

# Identification of landscape disturbance in the Parangtritis sand dune area for sustainable environment

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**Abstract.** In 2014, the Parangtritis sand dunes area has been established as a geological natural preserve. Due to its distinctive characteristics and uniqueness, the Parangtritis sand dunes area is included to the privilege values of Yogyakarta Province. This research aims to 1) identify various anthropogenic activities that possibly affecting the natural process of the Parangtritis sand dunes, 2) formulate appropriate management actions to ensure the continuity of aeolian process. Several anthropogenic activities were identified in the research area such as settlements, agriculture, fishponds, and coastal forest cultivation. Among those anthropogenic activities, coastal forest cultivation is the most threatening activity to the aeolian process of the Parangtritis sand dunes. Beside the density of the vegetation, much also inhibit the sand transport as the main controlling factor for the formation of sand dunes. For precise management actions, sand dunes zonation is urgently required. The whole area in the supply zone must be cleared from any anthropogenic activities to keep the sand sufficient. The transport zone, where the sand is actively transported also should be cleared from anthropogenic activities, especially from coastal forest cultivation. In this zone, indigenous vegetation are allowed to grow as biodiversity icon. The accumulation zone is suitable for coastal forest cultivation as a barrier and protection for the settlement area and agriculture area outside the Parangtritis sand dunes.

**Keywords:** landscape disturbance, sustainable environment, Parangtritis sand dune

## 1. Introduction

Coastal sand dunes are typical landform that occur by the aeolian processes. Aeolian process is a geomorphological process that have two aspects which are erosion and deposition. The sand accumulation work is very dependent on the grain size of the sands [1]. Wind is the main transport agent in the aeolian process. The wind blown out the sand particle and naturally sort the sands based on its grain size [2]. The sediment transport sediment in three different ways i.e. rolling, saltation, and suspension [3]. One of the results of sand accumulation process is the formation of sand dunes. Barchans dunes or crescent moon dunes is very distinctive sand dunes type. Parangtritis coastal area is one of the locations in the world where the barchans dunes are formed.

The uniqueness of Parangtritis coastal area is the existence of barchans sand dunes, which commonly formed in a region with dry climate. However, the coastal area of Parangtritis is considered as wet tropical climate region. Parangtritis coastal area is very suitable for the formation of sand dunes because of several controlling factors such as 1) the wind blowing from the sea to the hinterland; 2) the existence of wind corridor or natural wind tunnel; 3) sufficient sands supply; 4) unconsolidated materials; 5) beach



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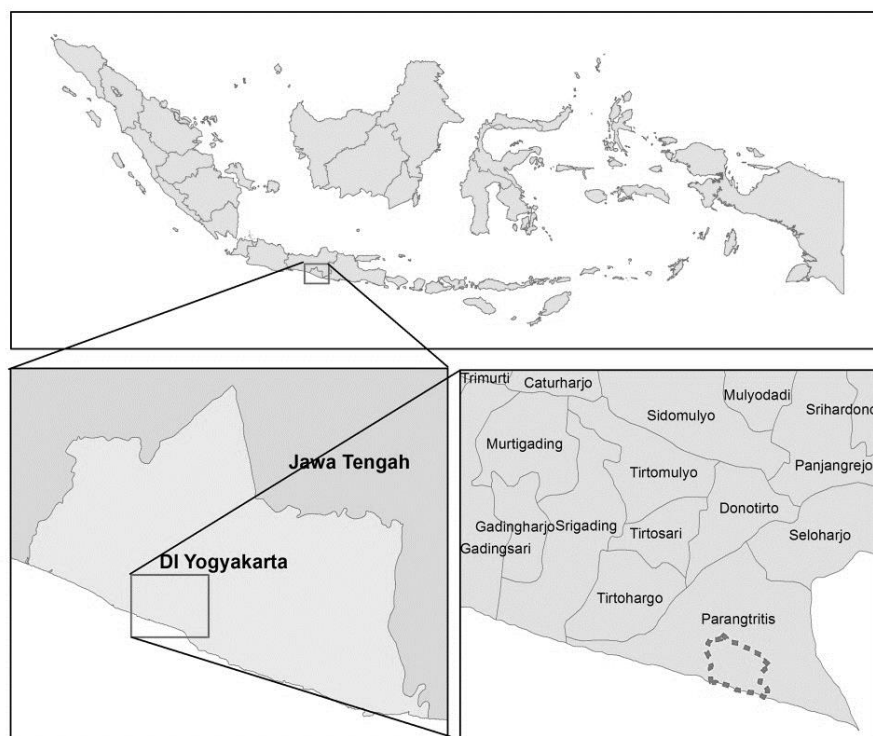
morphology; 6) beach sloping factors; 7) beach width; and 9) the tidal range [4]. The composing material of Parangtritis sand dunes were originated from Merapi Volcano, and mainly composed by magnetite, volcanic glass, andesitic rock fragment, plagioclas, augit, hyperstin, and some ilmenite [5].

The existence of sand dunes are becoming one interesting factors for tourism activities in coastal area. Sand dunes phenomenon in the coastal area is a very interesting and attractive factors in terms of tourism development [6]. The development of tourism in Parangtritis coastal area lead into rapid anthropogenic development within the coastal area. This research aims to identify several anthropogenic activities that possibly disturb the process of sand dunes formation and propose a suitable micro zonation to protect the sand dunes sustainability.

An example of serious protection effort by the government, formal regulation has been released (governmental legislation). The formal legislation expressed in Government Regulation number 26 year 2008 about Spatial Planning of National Region and Regional Regulation of Yogyakarta Province number 2 year 2010 about Province of Yogyakarta Spatial Planning for 2009-2029, as provincial strategic region of protection and cultivation. Therefore, several aspects related to detailed landscape planning in Parangtritis Coastal Area is necessarily important and must consider the natural process to keep the sustainability of the sand dunes.

## 2. Method

The main data for this research was collected by field survey and measurement of several natural processes such as wind and sand movement in sand dunes area. The observation began with aerial photograph and satellite images interpretation to identify anthropogenic activities in the reseach area. The research area map can be seen in Figure 1. The identification results then validated on the field to identify the real condition in the research location. Further observation carried out to determine the impacts of each anthropogenic activities to the sand dunes formation.

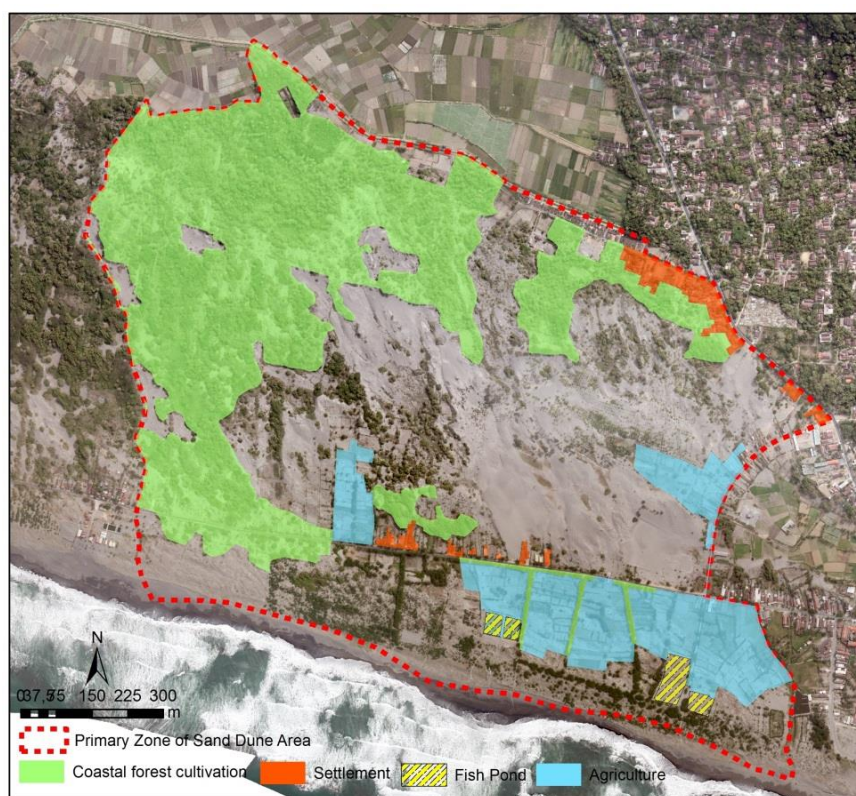


**Figure 1.** The research location map at the primary zone of Parangtritis sand dunes.

In addition wind velocity measured by hand held anemometer and wind direction measured by compass, while the sand movement measured using vertical sand trap or sand sampler [7]. Result from wind measurement presented as m/s for wind speed, while sand movement (transport) presented as gr during one hours measurement. Others weather condition measured by automatic data recorder installed in sand dune area near research location. The results from the measurements then used as the main data that provide scientific consideration for proposing microzonation in the primary zone of Parangtritis sand dunes. The microzonation could be very useful for more detailed landscape management.

### 3. Result and Discussion

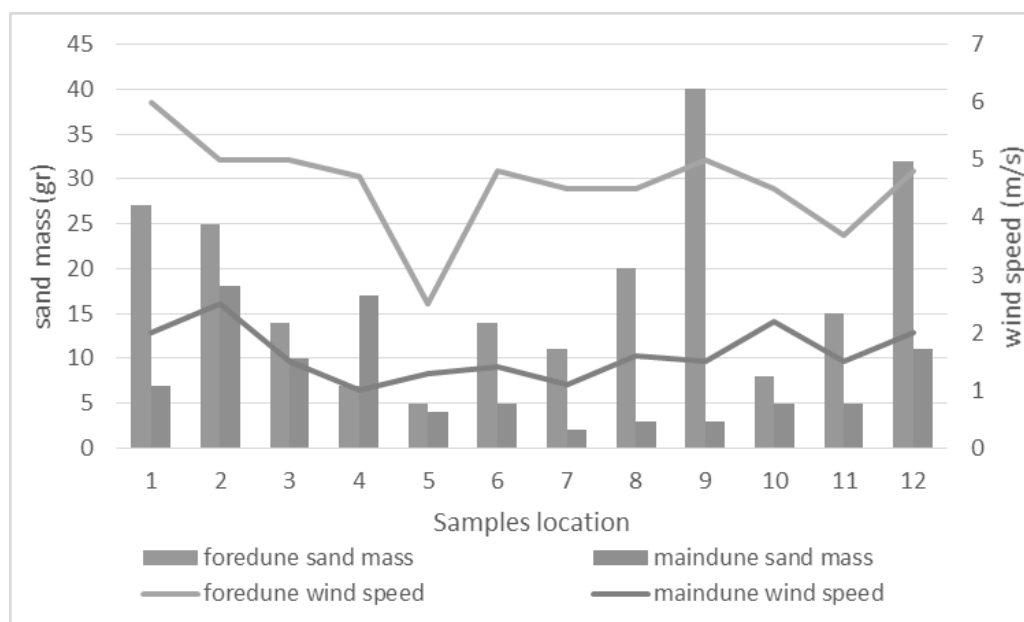
According to the interpretation of 2014 aerial photograph, it can be recognized that the sand dunes area occupied by several land use. Land use is considered as anthropogenic activity within the sand dunes area, especially in the primary zone. Several land use type that occupy the primary area are coastal forest, paddy field, husbandry, settlement, fishponds, bare land, pasture, and dry land agriculture. Coastal forest is the most dominating land use in the primary zone. Coastal forest occupy 86 hectares of the primary zone. The most dominating vegetation in the coastal forest is *Causarina equisetifolia* and *Acacia mangium*. The delineation of land use by 2014 aerial photograph shown in Figure 2.



**Figure 2.** Primary zone land use in 2014 from the sand dune area of Parangtritis.

To determine which land use with the most considerably impact on sand transport process, therefore the land use change pattern over years should be analyzed. From 1980 to 2014, the land use change was very rapid, especially the vegetation cover. Forest plantation program initiated by certain department causing the increasing of vegetation cover. Uncontrolled vegetation cover might interfere the sand transport as the main process of sand dunes formation. The measurement results from the vertical sand trap also show the different between open space area and area that covered by vegetation cover. Result from sand transport measurement shows in Table 1. Based on the measurement there was different sand

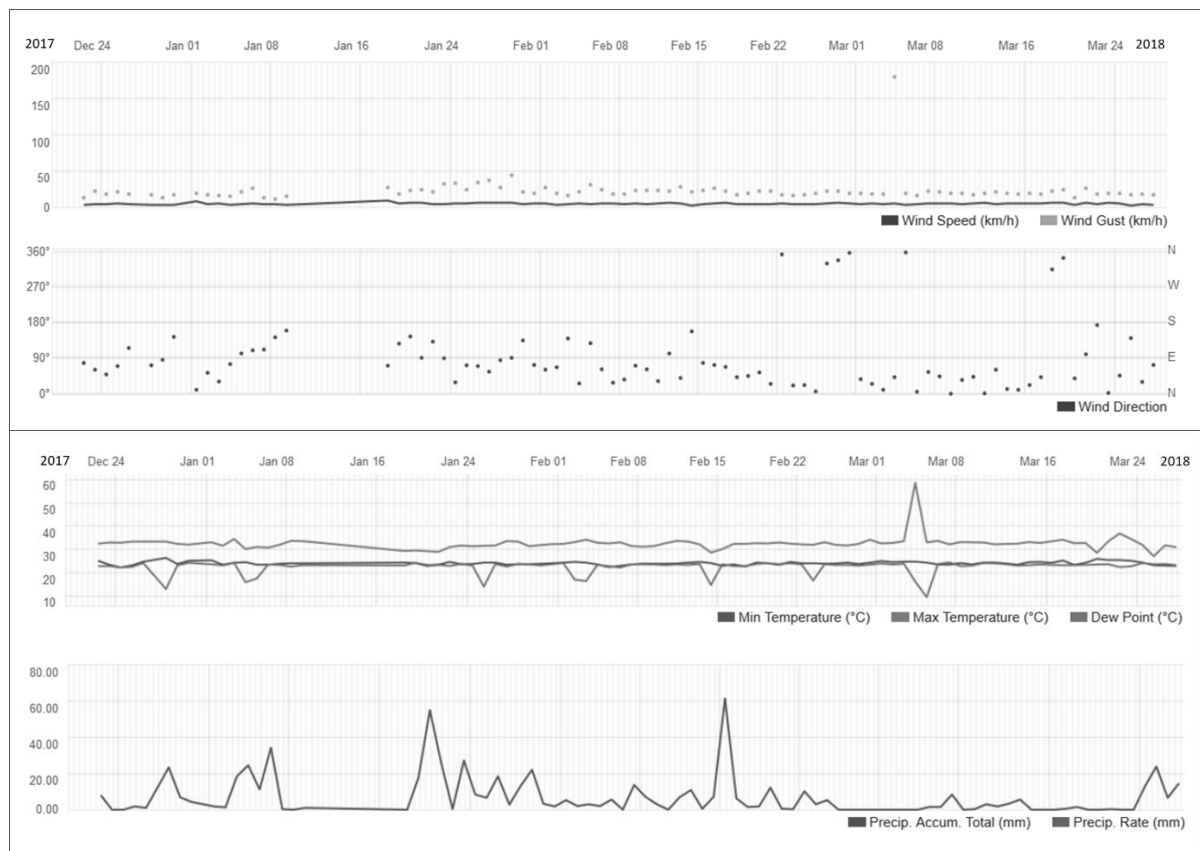
mass transporting by wind between fore dune and main dune. Sand mass transported on the fore dune are greater than main dune. Heaviest sand mass recorded on the fore dune was 40 gr transported by wind with speed 5 m/s. Smallest recorded sand mass transported by wind was 2 gr with wind speed 1.1 m/s on the main dune. Based on Figure 3, also inferred that sand transport reduced by anthropogenic disturbance between fore dune and main dune. Besides that, wind speed also reduced. Average wind speed reduced by anthropogenic disturbance between fore dune and main dune is 3 m/s. However, sand transport has greater reduction with average sand mass is 10 gr. This data provide some facts that anthropogenic disturbance significantly affected to the natural Aeolian process, especially sand movement by wind.



**Figure 3.** Comparison sand transport field measurements on the fore dune and main dune area of Parangtritis.

Weather condition on sand dune are of Parangtritis has unique condition especially some parameters related to sand transport process. The most influenced parameter is wind speed. From weather data recorded from automatic weather station (AWS) installed on sand dune area managed by collaboration between Parangtritis Geo-maritime Science Park (PGSP) and Faculty of Geography of Gadjah Mada University, showed that maximum wind gust recorded on December 2017 to March 2018 is 44 km/h and maximum wind speed is 9 km/h (Fig. 3). Based on Beaufort's scale wind gust classified as strong breeze and wind speed mostly classified as light breeze. Those wind are dominance blown to northern direction. Other parameter that influenced to sand transport process is precipitation. When sand became wet due to heavy rainfall, sand cannot move because their density is increase. The maximum rainfall recorded is 61.5 mm per day on February. However, beside all recorded data is dominance by rainy day, a couples days on March recorded as no rainfall events. This events might be the best events for sand transport process on sand dune area. Therefore, sand transport will effectively occurs on dry season (Figure 4).



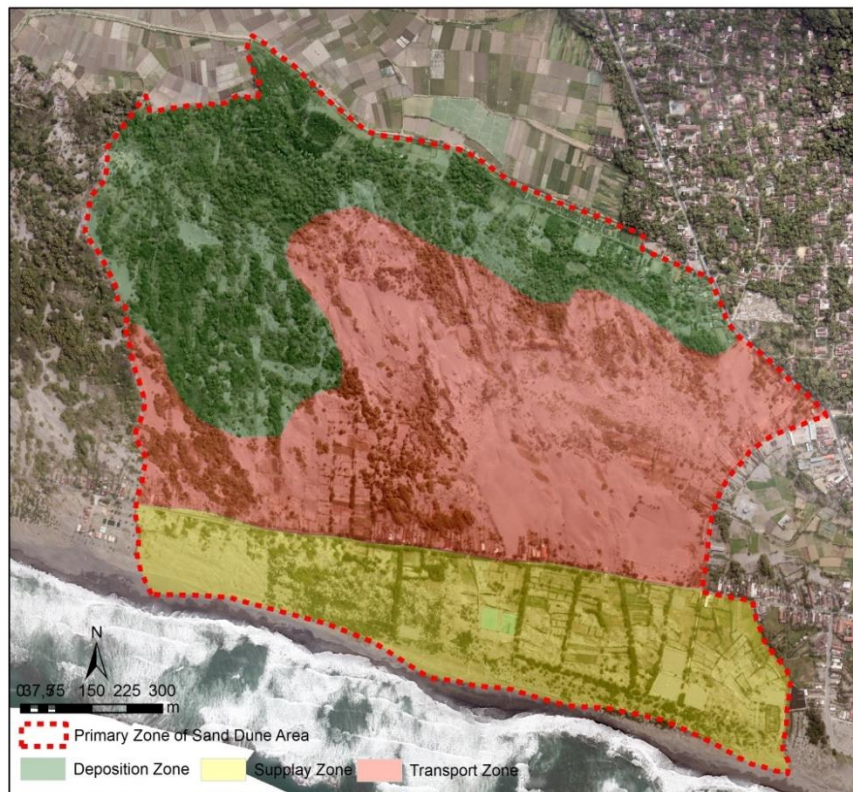


**Figure 4.** Some weather conditions recorded from AWS installed on sand dune of Parangtritis.

The AWS recorded data can be easily downloaded on: <https://goo.gl/pdn69W>

To manage the sustainability of Parangtritis sand dunes ecosystems, microzonation based on the effect of anthropogenic activity and intensity is required. The main consideration for this microzonation is sand movement process. Based on the identification, it is recognized that the sand transport zonation divided into three zone namely supply zone, transport zone, and deposition zone. The supply zone is where the sand material source located and being transported by the wind. The sand material originated from marine deposition that located in fore dune area. The transport zone is where the sands actively transported by the wind. The dynamic wind movements transport the sand with different movement types. According to the measurement, 60% of the sands transported by creeping, 35 % by jumping, and the rest transported by floating in the air (Table 1). The deposition zone is where the sands accumulated and become the last location for the sand movement. This zone is adjacent with the other zone outside the sand dunes primary zone. The sand dunes zonation shown in Figure 5.

Not only the spatial distribution, but activities management inside the primary zone also necessarily important especially related to land use management. In the supply zone, the anthropogenic activities that should be restricted are fishponds, settlement, and agriculture. The vegetation existence are needed in several locations to reduce the impacts of high tide and marine erosion. In the transport zone, all the anthropogenic activities that already mentioned before should be restricted. Only indigenous vegetation that allowed to grow, which is *Siwalan*. In the deposition zone, the anthropogenic activities that must be restricted are agriculture, fishponds, and settlement. The indigenous vegetation are allowed as a barrier to prevent the sand movement to the settlement area outside the primary zone.



**Figure 5.** Microzonation of primary sand dune area of Parangtritis.

#### 4. Conclusion

Sand transport measured on field provide that anthropogenic disturbance significantly affected to the Aeolian processes, this is indicated that landscape disturbance has occurred on the study area. There are four type of anthropogenic intervention that caused landscape disturbance in Parangtritis sand dune area, i.e. settlement, fishpond, coastal forest, and agriculture. Coastal forest cultivation is the most influence due to environmental change. Primary zone need to divided into three micro zonation based on geomorphological process. Each microzonation created for proper landscape and environmental sustainability, especially for sand dune natural processes.

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