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*by* Endang Hilmi

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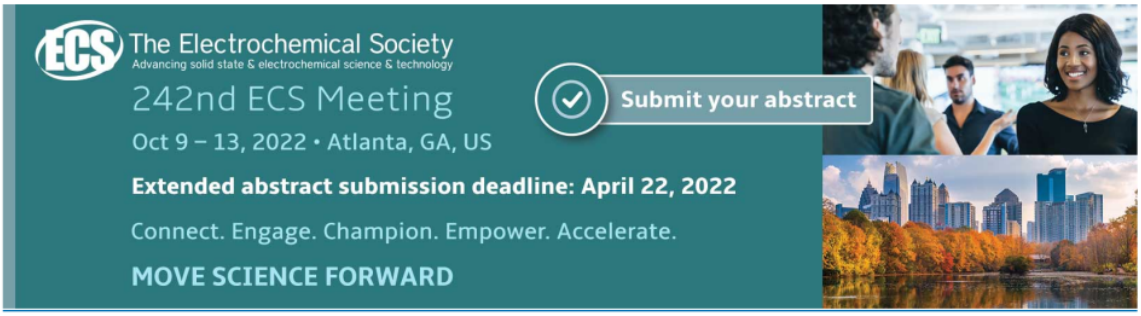

# The potential of high tidal flooding disaster in North Jakarta using mapping and mangrove relationship approach

**Endang Hilmi [1, *], Amron [2], and Dandhy Christianto [3]**

[1]Program of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, Universitas Jenderal Soedirman. Jl. Dr Soeparno, Purwokerto Utara, Banyumas 53122, Central Java, Indonesia. Tel.: +62-281-6596700
[2]Marine Science Proram, Faculty of Fisheries and Marine Sciences, Universitas Jenderal Soedirman. Jl. Dr Soeparno, Purwokerto Utara, Banyumas 53122, Central Java, Indonesia. Tel.: +62-281-6596700
[3]Under graduade of Marine Science Proram, Faculty of Fisheries and Marine Sciences, Universitas Jenderal Soedirman. Jl. Dr Soeparno, Purwokerto Utara, Banyumas 53122, Central Java, Indonesia. Tel.: +62-281-6596700

[*]Email: dr.endanghilmi@gmail.com

**Abstract**. North Jakarta is widely used for various activities including industry, settlement, transportation, tourism and others. North Coast Jakarta also has high probability of coastal disaster including high tidal flooding which is caused by sea level rise, mangrove degradation and geomorphologicly area. This paper aimed to analysis the potential of high tidal flood using mapping analysis and mangrove density relationship. Mapping analysis and mangrove ecosystem relationships were used to analyzing the potential for tidal flooding. Data showed the density of mangrove ecosystems reaches 220-1100 trees $ha^{-1}$, a single daily tide, sea level reached 2.75m, sea level rise reached 2.74m (the rate reached 0.71 cm/year), tidal flooding to reach an area of 1014.69-1548.91 ha and land subsidence reach 12 cm/year

## 1. Introduction

North Jakarta is an area in Jakarta which located on the northern of the Java Sea [1], [2] which has many ecosystem that are the estuary ecosystem [2], [3], swamp ecosystem, coral reef and mangrove ecosystem.[2], [4]. The North Coast of Jakarta is an area to buffer and support development center and market building. In addition, based on economic activities, the North Coast of Jakarta is a main area in Jakarta to support many economic activities, like as industry, ports, settlements, markets and villages. Mangrove ecosystem has important fuction to support economic activity in North Jakarta

The mangrove ecosystem is a green growth and natural resources which have many important functions like as the function as a green belt and buffer to reduce coastal disasters. Some of the coastal disasters in the north coast of Jakarta are tidal waves, ROB, abrasion and land subsidence [5]–[8]

Tidal Flood or ROB is a natural disaster phenomena in the north coast of Jakarta which occurs during the full moon or new moon and will known as the Spring Tide process. Tidal flooding is a serious disaster to cities in coastal areas [9] for example in La Briere, Nantes, France and Rotterdam, the Netherlands [10]. North Jakarta has high potential of tidal waves which caused by sea level rise and relatively low and flat topography. In 1925-2010, North Jakarta has increasing of sea level with average of 0.5 cm/year, and rate of land subsidence reached 5 cm to 12 cm/year (in some locations reached 20-

28 cm/year) [11]. This conditions are the influencing factor of tidal flooding[9], [11]–[13], including in North Jakarta .

The phenomenon of tidal flooding give negative impacts on coastal areas like as change the physical environment, high pressure for communities, buildings, and settlement infrastructure, and ecosystems and landscapes damages. And the mangrove ecosystem in North Coast of Jakarta has function to reduce impact of tidal flooding and land subsidence [2], [7], because mangrove has strengthen and elasitic of mangrove wood and a distinctive root system to reduce impact of high tidal waves [7]. This paper aimed to analysis the potential of high tidal flood using mapping analysis and mangrove density relationship

## 2. Methods

### *2.1. Research Site*

This research was conducted on the North Coast of Jakarta from 2016 – 2021. The location determination is determined from the possibility of potential tidal flooding and the presence of mangrove ecosystems (Figure 1).

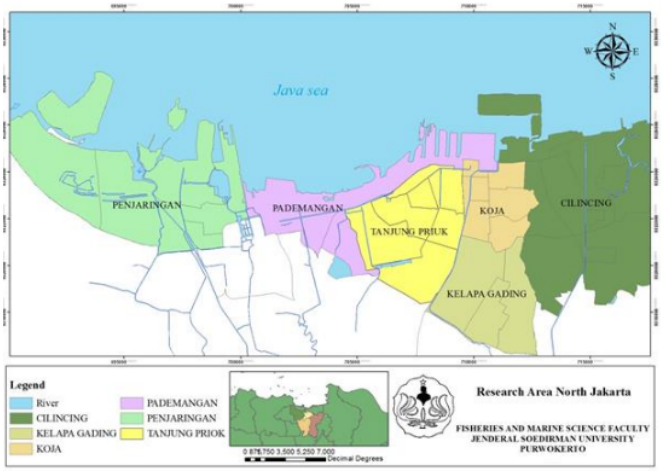


**Figure 1**. Research site

### *2.2. Research Procedure*

#### *2.2.1. Vegetation Analysis*

The vegetation samples for each sampling plot were collected using a 10 m x 10 m transect with 3 replications [14]–[16] (Figure 2). For each sampling plot was measured the number of mangrove species, the number of mangrove tress, diameter of breast high (for mangrove diameter > 4 cm) (Figure 2)[15] And then the vegetation from line transect will be calculated the mangrove density following [14], [15], [17] with equation :

$$mangrove\ density = \frac{the\ number\ of individual\ for\ mangrove\ trees}{area\ of\ sampling\ plot} \quad (1)$$

#### *2.2.2. High Tidal flooding (ROB) analysis*

The ROB analysis was built by analyzing

*2.3. Data Analysis*

Data analysis was carried out using a geographic information system which was integrated with mean sea level (MSL), DEM, highest sea level value (HHWL) and Interferometric Synthetic Aperture Radar (InSAR).

## 3. Result and Discussions

*3.1. Mangrove density in North Jakarta*

The potential of mangrove density in North Coast Jakarta can be seen in Table 1. The density data showed the potential density of mangroves (for diameter > 4cm) between 220 trees/ha-1565 trees/ha. According to Hilmi, 2019, the potential density of mangroves is classified as very rare - dense. This condition will lossing of the mangrove ecosystem as a buffer and preservation to reduce coastal disasters in North Jakarta [2], [4], [7]

**Table 1**. Mangrove Density in North Jakarta

| *Indicator* | **Mangrove density (trees/ha)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **North Jakarta (station)** | | | | | | | | |
| | Ekowisata | Lindung 1 | Lindung 2 | Lindung 3 | Arboretum | galatama | Muara gembong | Cilincing | Tol Sedyatmo |
| *Total* | 1100 | 311 | 330 | 220 | 600 | 738 | 1575 | 335 | 1025 |
| *SD* | 255 | 32 | 66 | 54 | 113 | 278 | 480 | 60 | 556 |
| *Class* | rare | very rarely | very rarely | very rarely | rare | rare | dense | Very rare | rare |

*3.2. Tidal and Sea level Rise*

The trend projections of annual sea level rise between 1984 - 2030 were shown in Figure 2. Base on Fromzahl's number = 12.91 (or F > 3), had meaning that the tidal tyoe in the North Coast was a single daily tidal type. These result is similiar with Indriani's research (2010) writes that the tidal type around Tanjung Priok Port is a single daily with a value of 3.44 fromzahl. This data also showed that North Jakarta [19] had one high tide and one low tide/day. The monthly tidal data and an average every year from Tanjung Priok station were processed by least square linear regression on the bivariate distribution value for 27 years of observation (1984 – 2010) showed increasing trend of sea level rise with the equation y = 0.0588x + 212.83, with increasing of sea level rise reached 0.71 cm/year.

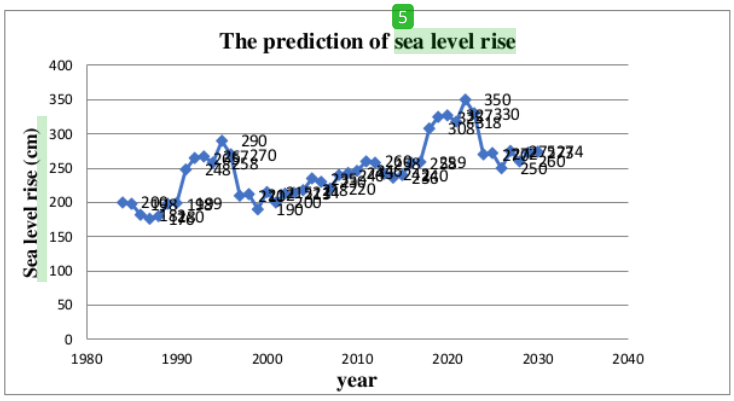


**Figure 2.** Sea level rise in North Jakarta

*3.3. Affected area of ROB or high tidal flooding and land subsidence*

The potential of affected area for tidal flooding due to tides, sea level rise and land subsidence can be seen in Figures 3 and Tables 2.

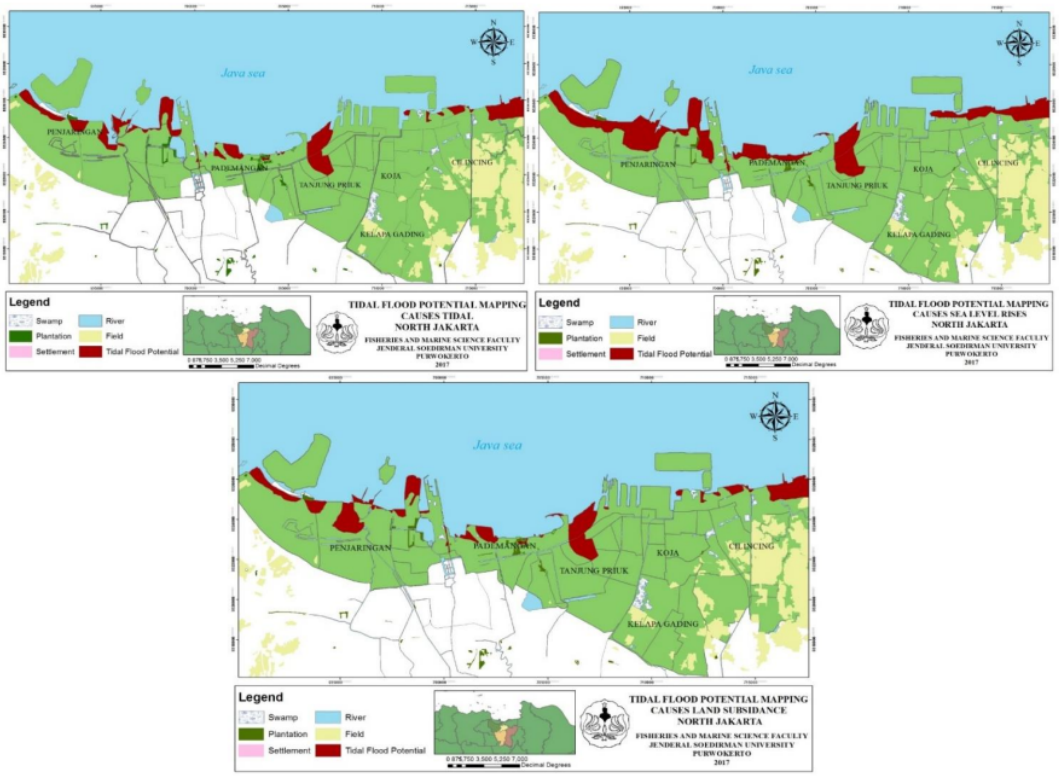


**Figure 3.** Potential of affected area of ROB or Tidal flooding and land subsinece

The potential area on the North Coast of Jakarta to be affected by ROB between 110.81 ha/district - 385.09 ha/district with a total area reached 1014.69 ha. Potential tidal flooding due to sea level rise reached 1548.91 ha with potential affected area between 110.76 ha/district– 826.09 ha/district. The potential ROB also due to land subsidence reaches 1197.02 ha with the distribution of each sub-district between 152.85 – 409.08 ha.

Based on the data between period 2000-2015 showed that an average of tidal height was 2.05 m with the highest potential in 2030 approximately 2.75 m and with rate of sea level rise reached 0.71 cm/ year. [20] writes that the sea level rise in North Jakarta is 0.575 cm/yr and land subsidence varies between of 1-15 cm/year (in other area can reached 20-28 cm/year). Using InSAR showing Land subsidence in the coastal area of North Jakarta in the period June 2006 - February 2007 reached 12 cm/year. [9], [18], [21]write that the trend of land subsidence in Jakarta is 80 cm (1982-1991), 160 cm (1991-1997) and 20 cm (1997-1999).

**Table 2.** The potential of affected area of ROB, sea level rise and land subsidence

| District | District area (ha) | Affected area of ROB | Affected area of sea leve rise | Affected area of land subsidence |
|---|---|---|---|---|
| Penjaringan | 3478,57 | 385,09 | 826,09 | 409,08 |
| Pademangan | 1773,76 | 231,86 | 323,87 | 242,31 |
| Tanjung Priok | 1988,10 | 110,81 | 110,76 | 152,85 |
| Cilincing | 4194,40 | 286,93 | 287,79 | 392,78 |
| Jumlah | 11434,83 | 1014,69 | 1548,91 | 1197,02 |

*3.4. The total affected area of tidal flooding (ROB) and Land subsidence*

The total potential of affected area of ROB due to tides, sea level rise and land subsidence could be seen in **Figures 4** and **Table 3**. The integration data between tides, sea level rise and land subsidence showed the total potential of affected area of ROB floading in North Jakarta reached 3581.83 ha.

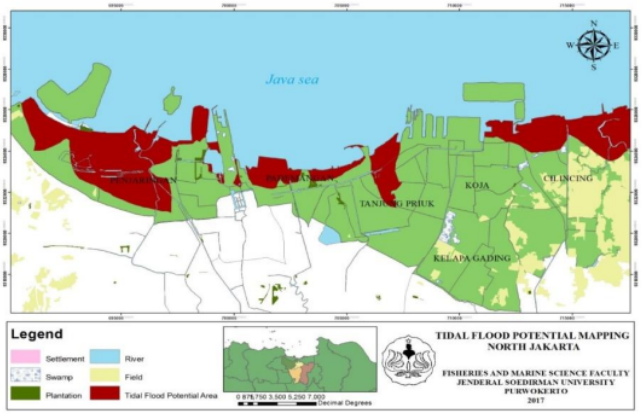


**Figure 4.** The total of affected area of ROB and Land Subsidence

The total area of tidal flooding in North Jakarta using overlaying DEM data (digital elevation model) with data from tides, sea level rise, and land subsidence. The data's showed that in Penjaringan being inundated between 100 – 150 cm and Pademangan between 30-100 cm give high negative impact for settlements and developments, groundwater exploitation and land subsidence [2], [9], [18], agriculture, industry, housing and others [21]

**Table 3.** The total of affected area of ROB and Land Subsidence

| No | districts | Districts area (Ha) | Area of tidal flooding and land subsidnece (Ha) |
|---|---|---|---|
| 1 | Penjaringan | 3478,57 | 1872,21 |
| 2 | Pademangan | 1773,76 | 505,24 |
| 3 | Tanjung Priok | 1988,10 | 166,58 |
| 4 | Cilincing | 4194,40 | 1037,80 |
| | Jumlah | 11434,83 | 3581,83 |

## 4. Conclussion

The potential of tidal flooding (ROB) in North Jakarta reached 3581,83 ha give negative impact for settlement, industry, market, ground water and land subsidence. The factors influence tidal flooding are sea tide and degradation of mangrove ecosystem. The mangrove ecosystem has function to reduce impact high tidal because the mangrove ability to preserve and protect from ROB disaster.

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