CLIMATE CHANGE, LAND USE COVER CHANGE AND ITS IMPACT ON COASTAL AREA

Dewayany Sutrisno[1], Mulyanto Darmawan[1], Muhammad Helmi[2]
[1] Center for research, promotion and cooperation-Badan Informasi Geospasial, Indonesia.
Jalan Raya Jakarta Bogor Km 46, Cibinong 16911- IDN
E-mail: dewayany@gmail.com, drmoel2011@gmail.com
[2] The Faculty of Fisheries and Marine sciences, Diponegoro University,
Jl. Prof. H. Soedarto, S.H, Tembalang, Kec. Tembalang, Kota Semarang, Jawa Tengah 50275 - IDN
622187906041
E-mail: muhammadhelmi69@gmail.com

KEYWORDS: Flooding, Climate Change, LUCC

ABSTRACT: Climate change, in conjunction with land conversion, has a major effect on the world's coastline region. Low-lying coastal communities and villages have already suffered devastation from catastrophic floods and must now contend with increasing seas. The world's 11 fastest sinking cities have been identified (CNN, 2018). The source of flooding, impact, mitigation, and adaption strategies within the coastal area are vary across those rural areas. As a result, it is important to examine the influence of the two primary causes of coastal flooding, there is land use change and climate change. The purpose of this article is to assess land use cover change (LUCC), climate change's influence, and the sinking coast's impact due to those phenomenon. The method includes combining multiple-date remote sensing data analysis and spatial analysis, either through change detection of land and water and the accuracy assessment analysis. The findings, deductively, show a link between LUCC, climate change, coastal flooding, and indicate the role of water change detection (WCD), LUCC detection (LUCCD) and Built-up area change detection (BCD) for rapidly mapping the coastal flooding for mitigate any devastation.

1. INTRODUCTION:

Climate change, in conjunction with land conversion, has a major effect on the world's coastline area. Because of this, low-lying coastal communities and villages have already suffered devastation from catastrophic floods and must now contend with rising sea level. The world has identified the 11th fastest sinking cities there is Jakarta, Lagos, Houton, Dhaka, Venice, Virginia Beach, Bangkok, New Orleans, Rotterdam, Alexandria and Miami (World Economic Forum, 2019). However, for the sake of this study, we will concentrate on rural coastal regions that are at risk of land conversion to non-agriculture uses and are confronted with technological challenges. The source of flooding, impact, mitigation, and adaption strategies within the coastal area are vary across those rural areas. As a result, it is important to examine the influence of the two primary causes of coastal flooding, there is land use change and climate change.
With a deductive approach, multi-date remote sensing analysis can be utilized to analyze the dominant factors affecting coastal flooding. The deductive method elucidates the theoretical concepts that connect the general issue to the specific one (Winarso, 2014). While the implementation of remote sensing for climate change impact on coastal flooding has been assessed by Sutrisno et al (2020); Appeaning (2011). Indeed, the implementation of remote sensing for landuse cover change (LUCC) to coastal flooding has been widely implemented, such as the research by Yang et. al (2016).

Flooding may take on a variety of forms depending on one's perspective. The issue might be classified according to biophysical elements such as geology, geography, meteorology, and the environment, as well as the opposing socioeconomic forces and policy that influence them. Therefore. the purpose of this article is to assess land use cover change (LUCC), climate change's influence, and the sinking coast's impact due to both phenomenon. The research area was the rural coastal area of Sayung Sub-district in Central Java, Indonesia (see Figure 1). Aside from the constant floods, parts of the coastal regions are sinking and the shoreline is shifting landward. This coastal region scenery is made up of marsh, channels, and muddy beaches, and it is progressively sinking as a result of land use cover change and relative sea level rise (Sutrisno et al, 2021).

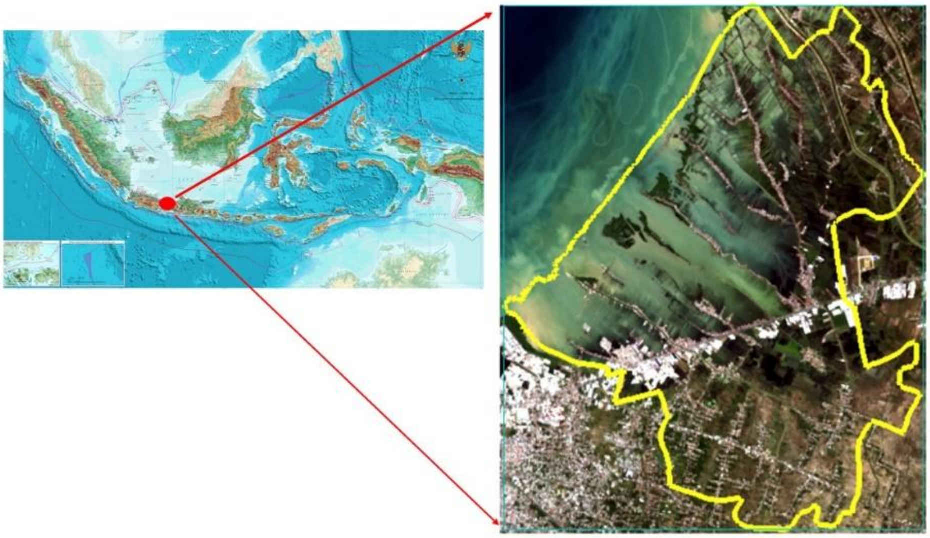
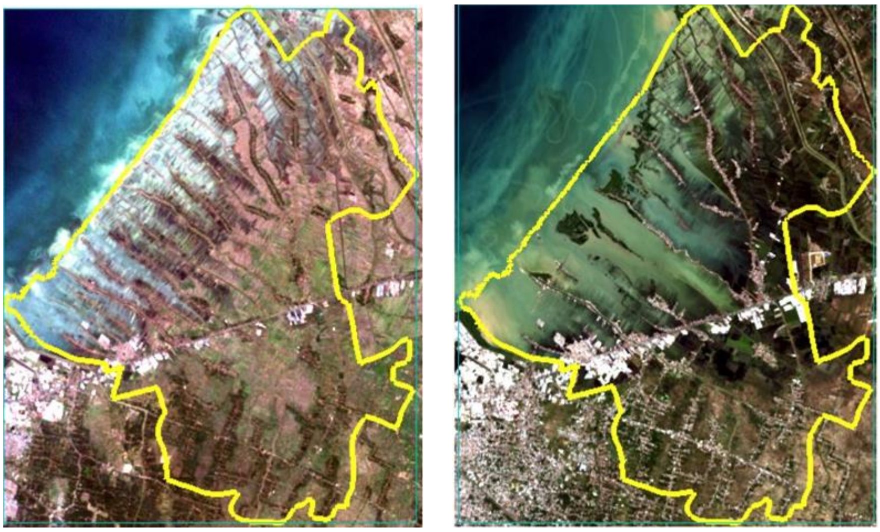


Figure 1. Study site, Sayung Sub-district- Central Java, Indonesia

2. METHOD.

This article makes use of Landsat TM data obtained on August 13, 1999, and Landsat 8 Oli data acquired on July 29, 2020. Both were obtained from the USGS (https://earthexplorer.usgs.gov) and big scale map of Sayung Sub-District from Badan Informasi Geospasial or BIG (2013). The imageries can be seen Figure 2



(a) (b)

Figure 2. The data used for analysis, (a) Landsat TM of August, 13th 1999 and (b) Landsat 8 Oli of July 29th 2020

The method includes combining multiple-date remote sensing data analysis, through change detection of land and water, accuracy assessment and descriptive deductive-based analysis. The amount to which climate change, in this case sea level rise, affects coastal flooding may be assessed by examining the extent to which flooding occurs on land. The water change detection method is one way for analyzing changes in land area due to flooding. Meanwhile, with relation to LUCC, the loss of the protective coastal green belt, upstream land conversion, and physical development in coastal areas can all contribute to coastal flooding. Similar to the impact of climate change on coastal regions, one approach for analyzing this land change is change detection. Thus, in this method, we will employ the water change detection (WCD) method by applying Normalize Differentiate Water Index (NDWI) to both imageries and then analyzing the changes; the LUCC detection (LUCCD) method by applying Normalized Differentiate Vegetation

Index (NDVI) to both imageries and then analyzing the changes; and the built-up area change detection (BCD) method by applying Normalized Differentiate Built-up Index (NDBI) to both imageries and then analyzing the changes.
For water, land and built-up area change detection employ the image differencing method, which involves the pixel-by-pixel subtraction of two spatially registered imageries (Al-Doski et al, 2013). Whereas, the pixels with changed area are intended to be dispersed in the two tails of the final image's histogram, while the pixels with unchanged area are expected to be clustered around zero. This straightforward approach produces a picture that is clearly interpretable; nonetheless, it is critical to appropriately establish the criteria for distinguishing change from non-change areas (Al-Doski et al, 2013). The process of analysis can be described in Figure 3

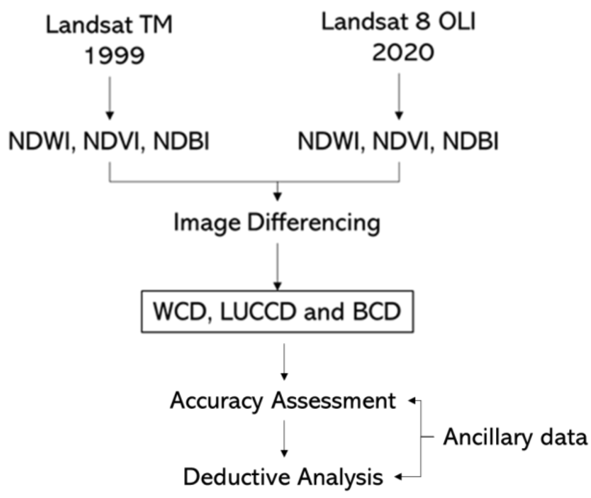


Figure 3. The process of Change detection for water, and built-up area

An explained in the following formula:

$$NDVI = \frac{B_{red} - B_{NIR}}{B_{red} + B_{NIR}} \quad \ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

$$NDWI = \frac{B_{NIR} - B_{SWIR}}{B_{NIR} + B_{SWIR}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

$$NDBI = \frac{B_{SWIR} - B_{NIR}}{B_{SWIR} + B_{NIR}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

And

$$IM_{def} = I_{1_{x,y}} - I_{2_{x,y}} \quad \ldots\ldots\ldots\ldots\ldots.(4)$$

Following the findings of WCD, LUCCD and BCD, the accuracy assessment was employed by using Sutrisno et al (2020) formula, which was described as follow

$$Ev = \frac{\sum t_1 + t_n}{\sum (P)_{ref}} \; x \; 100 \; \% \qquad (6)$$

$$if\,(x,y)_1 = (x,y)_n \quad then\;(x,y)_1\; is\; true \qquad (7)$$

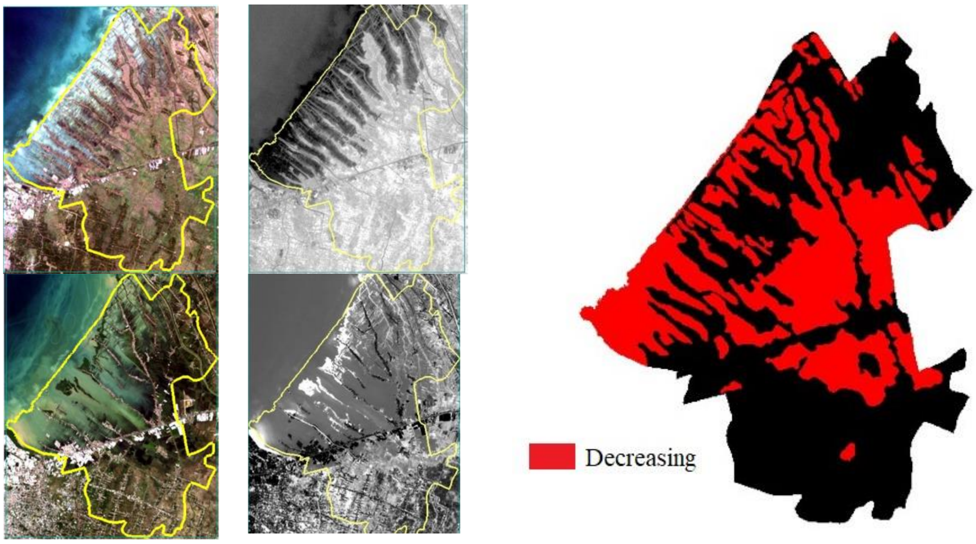
$$if\;(x,y)_1 \neq (x,y)_n \; then\;(x,y)_1\; is\; false \qquad (8)$$

where *Ev* is the result of the evaluation (%), based on *t* = a true value, *1…n* are the points from the classified image, and $\boldsymbol{P_{ref}}$ is the field reference data and $(\boldsymbol{x},\boldsymbol{y})_{\boldsymbol{n}}$ is a reference point object within the classified image. The reference maps were the original images and the big scale maps from Badan Informasi Geospasial (BIG)

Finally, the underlying cause of this coastal flooding problem was descriptively examined using the results of the water and land change detection analysis, as well as by examining prior study findings.

3. RESULT AND DISCUSSION

The findings of WCD analysis utilizing the image differencing method is shown in Figure 4, which depicts substantial changes from 1999 to 2020. Not only does the result demonstrate coastal inundation, but also the shoreline retreating landward.

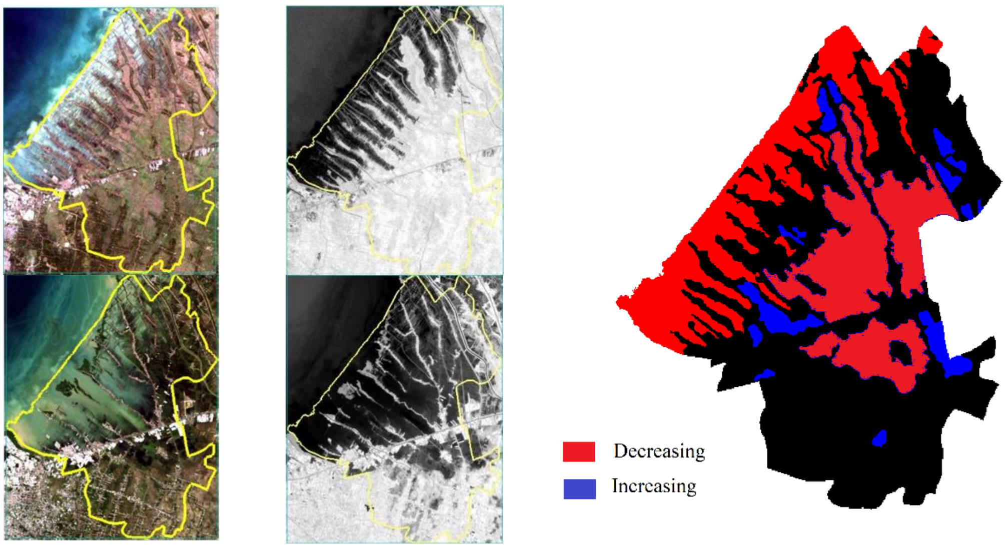


(a) (b) (c)

Figure 4. WCD (c), Original images (a), NDWI (b)

According to the calculations, an area of 16,291.09 hectares has been submerged.

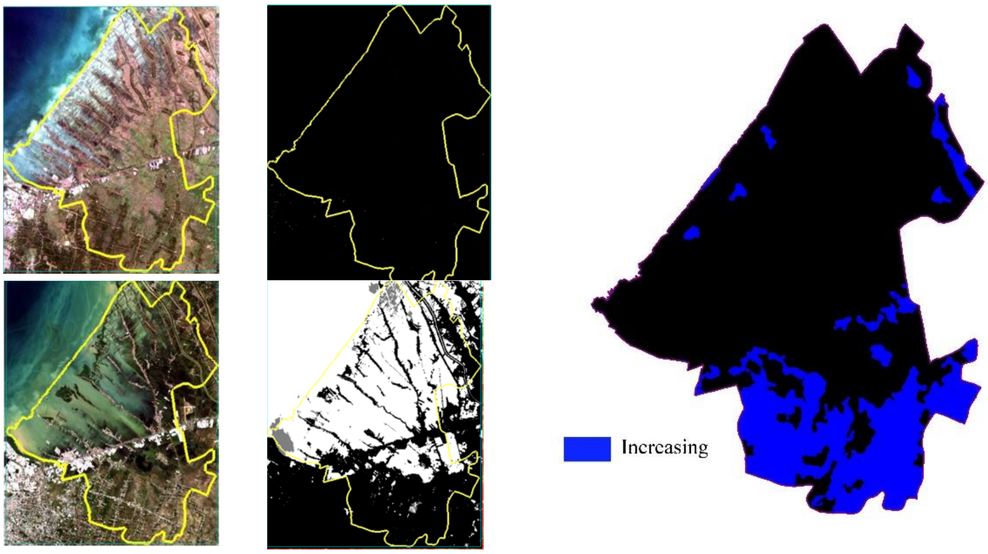
Additionally, the result of LUCC detection analysis of both NDVI data from 1999 and 2000 indicates a decrease in green area in almost all of the sub-center district's part, indicating the intrusion of water into the green area that was previously used for agriculture land in 1999 (Figure 2). According to calculations, a total of 17,033.86 hectares have been transformed or repurposed.



(a) (b) (c)

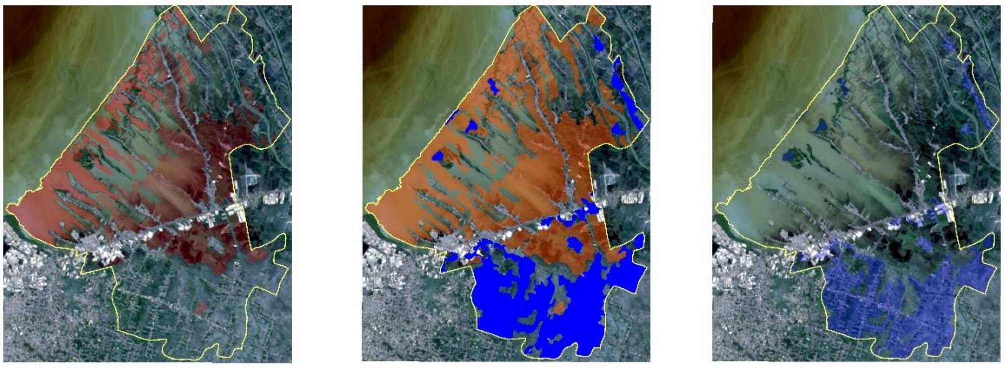
Figure 5. LUCCD (c), Original image (b) and NDVI image (b)

Indeed, the results of the BCD analysis suggest a rise in built-up area in the southern part of Sayung Subdistrict (Figure 6), whereas the area is about 8, 429.13 ha.



(a) (b) (c)

Figure 6. BCD (c), Original Images (a), NBVI (b)

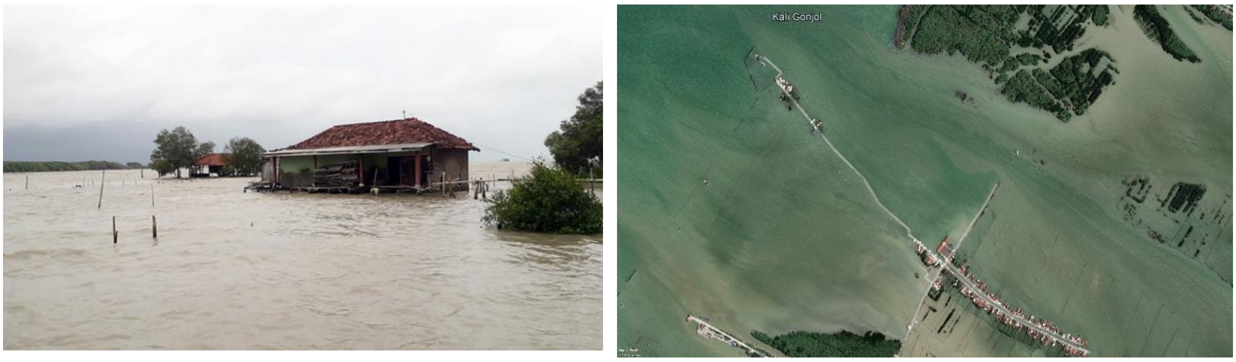


(a) (b) (c)

Figure 7. Comparison the result with original imageries, (a) WCD, (b) LUCCD and (c) BCD

The result overall accuracy for WCD, LUCCD indicates 86,2 % for WCD, 75,6 % for LUUCD and 91% For BCD. Figure 7 illustrates the WCD, LUCCD, and BCD results in the 2020 image to demonstrate the data's accuracy. The second approach is to compute it in a convolution matrix using a large-scale topographic map as a reference, resulting in the accuracy values as mentioned above.

While it is true that the expansion of built-up areas and the conversion of land to water bodies have high accuracy values, these values cannot be used to determine the major cause causing coastal flooding and shoreline retreat. However, based on prior research, a connection appears to exist between those values and the cause of coastal flooding. Where industrial and residential development raises demand for ground water, excessive ground water discharge occurs. Indeed, one of the factors contributing to ground subsidence is the increased demand for water by communities and industry (Rahman et al., 2018). As a result, the sea level rise in this region may are caused by land subsidence and can be defined as a relative sea level rise (Sutrisno et al, 2020; Sutrisno, 2014). This phenomenon of relative sea level rise is aggravated by the existence of tidal waves, known locally as rob, which cause abrasion and flooding of coastal areas as well as shoreline retreat. The changing patterns of tidal waves, one of which is a result of climate change. Climate change has an effect on variations in air pressure both on land and at sea, affecting the velocity and height of tidal waves propagating landward, causing devastation through abrasion and floods. As a result, the Sayung shoreline receded about 6 kilometers landward (Helmi, 2019), drowning some villages in the downstream area (Figure 8).



(a) (b)

Figure 8. Illustration of (a) submerging village (Mana, 2021) and (b) Image of submerging villages (image donwnloade form google earth, 2021)

4. CONCLUSION:

Although it cannot identify the major factors that cause coastal flooding and shoreline retreat, the WCD, LUCCD, and BCD methods are the most rapid technique that can be used for immediate flood, LUCC and built-up area development mapping. The combination of these three techniques can aid in resolving any disaster associated with floods and LUCC issues. Alternatively, by examining the distribution of changes within an area using this approach, the pattern of future changes may be predicted and used as input by relevant policymakers.

Acknowledgement:

This article is the initial steps of the 2019-2021 Asia Pacific Network for Global Change (APN) project. The findings have been utilized to develop the SPBEA model that has been finalized in the mid-2021. Therefore, we would like to thank APN for their assistance, so we can develop technique and model that can be shared and published. Related to the article, Dewayany Sutrisno and Mulyanto Darmawan are the primary contributors, while Muhammad Helmi is the member.

References:

1. Al-doski, J., S.B. Mansor and H. Z. Mohd Shafri. 2013. Change Detection Process and Techniques. Civil and Environmental Research. Vol.3(10), pp 37-45
2. Appeaning A., K., Larbi, L., Amisigo, B., & Ofori-Danson, P. K. 2011. Impacts of Coastal Inundation Due to Climate Change in a CLUSTER of Urban Coastal Communities in Ghana, West Africa. Remote Sensing, 3(9), pp 2029–2050. doi:10.3390/rs3092029
3. Badan Informasi Geospasial. Topographic maps of Sayung and Weung, sheet scale 1: 25.000. BIG, 2013.
4. Chu, H.-J., Ali, M. Z., Tatas, & Burbey, T. J. 2021. Development of spatially varying groundwater-drawdown functions for land subsidence estimation. Journal of Hydrology: Regional Studies, 35, 100808. doi:10.1016/j.ejrh.2021.100808
5. Gao, B.C. 1996. "NDWI—A normalized difference water index for remote sensing of vegetation liquid water from space" (PDF). Remote Sensing of Environment. 58, pp 257–266. doi:10.1016/S0034-4257(96)00067-3.
6. Helmi, M.; Pribadi, R. 2019. Integrated Coastal Landscape Management: An Adaptation to Related Climate Change Impact Case 562 Study: Sayung District, Demak, Central Java. Presented at Kick off Meetings Integrated Coastal Landscape Management: An 563 Adaptation to Related Climate Change Impact, Semarang, Nov 20th - Indonesia, 2019.
7. Manan, A. 2021. Halaman menjadi lautan. Lingkungan, Tempo, https://majalah.tempo.co/read/lingkungan/162339/nasib-desa-bendono-di-demak-yang-tenggelam-akibat-banjir-rob. Accessed on September 25th 2021.
8. Sutrisno, D. Sea Level Rise and Its Impact on Rural Deltas: A Shoreline Retreat Approach. Lap Lambert Academic Publishing Com-524 pany – Germany, 2013.

9. Sutrisno D, Rahadiati A, Rudiastuti AW, Dewi RS and Munawaroh. 2020 .Urban Coastal Flood-Prone Mapping under the Combined Impact of Tidal Wave and Heavy Rainfall: A Proposal to the Existing National Standard. *ISPRS Int. J. Geo-Inf. 2020* **9,** pp 525; doi:10.3390/ijgi9090525
10. Sutrisno, D., Darmawan, M., Rahadiati, A., Helmi, M., Yusmur, A., Hashim, M., … Zhang, L. 2021. Spatial-Planning-Based Ecosystem Adaptation (SPBEA): A Concept and Modeling of Prone Shoreline Retreat Areas. ISPRS International Journal of Geo-Information, 10(3), 176. doi:10.3390/ijgi10030176
11. Rahman, S. U, Sumotarto and H. Pramudito. 2018. Influence the condition land subsidence and groundwater impact of Jakarta coastal area. IOP Conference Series: Earth and Environmental Science, Vol.106, The 4th International Seminar on Sustainable Urban Development 9–10 August 2017, Jakarta, Indonesia
12. World Economic Forum. 2019. These 11 sinking cities could disappear by 2100. https://www.weforum.org/agenda/2019/09/11-sinking-cities-that-could-soon-be-underwater. Accessed on September, 23rd 2019.
13. Winarso, W. 2014. Membangun Kemampuan Berfikir Matematika Tingkat Tinggi Melalui Pendekatan Induktif, Deduktif dan Induktif-Deduktif Dalam Pembelajaran Matematika. EduMa Vol.3 (2), pp 95-118
14. Yang, Xiaoliu, Huili Chen, Yueling Wang, Chong-Yu Xu. 2016. Evaluation of the effect of land use/cover change on flood characteristics using an integrated approach coupling land and flood analysis. Hydrology Research, Vol 47 (6), pp 1161–1171. https://doi.org/10.2166/nh.2016.108