Water Change Detection and Its Effect on Land Value

D Sutrisno¹, M Darmawan² and R Windiastuti³

¹Center for Research, Promotion and Cooperation, Geospatial Information Agency, Jalan Raya Jakarta Bogor Km 46 Cibinong, Indonesia
²Center for Atlas and Spatial Planning, Geospatial Information Agency, Jalan Raya Jakarta Bogor Km 46 Cibinong, Indonesia
³Center for Research, Promotion and Cooperation, Geospatial Information Agency, Jalan Raya Jakarta Bogor Km 46 Cibinong, Indonesia

dewayany@gmail.com

Abstract. Human economic activities on natural resources may affect the sustainability of environment and its economic value. Remote sensing analysis is able to evaluate the environmental changes related to project on economic value. Therefore, by using multi temporal remote sensing data such as Landsat 5 and Landsat 8 Oli, this paper intends to illustrate the impact of changes in the coastal region on its economic value. The method of water change detection, direct cost based on replacement value of land was used for this assessment. Meanwhile, Bedono village was selected as study area. The results show a significant depreciation of 98 % of land value was occurred in the study area caused by inundation of sea water landward.

1. Introduction
As the largest archipelagic state in the world, Indonesia has the 2nd longest coastline in the world after Canada. The length of the coastline, based on mapping technique from the team work of standardization for geographical names, is about 99,053 km in 2013 and has been updated to 108,000 km in 2018 [3]. However, human activities on natural resources may affect the sustainability of coastal environment and its economic value. This condition brings up the idea of a simple method to evaluate how far the human pressure on nature of the coastline will affect the sustainability of the coastal environment and its economic value.

Coastal area is the home for many coastal ecosystems such as coral reefs, seagrass, mangrove, marsh and other. Mangrove and marsh usually become good places for marine culture activities that make these ecosystems become the target of fish pond conversion. Human pressure on coastal ecosystem for marine culture industries may give way to coastal recession due to the high tide, abrasion or sea level rise impact on forestless area. Finally, it can impact the coastal economic value as well. How far this coastal recession will affect the coastal ecosystem economic value becomes an issue to assess with the assistance of remote sensing technique.

Remote sensing analysis is able to provide the faster spatial information regarding the changing of coastal environment, one of which is coastal recession caused by human clearing activities on coastal environment. Besides, an economic depression caused by the coastal recession can also be predicted by using a simple method such as direct cost of the land price. Therefore, by using multi temporal remote sensing data such as Landsat 5 and Landsat 8 Oli, this paper intends to illustrate the impact of coastal
recession on its economic value. The coastal recession was assessed based on water change detection approach. Sayung Subdistrict, north coast of Demak District – Central Java was selected as the study area due to the extensive mangrove ecosystem conversion that has been occurred in the area for years (see Figure 1).

Figure 1. Study area, Sayung Subdistrict – Demak District, Central Java

2. Method

2.1. Assessing coastal recession by using water change detection.

Remote sensing may become a good tool to indicate the changes of earth features due to its synoptic and multi date coverage system. Indeed, it may give support to indicate the changes of coastal area either by human or nature catastrophic. Reflective infrared bands can extracted the coastline better since the water is nearly equal to zero in by using this bands. Experience has shown that mid infrared band 5 of Landsat TM can be considered the best for extracting the land-water interface [4]. Indeed, it will exhibits a strong contrast between land and water features, because mid-infrared energy has high absorption by water and mid-infrared has strong reflectance by vegetation, bare land and concretes. [1] also support the idea that band 5 is the best spectral band to identify the boundary of land to water. The method for water change detection to assess the coastal recession was consisted of employing histogram threshold on one of the infrared bands of multi date optical imageries and unsupervised classification method followed by subtraction method. Dynamic and complex land-water interaction makes the discrimination of land-water features less certain. Therefore, to find the exact value, classification of composite image of band 457 for Landsat 5 (derived on September 5th 1993) and Landsat Oli (derived on august 28th 2018) were being employed, followed by the image subtraction method. Histogram thresholding and unsupervised classification can be employed prior to subtraction method in order to get the better result.
Histogram thresholding is the simple method that assumes the image is divided into two main classes, there is which are land and water bodies and is explained as:

\[ f(x,y) > T \text{ then } f(x,y) = 0 \text{ else } f(x,y) = 255 \]

Meanwhile, the classification method was simple using the Isodata, unsupervised classification, where it classified the area into two classes, i.e. water bodies and land area.

Then, subtraction method was following both of the formula and can be illustrated as follow;

\[ R = I_1 - I_2 \]

Where \( R \) = coastal recession area, \( I_1 \) is 1993 image 1993 and \( I_2 \) is 2018 image

2.2. Economic evaluation

To assess how much the coastal recession will affect economic value, the economic depreciation based on direct cost method was employed. The direct cost was got by simply calculating the initial land value \( (V_0) \), then the future value of those land was calculated for assessing the lost economic value of the land. The formula of the method was described as:

\[ V_0 = A_0l_o \text{ and } F_{vn} = V_0 (1 + r)^n \]

Where \( V_0 \) is the total land value at initial condition/year \( 0 \) (in IDR), \( A_0 \) is the area before inundation (in meter\(^2\)) and \( l_o \) is the land price at year \( 0 \) (in IDR), \( F_{vn} \) is the total future value at year \( n \) (in IDR), \( r \) is the return rate and \( n \) is the number of periods.

The land rent per square meter can be described as

\[ N_v = N_0(1 + r)^n \]

Where \( N_0 \) is the land rent per meter\(^2\) at year \( 0 \) (in IDR) and \( N_v \) is the land rent per meter\(^2\) at year \( n \) (in IDR), \( r \) is the return rate and \( n \) is the number of periods. The value of land was based on indication rate value (NIR).

3. Result and Discussion

The northern coast of central Java is a large ecological system influenced by fresh water (river), whereas the wetlands are the major ecosystem. Mangrove forest is a common ecosystem extends over the wetland area. Recently, mangroves have suffered extensive declines, predominantly due to the development of fishpond. This means conversion of mangrove areas into fishponds for rearing fish, crabs and shrimp has occurred. This is possible because the type of soil, slope, source of water from river, sea and rainfall are suitable for fishpond development. As consequences aquaculture has been rapidly growing on this type of ecosystem. This was supported by [2] who stated that starting in the 80’s the conversion of mangrove land into shrimp farms on a large scale has occurred. However, conversion of mangrove to shrimp ponds without considering the green belt and oceanographic phenomenon may cause coastal recession. [2] added the reclamation for construction of the City port Semarang was also suspected to cause changes in the current pattern, which triggered coastal erosion in the Coast Bedono Village, thus damaged the aquaculture in the area. How far the coastal recession has occurred can simply be assessed by using water change detection, and the result can be seen in Figure 2.
The water change detection analysis of this area can be seen in figure 3, showing the intruded of water landward and causing coastal recession or inundation/ flooding on the existing shrimp ponds area.
Analysis of water change detection indicated that 6,459.30 ha has been changed to water bodies, almost similar for coastal recession value. [6] assessed that the inundation of coastal area in Sayung District was about 2,078.45 ha while [5] has developed the model showing the inundation of coastal area was about 7,200.36 to 10,826.7 ha. The differences in number because both of previous researches used tidal data for assessing the high tidal floods on coastline. While, [11] stated that the inundation of Sayung District was about 6,172 ha. This value was closer to water change detection result of the current research.

The economic value become the concern for this study since it will affect the social economic of the locals. The majority of the inundation covered areas that were used to be fish ponds with the indication rate value of the land at about 5000 IDR/m2 for ponds. By considering the average of inflation value, the value of the land was turned to be 299,576 IDR/m2 in 2018. This value was closed to the land value in Bedono at about 300,000 IDR/m2 in 2018 [7]. Therefore, the depression value was about 294,000 IDR/m2 caused by inundation or about 98%. This value is a slightly similar with [8] that assessed the degradation of the land value based on NJOP (Tax Object Selling Value) as much as 80% because of the inundation/flooding. The depression was about 48,000 IDR in 2012 to 5,000 IDR in 2017. The difference must be related to the year of assessment, whereas the longer the times differences, the higher the depression will be.

Finally, the result above indicated the need to sustainably manage the impacted coastal area by applying scenario models for adaptation and mitigation. [9] showed that the implementation of silvo-fisheries in ponds culture was able to maintain the environment and the income of the farmers/fishermen. Meanwhile, for the recommendation of the green belt along the coastline had also been suggested for coastal village such as by [9].

4. Conclusion
Water change detection is one of the methods used to assess the changing of water bodies landward, such as inundation or flooding, caused by high tide or sea level rise. For the better assessment of the impacted area the use of Band 5 and infrared band are suggested since these bands are sensitive to reflectance of water bodies. Water change detection in combination with unsupervised and band thresholding is not the only one of remote sensing techniques to assess the inundation or flooding, but can be acknowledged as the simple and faster one. The impacted area caused by water changing can become an input for assessing the depreciation of the land value in monetary units, in this case IDR (Indonesian rupiah). Indeed, the simple economic valuation based on land value can be applied for illustrating the economic depreciation of the impacted area.

5. References
[1] Alesheikh, A.A., Ghorbanali, A., Nouri, N., (2007). Coastline change detection using remote sensing. Int. J. Environ. Sci. Tech., 4 (1), 61-66.
[2] Chaffid, MA, R Pribadi, A Anugroho DS. 2012. Kajian perubahan luas lahan mangrove di Desa Bedono Kecamatan Sayung Kabupaten Demak Menggunakan Ikonos tahun 2004 dan 2009. Journal of Marine Research, Vol 1(2): 167-173
[3] Galugu, P. 2018. Panjang garis pantai indonesia tahun 2018 mencapai 108.000 km, sebelumnya 99.093 km. Menginsprasi.com. https://www.menginspirasi.com/2018/
[4] Kelley, G.W., Hobgood, J.S., Bedford, K.W., Schwab D.J.,(1998). Generation of three-dimensional lake model forecasts for Lake Erie, J. Weat. For., 13, 305-315.
[5] Ondara, K. and UJ Wisha. 2016. Simulasi numerik gelombang (spectral waves) dan bencana rob menggunakan flexible mesh dan data elevation model di perairan Kecamatan Sayung, Demak (numerical simulation of spectral waves and rob disaster using flexible mesh and data elevation model in waters of Sayung District, Demak). Jurnal Kelautan Vol 9(2); 164-174. Doi: dx.doi.org/10.21107/jk.v9i2.1694
6. Acknowledgments
Our appreciation goes to the small discussion group of Indonesian society of remote sensing for the coastal changes in Jakarta, April 2018, that has provide the idea and the data for this article