Primary Valuation of Coastal Flood Impact to Fish Farming in Brebes, Central Java

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Abstract. High tide event has been recognized in most of coastal area especially in urban region. Meanwhile, there is still limited interest on tidal flood impact on non-urban area including fish farming in developing region. This study aims to identify coastal flood due to high tide event in Brebes, Central Java and its impact on fish farming area. Here we local information from in-depth interview to local group of fish farming and Geographic Information System (GIS) within inputs from national seamless Digital Elevation Model (DEM) data from Geospatial Agency (BIG), and land use data from Google Earth. Additionally, this study also propose local context of coastal flood events on mapping the impact upon fish farming area. This research found that 3,309.53 ha of fish farming area has been flooded in the morning event of and 4,810.32 ha in the afternoon of mangsa peteruan. Meanwhile, in mangsa lanjar, the morning event has submerged around 4,521.72 ha, and 3,703.17 ha for afternoon event. This study depicts beneficial information for coastal zone planning as well as coastal disaster risk management in Indonesia.

1. Introduction
Coastal area is interfacing land and sea process through endogenous and exogenous processes. In some parts, coastal area grows as fundamental location for economic, politic, and cultural sites. By natural process, this area preserves high rank for environmental activities including changing of sea level, land subsidence, abrasion and coastal flooding [1]. The increasing of coastal flood inundation risk on coastal population together with other hydro-meteorological hazards [2]. Meanwhile, as one of major income of coastal community the fish farming sector is affected to this environmental uncertainty. Some direct impacts involve changes in water temperature and its availability also the raise of extreme events such as flooding and storm surges [3]. Currently, the impact studies underline the economic consequences of climate change, recognise the alternative options and calculate potential adaptation [4]. The integration between coastal flood using physical measurement and community information may lead into basic and valuable information of this issue. In Southeast Asia region like Indonesia, the fish farming has been majorly developed and at the same time facing the implication of coastal hazards including storm and coastal flood due to high tide.

Java as the densest island in Indonesia has integrate agriculture and fisheries sector as major economic income for its population. In north part of this island, agriculture and fishery sector dominate and shape coastal landscape. In Brebes, Central Java, the traditional fishpond lies in more than 53 km length of the coastal area with its approximately 1,897-kg/ha productivity [5,6]. In 1990-s, national government has decided that fisheries was one of the promising economic sector for international market, and through that Brebes continued to expanded the brackish water pond and produced more
shrimp for market demand. During the last decades, coastal flood due to high tide contributes majorly in lowland of Brebes infrastructure disruption [7,8]. Agriculture area, settlements and industries often collapse through this hazardous phenomenon, while fisheries sector is also facing huge impact because of this hazard. The damage of the dikes and fish escaping has influenced in local community sector when the disaster occurred and mostly remains economic loss and social distraction in local until regional level.

2. Study area description

This study is situated in Brebes, Central Java as major location of fish farming in Indonesia. Brebes coastal area is located in 6°44'56"-7°20'51" S and 108°41'37"-109°11'29" E. This region lies on the northwest of Central Java Province and bordered to West Java Province (see Figure 1). North part of Brebes is adjacent to Java Sea, with approximate tidal range around 1.2-2 meter [9]. As located in provincial boundary, Brebes become hinterland for several major cities, including Tegal in east part, Purwokerto in south part and Cirebon in western part. Brebes regency covers 1,661 km² within 633.53 km² of agriculture area and 1,027.64 km² of dry land. Brebes coastal area has relatively flat topography with average elevation <5 meter above sea level. This typical condition dominates in most of coastal area in north part of Java with flat beach; consist of alluvial sediment with muddy, sandy beaches. This region also locates two delta system; Cisanggarung watershed delta in west part, and Pemali watershed delta in east. These delta systems mainly control soil material through sedimentation process. The material reaches from north part that is mountainous landscape and continually delivers sediment material due to erosional process. The complexity of natural process in coastal area of Brebes shows high interaction between land and sea. Brebes relatively has low wave and weak current, so majorly appropriate for fishpond site.

Figure 1. Geographical position of the study

3. Methodology

3.1. Data acquisitions

This study aims to describe coastal flood due to high tide event in Brebes region and its implication to fish farming area. This study has used several datasets including, including spatial data and non-spatial data. Firstly, we digital elevation model of DEMNAS from Indonesia Geospatial Information Agency (BIG) (free download on http://tides.big.go.id/DEMNAS/). Additionally, fishpond area of Brebes was identified through manual digitation of Google Earth satellite image (updated 2017) in scale
of 1:25,000. Furthermore, in-depth interview to six groups of fish pond in Brebes to get information about tidal flood events (including timing, duration, and water level) in each area.

3.2. Data analysis
First, we prepared the spatial data including land use on coastal area of Cirebon captured from Google Earth satellite image. This dataset is used as input to create the fish farming area map. In-depth interview with groups of fish farmer were initiated during fieldwork in 2017. These local information were used to gather local information about period of the coastal flood. The interview also examines the duration of flood and water depth information as initial input for the raster model. The raster analysis using previous method of [10,11] where the inundation is expressed through bathtub model. The following Figure 2 draws the details explanation of the study.

4. Results and Discussion
4.1. Coastal flood events along the coast
Typical characteristic of tidal, topographical sequence and land use have affected the coastal flood in Brebes region. Several districts have been submerged especially when highest tide occurred. BPS Brebes [12] mentioned that Randusanga Kulon village has largest fishpond area in Brebes with more than 1,161.5 ha (48%), Kaliwlingi village 734.53 ha (29.5%). Here, it shows that brackish fishpond in Brebes district covers 9,954.08 hectares (22.26%) from 44,723.56 ha covering area including paddy field, dry land agriculture area, and settlement (see Figure 3).

Figure 3. Land use of Brebes coastal area which is dominated by paddy field agriculture, dry land and fishpond
Tidal pattern in Brebes is mainly controlled by moon gravity [13]. Furthermore, tidal duration, timing, frequency and height are not only influenced by phase and position of moon and sun, but also coastal morphology and beach characteristic [14]. Based on interview with chief of fish culture group (locally referred to Pokdakan) coastal flood frequently takes place in Brebes district in two seasons. They have locally called for each season as mangsa, and disposed in three months. First is mangsa peteruan that described as month of tidal flood events. This period happens in April to June when west monsoon dominantly breezes the coastal area. Meanwhile, the local people also notice small number of tidal flood around November to December has been noticed as mangsa lanjar. The typical wind in this period is dominated by east-monsoon. Both seasons typically have similar pattern with tidal pattern in Java Sea [15,16].

Coastal flood in Brebes district appears frequently due to moon position. This sequence correlates to coastal morphology that consists of sand material, and relatively flat topography. It is noticed that coastal flood occurrence in mangsa peteruan has two periods when the highest level of flood experienced on each day. First strikes usually happen at 3.00-6.00 am (local time) and second event happens at 5.00-8.00 pm (local time) (interview with fish farming group in Randusanga Kulon). In this particular season, naturally moon is in opposition until elongation (270°). In first week of April, coastal flood often occurs >50 cm height, continually happens in the 1st week of May then in the 2nd week of June. Here, the local group records that depth of inundation during mangsa peteruan reaches 76 cm in early morning and increases to 99 cm in the afternoon. During the interview, the local group records that 21 coastal flood occurrences has happened in 2017.

East monsoon potentially involves for tidal pattern in mangsa lanjar season, which occur during November–December. Chief of fish farming group in Kaliwlingi who have been living for years in coastal area of Brebes also noticed that inundation during mangsa lanjar occurs twice a day in the early morning and afternoon. Particularly, coastal flood events rise last week of October and November, and 1st week of December. Based on interview, water depth during early morning is closely about 95 cm, but reduces into 82 cm in the afternoon (Figure 4). This pattern has opposite with previous season, where tidal flood usually occurs at 02.00-03.00 am and 5.00-8.00 pm. Moon as theoretically influences the tidal dynamic in global scale is positioning at conjunction phase. Local people record that around 20 events had been happening during this season in 2017.

![Figure 4. Water depth during coastal flood events for each season](image)

In this area, local fish ponders remark that both seasons have unique characteristic related with number of occurrences and their impact (see Table 1). While timing and depth of season verify relatively a slight difference (see fig. 6). Those seasons annually change from one to another and extreme event also potentially happen due to climate uncertainty. Currently, local people tend to have this tidal phenomenon and describe local information based on cultural thought and beliefs. This local knowledge contains ancestor awareness about natural changing especially in coastal community who examines weather, rain, tidal and wave dynamic for years or decades.
Table 1. Number of events based on local information

| Season     | Months (in abbreviation) | J | F | M | A | M | J | J | A | S | O | N | D |
|------------|--------------------------|---|---|---|---|---|---|---|---|---|---|---|---|
| Mangsa peteruan | n n n 7 7 7 n n n n n n |              |   |   |   |   |   |   |   |   |   |   |   |
| Mangsa lanjar  | n n n n n n n n n l 7 12  |              |   |   |   |   |   |   |   |   |   |   |   |

n: no records

4.2. Tidal exposure on fish farming area

Coastal flood due to the high tide negatively affects urban area [17], agriculture field land [18], and also fish farming along the coast. Based on raster analysis, during mangsa peteruan, the tidal flood has covered 3,309.53 hectares (33.25%) fishpond area in Brebes, respectively. This event happens in early morning when tidal level reaches 76 cm. Meanwhile, flood will drastically increase in the afternoon with more than 4,810.32 hectares of fish farming inundated (see Figure 5). This situation have gradually decreased when the effect of ocean tide recede.

![Figure 5. Tidal flood distribution in mangsa peteruan in a) morning time (3.00-6.00 am) and; b) in the afternoon 5.00-8.00 pm (local time)](image)

During mangsa lanjar period (October-December), high tide also drive the tidal flood occurrence in several area along the coast of Brebes. This event have inundated some part the settlement, agriculture land and mostly fishpond.). Coastal flood event in afternoon generally covers more than 3,703.17 (37.2%) hectares of occupied brackish pond in coast, while 6,250.91 hectares (62.8%) remain secured. Dealing with this destructive events, most of traditional fish pond in Brebes tend to have more loss during early morning. There were 4,521.72 hectares (45.43%) covered by seawater during the tide flood, while another 5,432.36 hectares were not inundated (see Figure 6). In that time, there is more damage in the brackish pond area because of most people still in sleeping while flood came from tidal current. Dikes structure that constructed using mud in many case has devastating due to inundation (see Figure 7).

![Figure 6. Tidal flood distribution in mangsa lanjar in a) morning time (2.00-3.00 am) and; b) in the afternoon 5.00-8.00 pm (local time)](image)
Figure 7. Destructed fishpond dikes after events during fieldwork on April 2017

5. Conclusion
Tidal flood in north part of Brebes frequently happen due to moon phase and monsoon pattern. Indigenous people in this area record coastal flood events, namely mangsa peteruan and mangsa lanjar. Mangsa peteruan (April-June) is described as month of frequent coastal flood events, when local inhabitants have recorded a hazardous event. Mangsa lanjar (November-December) is dominantly influenced by east monsoon continually devastate fishpond, although impermanent recovery has been made. This disastrous situation affects fishpond culture activities; even often damage the structure and cultivation process. Through raster model, this research concludes the identical flooded area within confirmed depth in two seasons and dual periods. Local farmers live in vulnerable area compromised with frequent coastal flood events. Consequently, real supports from academic society, government and NGO’s at present and future are necessary, substantially in mangrove conservation to prevent worse incidents.

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