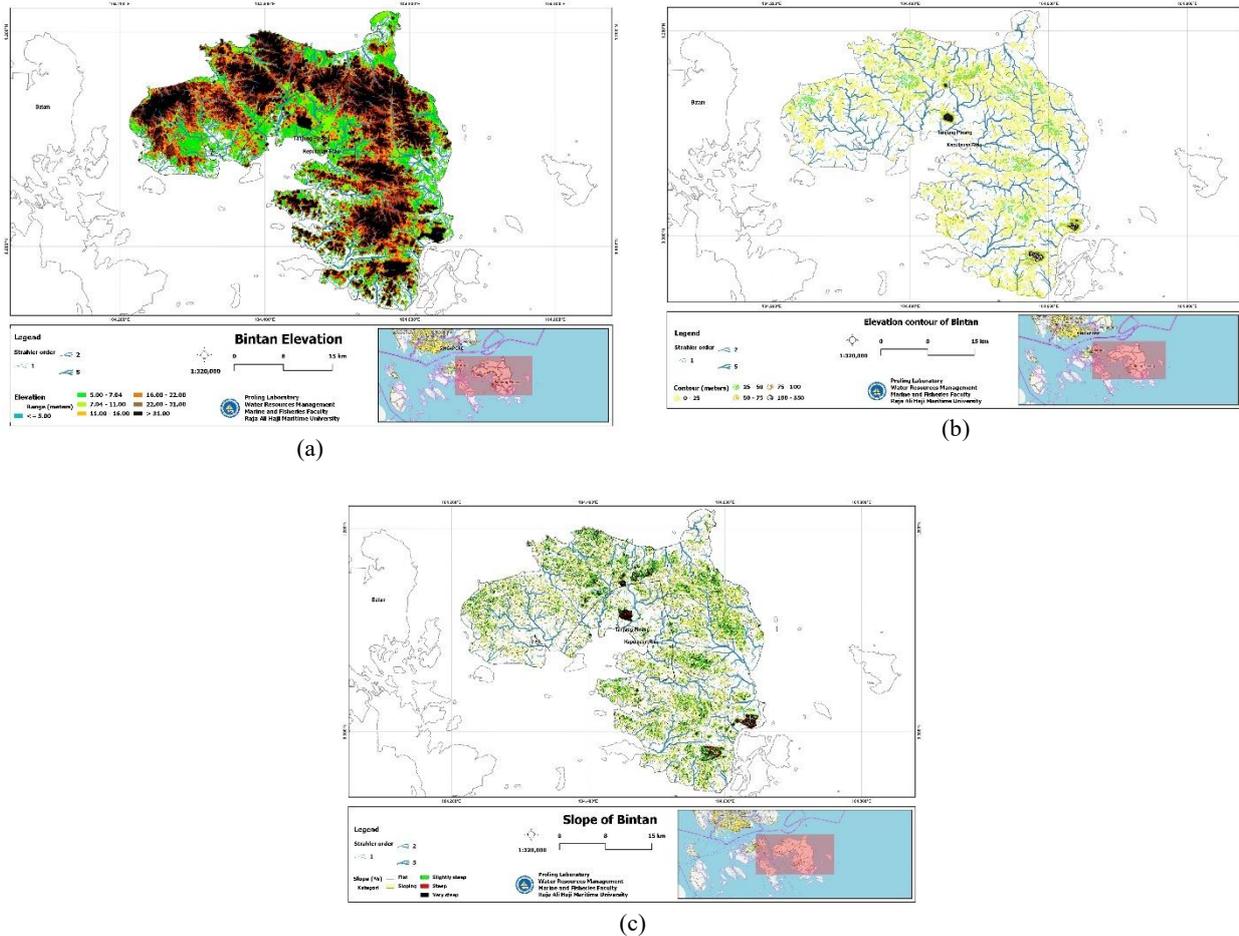


Fig 3. Bintan landscape:(a) elevation; (b) contour,and (c) slope

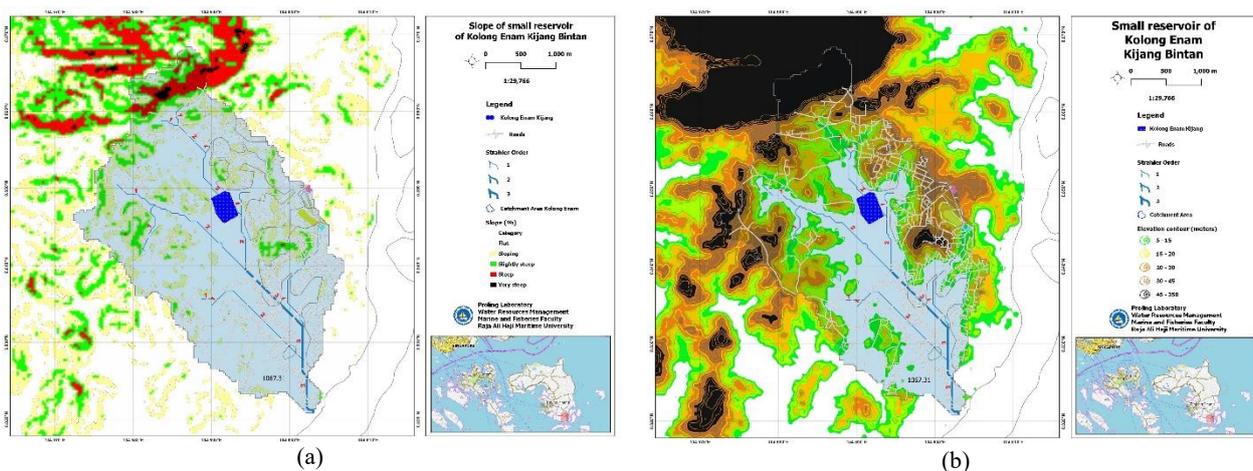


Fig 4. Kolong Enam retention basin: (a) Location; (b) Elevation and river orders

### 3.2 Vegetation Coverage

Climate change dynamics and human activities have various impacts based on environmental conditions in

the Kolong Enam retention basin area. As time goes by, the condition of the forest area can be seen from the condition of the vegetation coverage that has undergone rapidly and dynamically changes in accordance with

developments that occur. Changes in landcover, especially in vegetation coverage, have a major influence on the availability of water sources in an area [6].

Analysis of vegetation coverage result in the Kolong Enam retention basin area from year of 2000 to 2018 indicate a decrease in vegetation coverage in the water catchment area (Figure 5). In 2000 the vegetation coverage in the Kolong Enam retention basin area 710.18 hectares, until 2018 the vegetation coverage in the Kolong Enam retention basin was 383.24 hectares. There has been a decrease in area to 326.94 hectares for 18 years. Based on the condition of the vegetation

coverage in 2000, the vegetation coverage of forest land was still dominant, indicated by vegetation coverage that classified as dense. Based on vegetation coverage condition in 2018 it could be concluded that vegetation coverage is still dense only in the upstream areas, but has begun to turn into open land in the catchment area around the retention basin. The vegetation areas decreased year by year for 18 years occurred due to the conversion of forest land to other land uses so that it has implications for quality and area of the forest decreased. [12] stated that for more than 30 years, Kijang District was the center of concentration of bauxite mining on Bintan Island.

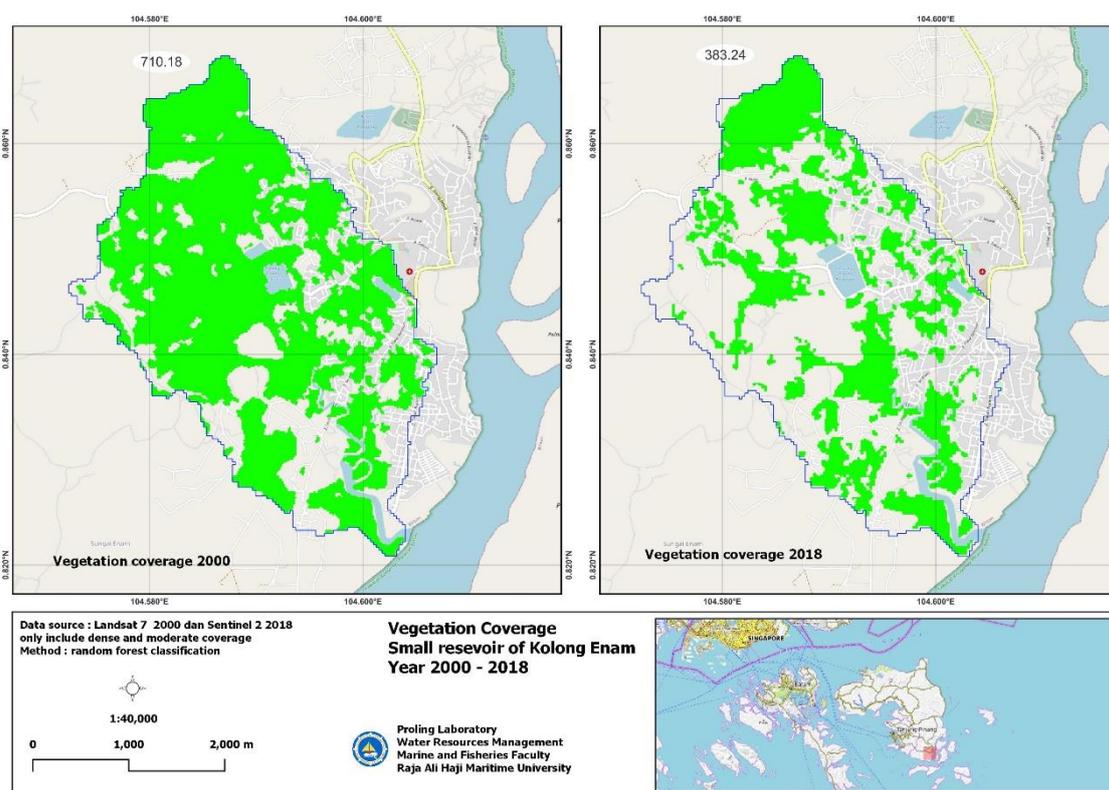


Fig 5. Vegetation coverage from 2000 (left) to 2018 (right)

## 4. Conclusion

Bintan has 9 sub-watersheds. Kolong Enam retention basin is located in the Kalang Tua sub-watershed. The catchment area of Kolong Enam retention basin has an area of 1067.31 ha which consists of 3 river orders. With regard to vegetation coverage, from 2000-2018, it is indicated that there has been a decrease in vegetation coverage in Kolong Enam retention basin water catchment area.

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