Nat. Volatiles & Essent. Oils, 2022; 9(1): 1921-1933

Study Of Seawater Flooding (Rob) In The Northern Area Of Medan

Ahmad Bima Nusa[1] , Ahmad Perwira Tarigan[2] , Sirojuzilam[3] , Agus Purwoko[4]

[1,2,3,4] Universitas Sumatera Utara, Medan, Indonesia.

Abstract

Tidal flooding is a natural event or phenomenon where seawater enters the land area when the sea level experiences high tide conditions, either directly or through overflowing river water. The tidal flood that occurred in the northern part of Medan was the same as what happened on every coast. The land area affected by tidal flooding is getting wider and wider, so there needs to be an analysis of the potential tidal flood vulnerability so that handling and prevention efforts can be right on target. The potential for tidal flood vulnerability uses 9 criteria, for that the AHP and GIS integration methods are used in order to make rational decisions from several criteria that produce a vulnerability map. The results obtained in the northern area of Medan city that 1,546.89 ha (16.39%) have a high to very high level of vulnerability, while 4,411.92 ha (46.83%) have a moderate level of vulnerability to tidal flooding. The results of the vulnerability level show that 13 environments are in the very high category of 6.16%, 44 environments are in the high category of 20.85% and 64 environments are in the medium category of 30.33%. In the mitigation strategy, the efforts that must be made by the Government are 1. building pump houses, 2. structuring buildings, especially in the environment adjacent to the coast, 3. providing maps of tidal flood-prone zones and vulnerability, 4. relocating the area by building flats

Keywords: Analytic Hierarchy Process; GIS; Prone Flood; Hazard; Vulnerability

1. Introduction

Belawan is one of the sub-districts located in the north of the city of Medan which has an area of ± 21.82 km². The problem that often occurs is the threat of tidal flooding/tidal flooding. This tidal flood event disturbed the balance of the ecosystem in Belawan, not only the physical elements were disturbed but also disrupted social and economic activities so that the welfare of the population decreased. Therefore, an in-depth study is needed to deal with the threat of tidal flood inundation.

There are several factors that cause tidal flooding, including: (1) the difference in elevation where the land is lower than the sea level at high tide. (2) subsidence of the existing land which causes its elevation to be below the high tide level. (3) sedimentation in the river which can result in reduced capacity of the river, so that the water will overflow and seek a lower place. (4) increase in sea level due to global warming. This is based on observations made from various sources, that the world's sea level is increasing every year

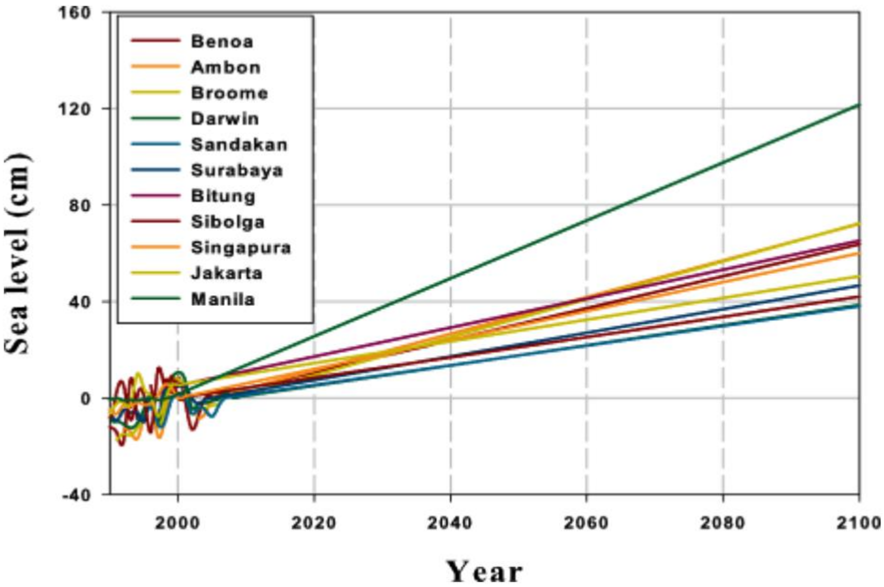

Figure 1. Estimation of Sea Level Rise (KTML) using some Tidal Data obtained from the University of Hawai'i Sea Level Center (UHSLC)

(5) human factors, such as indiscriminate disposal of garbage in rivers and improper drainage system planning and exacerbated by not maintaining the drainage system, can indirectly lead to tidal flooding. (6) high rainfall and other natural phenomena can also exacerbate tidal flooding (U.S. Global Change Research Program, 2018).

This research was conducted in the northern area of Medan city which consists of 3 sub-districts, namely Medan Belawan District, Medan Labuhan District and Medan Marelan District with only the number of affected villages. To determine an effective and efficient tidal flood management model, it is necessary to analyze various environmental factors and conditions. Such as land data, environmental conditions, social economic factors.

Multi-criteria decision making (MCDM) is a decision-making technique from several available alternative choices. There are two kinds of categories, namely Multiple Objective Decision Making (MODM) and Multiple Attribute Decision Making (MADM). Analytic Hierarchy Process (AHP) is a method of MADM. (Calizaya, Meixner, Bengtsson, & Berndtsson, 2010) (Papaioannou, Vasiliades, & Loukas, 2015). This analysis stage is in principle to provide a set of alternatives that will be evaluated by stakeholders based on conflicting and unbalanced criteria, and these criteria must be measurable so that they have a value that will later be calculated to produce a final value that points to the alternative as a decision. the best. This method has been widely used in various fields of work, for example to determine the contractor for a construction work (Al-Harbi, 1990), land suitability assessment (Agarwal et al., 2013; Aydi et al., 2016; Chabuk et al., 2017; Tarmizi et al., 2017, Gumusay et al., 2016; Kamali et al.,2015; Khodaparast et al., 2018), urban spatial planning (AHAKILI, 2016), water resources management (Calizaya et al., 2010; Chowdary et al., 2013), mapping of flood areas & their risks (Ouma and Tateishi, 2014; Papaioannou et al., 2015), environmental pollution (Serbu et al., 2016, Muda and wahyuni, 2019). Wątróbski (Wątróbski et al., 2019) said that to date many MCA methods have been developed, including: Analytic Hierarchy Process (AHP), Technique for Order by Similarity to Ideal Solution (TOPSIS), Simple Additive Weighting (SAW), Simple Multi Attribute Rating Technique (SMART), and many others. Each method has advantages and disadvantages, decision makers must be able to choose which method to use in accordance with the needs and conditions of the problems faced.

The stages in the AHP can be broadly divided into 2 stages, namely Structuring and Assessment. The structuring stage is the process of structuring the decision-making flow based on the AHP components, namely: determining the goals of the decisions to be taken, determining the criteria to achieve the goals determined by the appointed experts, stakeholders with an interest in making this decision or it can also be from references/ appropriate scientific research, and determine the available decision alternatives that are closest to the required criteria (Saaty, 1987). Assessment stage is the stage of assigning value or weight to variables, sub-variables, and alternatives (Al-Harbi, 1990). Giving this weight can be in the form of Direct Assessment or direct weighting, Verbal Assessment, giving weights based on the perception of the superior's assessment of several variables.

The criteria for AHP in this study were determined from literature studies, scientific journals and also based on the results of discussions with experts who are competent in their fields. Some of the scientific journals reviewed are scientific journals that use the AHP method with topics related to this research, namely (Ouma and Tateishi, 2014) which analyzes the level of vulnerability to flood risk using AHP and describes it on a map with GIS and Papaioannou (Papaioannou et al. ., 2015) analyzed areas with potential flood risk using AHP and GIS.

From various scientific journal reviews and discussions with experts, it was decided that the AHP criteria for determining tidal flood-prone zones in the northern area of Medan, especially Belawan: 1. Soil type; This criterion takes into account the clay and sand content in an area where high sand content can accelerate the flood shrinkage process. In (Ouma & Tateishi, 2014) that the type of soil that contains a lot of sand absorbs water faster. 2. Rainfall; One of the causes of increased river water discharge is from rainfall. So that an analysis of the level of rainfall in an area becomes very important, because it can increase the vulnerability of an area to tidal flooding. 3. Land use; This criterion relates to the use of land affected by the tidal flood. Because the tidal flood will have a very large impact, both in terms of material and immaterial, when it comes to areas that are used as densely populated settlements. However, the impact will be smaller if the tidal flood occurs on vacant land or areas that have no function. 4. Distance from the river; Tidal flooding is not only caused by the overflow of tidal sea water, but the flood can occur due to overflowing river water. This is because there is a possibility of narrowing the width of the river or sedimentation of the riverbed as a result of indiscriminate disposal of garbage. 5. Distance from the sea; Tidal flood is a flood that originates from the overflow of sea water, so the area that is first affected by this flood is the coastal area of the sea. Especially coastal areas that have an elevation lower than the high tide level. The further the area is from the coastline, the lower the level of vulnerability to tidal flooding. 6. Elevation; This criterion is quite important, because the characteristics of the tidal flood will inundate areas with an elevation lower than the high tide level. 7. Slopes; The slope factor is one of the factors that affect the risk of being exposed to tidal flooding. This is because tidal flooding will more easily inundate locations that tend to be flatter. The slope percentage can be considered as a surface indicator for flood vulnerability identification (Ouma & Tateishi, 2014) (Papaioannou et al., 2015). 8. Aspect; Similar to the slope factor, this aspect factor analyzes the direction of the slope of a location. For example, in a riverside area that has a slope/aspect direction towards the surrounding settlements, if there is a tidal flood from overflowing river water, the flood will flow towards the surrounding settlements in accordance with the direction of the slope/aspect in the area. (Papaioannou et al., 2015) assesses the aspect criteria by looking at the position of the river and the direction of the storm that causes frequent flooding in the area.9. Drainage density; At the research site there are many drainages that are not functioning properly, such as clogged due to indiscriminate disposal of garbage. So this criterion is quite important because it is closely related to prevention when a flood occurs or can also cause flooding in an area.

2. Method

This research is a type of descriptive quantitative research conducted in a certain area and time, in order to get a comprehensive picture of areas that are potentially (prone) to tidal flooding in the northern area of Medan city, Indonesia. The data used are sourced from several agencies, namely: the Regional Development Planning Agency (BAPPEDA) of North Sumatra, the Meteorology, Climatology and Geophysics Agency (BMKG) North Sumatra, Provincial Forestry Service. North Sumatra and other related agencies. These criteria will be given a weighted value so that AHP calculations can be carried out.

3. Result and Discussion

3.1. Result

This weight assessment involves experts from academia and several community leaders in the research area by filling out a comparison questionnaire between criteria, as shown in the example in Figure 2. The first stage of weight assessment between criteria is carried out by comparing the level of interest intensity between the 2 criteria. The basis of the assessment used is the basic scale (Saaty, 2004) by dividing it into 9 scales, as described in Table 1.

Table 2. Matrix of comparison between criteria

Kriteria	El	Sl	As	JDL	JDS	TGL	CH	DD	JT
El	1	3	4	2	1	3	4	5	5
Sl	0,33	1	2	0,5	0,5	0,5	2	4	4
As	0,25	0,5	1	0,25	0,25	0,33	2	2	2
JDL	0,5	2	4	1	1	2	4	5	5
JDS	1	2	4	1	1	2	4	5	5
TGL	0,33	2	3	0,5	0,5	1	3	3	3
CH	0,25	0,5	0,5	0,25	0,25	0,33	1	2	2
DD	0,2	0,25	0,5	0,2	0,2	0,33	0,5	1	1
JT	0,2	0,25	0,5	0,2	0,2	0,33	0,5	1	1
Σ =	4,07	11,5	19,5	5,9	4,9	9,83	21	28	28

CH JT

9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9

Figure 1. Questionnaire for comparison of rainfall criteria and soil types

Table 1. Scale of assessment between criteria

Source: Calculation results, (2019).

Table 2. Scale between criteria

Intensity of Interest	Description
1	Equally important
2	Not too important
3	Quite important
4	Enough is more important
5	The importance is high
6	The importance is higher
7	Very important
8	Very very important
9	The most important

Sources : T.L Saaty, (2004).

The values of the comparison scale between the agreed criteria are arranged in a matrix table, namely in Table 2. Next, the AHP calculation stages will be carried out, as summarized by Gumusay (Gumusay et al., 2016), namely:

1. Determine the normalization value by dividing the value of each criterion by the total value of each column.
2. Adding up each row of normalized values so that the priority vector value will be obtained as shown in Table 3.

To calculate the weight per criterion by dividing the value per priority vector by the total number of priority vectors, as shown in Table 3.

Table 3. Criteria weight

Criteria	**Weight**
Elevasi (El)	0,234
Slope (Sl)	0,099
Aspect (As)	0,058
Distance from sea (JDL)	0,181
Distance from river (JDS)	0,194
Land use (TGL)	0,117
Rainfall (CH)	0,050
Drainage density (DD)	0,033
Soil type (JT)	0,033

Source: Calculation results, (2019).

The analysis generated through this AHP will later be analyzed spatially using the Geographic Information System (GIS) as follows:

1. **The process of digitizing maps using GIS**; Every map obtained from the relevant agencies must be ensured that the map is ready to be processed using GIS software. So if there is a map in the form of a hardcopy or an image on paper, it must first be scanned and redrawn using GIS. The requirements for a map to be declared ready for further processing in this research are:

a. The map is a file with GIS format (.shp).

b. The map contains the required information, such as the name of the sub-district, land use and so on.

c. The map to be processed must be in accordance with the real conditions in the field.

2. **Classification of parameters on the existing map**; This classification process is changing the existing parameters on the existing map into values so that they can be processed arithmetically in AHP calculations. Determination of this classification is done through discussion with competent experts (Purba et al., 2020). The classification will be divided into 5 levels of risk which have different scores or values and colors. The classification of each criterion is shown in Table 5.

3. **Making a grid area of 10 m x 10 m**; In this study, the assessment locations were divided into areas or grids with a size of 10 m x 10 m using GIS. The basic considerations for determining these dimensions include:
a. The assessment of tidal flood-prone zone decisions is more rational and in accordance with field conditions.
b. An area of 100 m2 is assumed to be approximately equal to the area required for housing per one family.
c. In determining the size, we also consider the maximum ability of the hardware to process GIS data

4. **Merging all maps and AHP scoring**; This stage is the final stage of the integration process of AHP and GIS. This process is to add up the scores (the result of multiplying the grid score with the AHP weight) on the grid with the same position from all the criteria.

After the tidal flood-prone zone map is formed, then a verification process must be carried out, namely to test the correctness of the zoning. This verification process is carried out by taking direct evidence in the form of images or photos in real conditions in the field. To detect flooding with image analysis, in some literature studies generally consist of three ways, namely: (a) use of images from satellites; (b) use of images from cameras fixed on the ground; and (c) the use of images from airplanes or unmanned aerial vehicles (UAV) or what we are familiar with as drones. Taking into account data accuracy, cost and flexibility, the UAV method is a relatively cheaper method, more flexible but can produce good image accuracy, even in bad weather conditions (Popescu et al., 2017).

Table 4. Value of priority vector for each criterion

Criterion	El	Sl	As	JDL	JDS	TGL	CH	DD	JT	Priority vector
El	0,25	0,26	0,21	0,34	0,20	0,31	0,19	0,18	0,18	2,108
Sl	0,08	0,09	0,10	0,08	0,10	0,05	0,10	0,14	0,14	0,890
As	0,06	0,04	0,05	0,04	0,05	0,03	0,10	0,07	0,07	0,522
JDL	0,12	0,17	0,21	0,17	0,20	0,20	0,19	0,18	0,18	1,627
JDS	0,25	0,17	0,21	0,17	0,20	0,20	0,19	0,18	0,18	1,750
TGL	0,08	0,17	0,15	0,08	0,10	0,10	0,14	0,11	0,11	1,055
CH	0,06	0,04	0,03	0,04	0,05	0,03	0,05	0,07	0,07	0,448
DD	0,05	0,02	0,03	0,03	0,04	0,03	0,02	0,04	0,04	0,300
JT	0,05	0,02	0,03	0,03	0,04	0,03	0,02	0,04	0,04	0,300
										Σ = 9,000

Source: Calculation results (2019).

AHP Consistency Test

After obtaining the weight values of all criteria, the AHP consistency test is carried out with the following stages:

1. Calculating the multiplication of the matrix between the weights and the criteria scores.

$$0{,}234\begin{bmatrix}1\\0{,}33\\0{,}25\\0{,}5\\1\\0{,}33\\0{,}25\\0{,}2\\0{,}2\end{bmatrix}+0{,}099\begin{bmatrix}3\\1\\0{,}5\\2\\2\\2\\0{,}5\\0{,}25\\0{,}25\end{bmatrix}+0{,}058\begin{bmatrix}4\\2\\1\\4\\4\\3\\0{,}5\\0{,}5\\0{,}5\end{bmatrix}+0{,}181\begin{bmatrix}2\\0{,}5\\0{,}25\\1\\1\\0{,}5\\0{,}25\\0{,}2\\0{,}2\end{bmatrix}+0{,}194\begin{bmatrix}1\\0{,}5\\0{,}25\\1\\1\\0{,}5\\0{,}25\\0{,}2\\0{,}2\end{bmatrix}+0{,}117\begin{bmatrix}3\\0{,}5\\0{,}33\\2\\2\\1\\0{,}33\\0{,}33\\0{,}33\end{bmatrix}+0{,}05\begin{bmatrix}4\\2\\2\\4\\4\\3\\1\\0{,}5\\0{,}5\end{bmatrix}$$

$$+0{,}033\begin{bmatrix}5\\4\\2\\5\\5\\3\\2\\1\\1\end{bmatrix}+0{,}033\begin{bmatrix}5\\4\\2\\5\\5\\3\\2\\1\\1\end{bmatrix}=\begin{bmatrix}2{,}203\\0{,}906\\0{,}532\\1{,}689\\1{,}807\\1{,}104\\0{,}453\\0{,}306\\0{,}306\end{bmatrix}$$

Source: Calculation results (2019).

1. The result of the matrix multiplication of each criterion is divided again by the weight of the criteria, namely:

$$\frac{2{,}203}{0{,}234}=9{,}409;\ \frac{1{,}689}{0{,}181}=9{,}348;\ \frac{0{,}453}{0{,}05}=9{,}097;$$
$$\frac{0{,}906}{0{,}099}=9{,}158;\ \frac{1{,}807}{0{,}194}=9{,}293;\ \frac{0{,}306}{0{,}033}=9{,}177; \quad (2)$$
$$\frac{0{,}532}{0{,}058}=9{,}179;\ \frac{1{,}104}{0{,}117}=9{,}417;\ \frac{0{,}306}{0{,}033}=9{,}177$$

2. Calculate the value of max by adding up all the results in Equation 5 and dividing by the number of criteria, namely:

$$\lambda_{\max}=\frac{83{,}225}{9}=9{,}251 \quad (3)$$

3. Calculate the consistency index (CI) in the following way:
$$CI=\frac{\lambda_{\max}-n}{n-1}=\frac{9{,}251-9}{9-1}=0{,}031 \quad (4)$$
4. Determine the value of random consistency (RI) based on Table 5, which is 1.45.
5. Calculate the consistency ratio (CR) with the formula:

$$CR=\frac{CI}{RI}=\frac{0{,}031}{1{,}45}=0{,}021 \quad (5)$$

From the results of the AHP consistency test calculation above, the CR value is smaller than 0.1 so that this AHP analysis can be declared consistent.

Table 5. Random Consistency Value (RI)

Matrix size	1	2	3	4	5	6	7	8	9	10
RI	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49

Source: Calculation results (2019).

Scoring Results and Classification with GIS

The classification that has been carried out according to table 5, is then integrated with GIS, where the classification is divided into 5 levels according to Table 6. The results of the classification are in the form of a map of each criterion shown in Figure 6.

Table 6. Parameter classification

The level of Tidal flood vulnerability	Score	Color notation
Very low	1	Dark green
Low	2	Light green
Currently	3	Yellow
Tall	4	Orange
Very high	5	Red

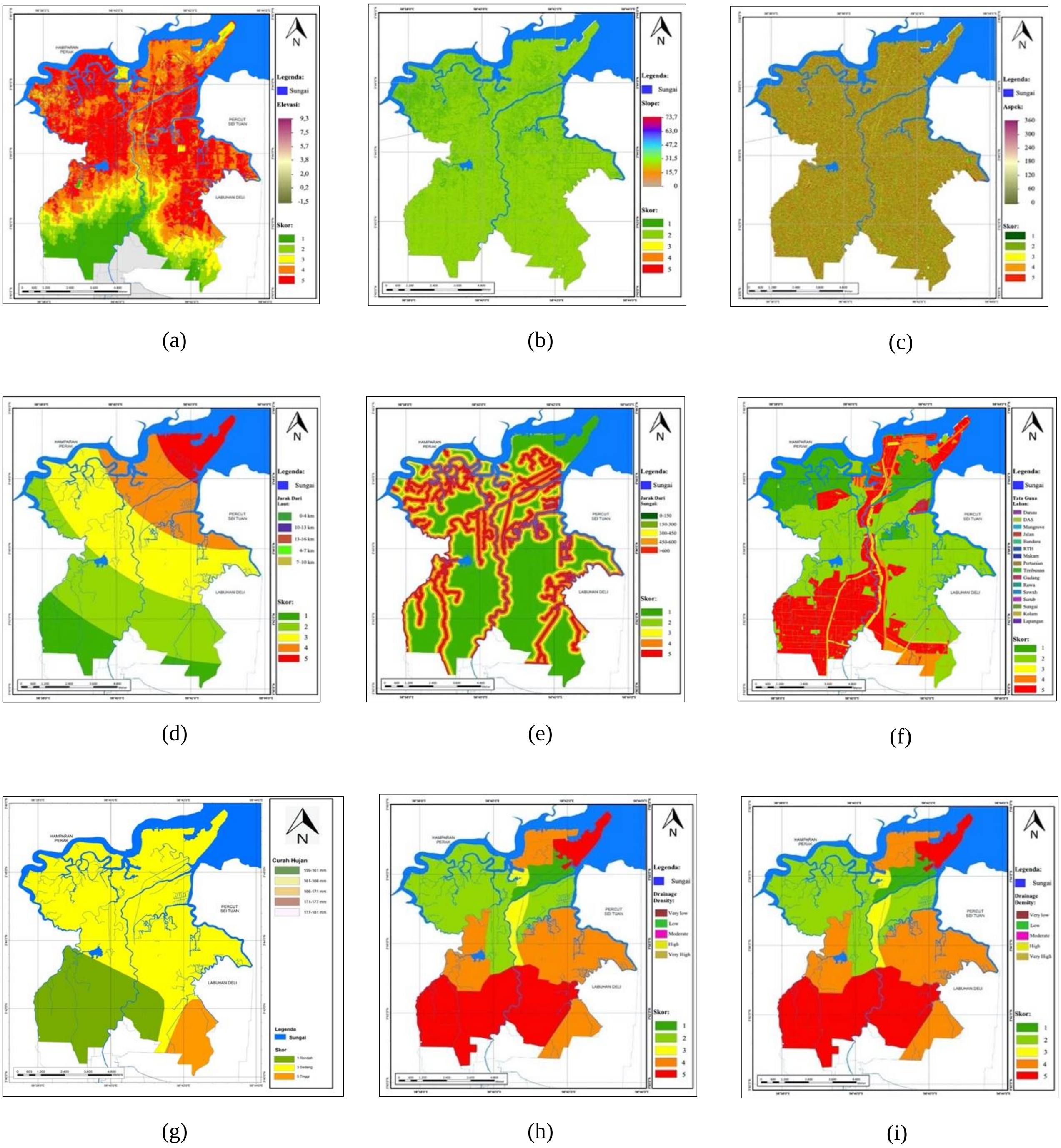

Figure 4. Map of classification results for each criterion: (a) elevation, (b) slope, (c) aspect, (d) distance from the sea, (e) distance from rivers, (f) land use, (g) rainfall , (h) drainage density, (i) soil type

Judging from the existing documentation, the condition of the tidal flood that hit the North Medan area was very severe, in 2017 it was reported that the maximum water level when there was a tidal flood had reached 50 cm (Santama, 2017). After classification, it is seen that the North Medan area has a lower elevation on the north side bordering the sea. The impact of tidal flooding is getting worse when it hits residential areas, as shown in Figure 4(f), the classification of residential areas is mostly in areas with low elevations. From the results of the slope classification in Figure 4(b), the majority of the North Medan area has a high level of risk,

because most of the land conditions have a low slope. This is also exacerbated by the relatively high drainage density in Figure 4(h). The tidal flood that hit the people of North Medan partly came from overflowing river water. This can be seen in Figure 4(e) which shows that this area is traversed by quite a lot of rivers. The high rainfall conditions in Figure 4(g) caused the tides moving inland to be blocked by the flow of water originating from heavy rain so that this condition caused tidal flooding (detikNews, 2012). From the type of soil in Figure 4(i), the soil condition in the northern area is actually soil with conditions that are not easy to absorb water, thus increasing the risk of tidal flooding in that area.

The result of merging all classification maps

The criteria classification map above is then made a grid with a size of 10 m x 10 m, so that each grid contains a score of 9 criteria. The score for each of these criteria is multiplied by the weight of the criteria and added up as a whole. The results of the analysis of the zoning map show that the area that has a high level of tidal flood vulnerability is on the north side. There are several locations such as harbors, although they are in the northernmost part, they only have a moderate level of vulnerability. This is because the design of the height of the building has taken into account the danger of tidal flooding. Locations with high and very high levels of tidal flood vulnerability, caused by tidal flooding through rivers located not far from the sea estuary.

Conformity Process

This process tests the correctness of the zoning results that have been made by conducting a direct observation to the field during the tidal flood as shown in Figure 5. Validation was carried out on July 4, 2019 at the time before and during the tidal flood. The location selected for validation is a location with a high level of vulnerability. The results of verification in the field, tidal flooding inundated settlements as high as ±40 cm and the duration of the flood was about 4-5 hours. And the results are shown in Table 7 below.

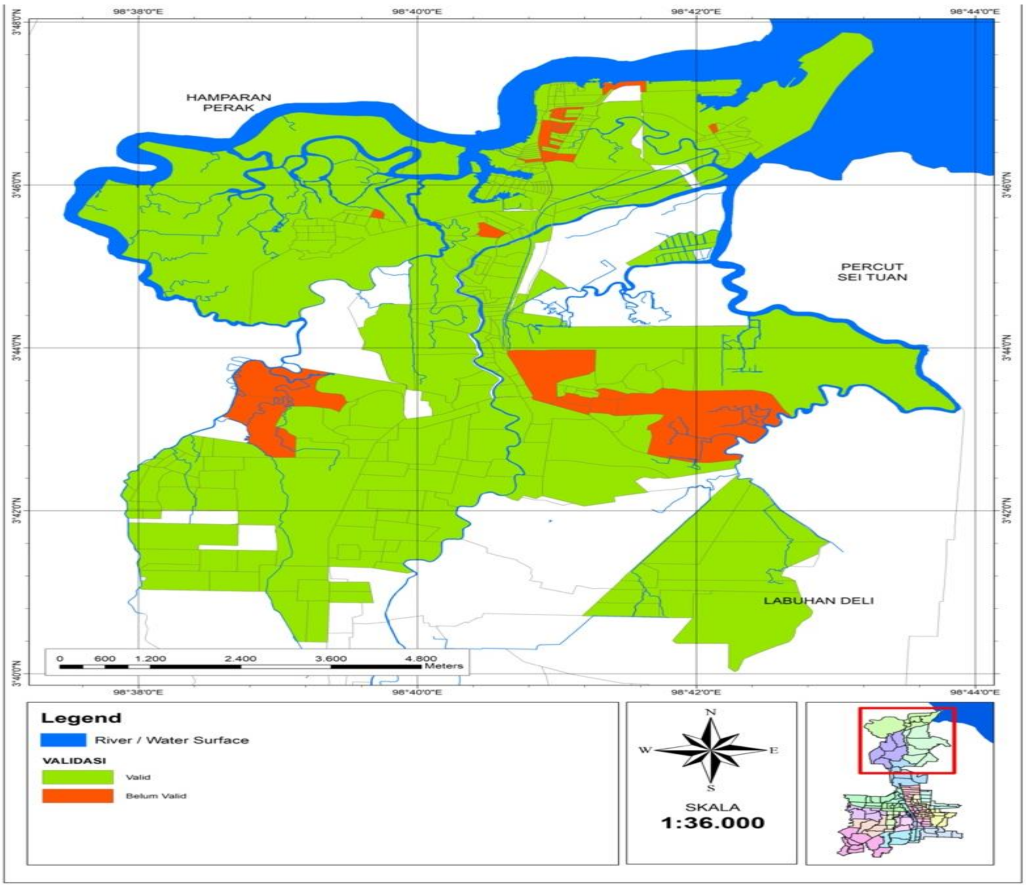

Figure 5. Map of Suitability of Rob Flood Prone Zone

Table 7. Conformity of AHP Map Results

AHP Map Results	Total Environment	Percentage
Invalid	36	17.06
Valid	170	80.57
Not recorded	**5**	2.37
Total	**211**	**100**

Source: Calculation results (2019).

4. Conclussion

Based on the results and analysis that has been carried out in this study, there are several conclusions that can be conveyed as follows:

1. Mapping of flood-prone zones can be carried out rationally and consistently based on AHP by considering 2 aspects, namely technical aspects in the form of elevation, slope, aspect, distance from the sea, distance from rivers, rainfall, soil type and drainage density, as well as aspects social environment in the form of land use. At this time, from the analysis of the level of tidal flood vulnerability in the North Medan area, the following results are obtained:
   a. Very low vulnerability level of 284.81 ha (3.02%).
   b. Low susceptibility level is 3,176.83 ha (33.72%).

c. The medium vulnerability level is 4,411.92 ha (46.83%).
d. High vulnerability level is 1,515.98 ha (16.09%).
e. Very high vulnerability level of 30.91 ha (0.33%)

2. From the results of the analysis, it is known that of the 3 sub-districts in North Medan, Medan Labuhan Sub-district has the largest area for a very high level of vulnerability (AHP score 4.3–4.7) which is 18.04 ha. However, if we also pay attention to areas with a high level of tidal flood vulnerability (AHP score 3.7-4.3), then Medan Belawan District has the largest area with a high level of vulnerability (712.71 ha) and very high (12.87 ha). Ha).

3. From the results of the scoring of tidal flood-prone areas at the kelurahan level, it is known that the top 3 rankings are for the areas most prone to tidal flooding with parameters of high and very high risk areas, including:
a. district. Medan Labuhan - Ex. Beautiful Fisherman with an area of 316.12 ha.
b. district. Medan Belawan – Ex. Sicanang Island with an area of 231.96 ha.
c. district. Medan Belawan – Ex. Bagan Deli with an area of 133.87 ha

4. From the results of testing the suitability of the map in the field with the AHP map results from 211 environments that were matched, then 170 environments (80.57%) were suitable and 36 environments (17.06%) were not suitable and 5 environments (2.37) were not recorded.

REFERENCE

Agarwal, E., Agarwal, R., Garg, R. D., & Garg, P. K. (2013). Delineation of groundwater potential zone: An AHP/ANP approach. Journal of Earth System Science, 122(3), 887–898. https://doi.org/10.1007/s12040-013-0309-8

Al-harbi, K. M. A. (1990). The analytic hierarchy process. European Journal of Operational Research, 45(2–3), 378. https://doi.org/10.1016/0377-2217(90)90209-t

Aydi, A., Abichou, T., Nasr, I. H., Louati, M., & Zairi, M. (2016). Assessment of land suitability for olive mill wastewater disposal site selection by integrating fuzzy logic, AHP, and WLC in a GIS. Environmental Monitoring and Assessment, 188(1), 1–13. https://doi.org/10.1007/s10661-015-5076-3

Calizaya, A., Meixner, O., Bengtsson, L., & Berndtsson, R. (2010). Multi-criteria decision analysis (MCDA) for integrated water resources management (IWRM) in the Lake Poopo basin, Bolivia. Water Resources Management, 24(10), 2267–2289. https://doi.org/10.1007/s11269-009-9551-x

Chabuk, A. J., Al-Ansari, N., Hussain, H. M., Knutsson, S., & Pusch, R. (2017). GIS-based assessment of combined AHP and SAW methods for selecting suitable sites for landfill in Al-Musayiab Qadhaa, Babylon, Iraq. Environmental Earth Sciences, 76(5). https://doi.org/10.1007/s12665-017-6524-x

Chowdary, V. M., Chakraborthy, D., Jeyaram, A., Murthy, Y. V. N. K., Sharma, J. R., & Dadhwal, V. K. (2013). Multi-Criteria Decision Making Approach for Watershed Prioritization Using Analytic Hierarchy Process Technique and GIS. Water Resources Management, 27(10), 3555–3571. https://doi.org/10.1007/s11269-013-0364-6

Gumusay, M. U., Koseoglu, G., & Bakirman, T. (2016). An assessment of site suitability for marina construction in Istanbul, Turkey, using GIS and AHP multicriteria decision analysis. Environmental Monitoring and Assessment, 188(12). https://doi.org/10.1007/s10661-016-5677-5

Kabir, G., Sadiq, R., & Tesfamariam, S. (2014). A review of multi-criteria decision-making methods for infrastructure management. Structure and Infrastructure Engineering, 10(9), 1176–1210.

https://doi.org/10.1080/15732479.2013.795978.

Muda, I., & Wahyuni, E. (2019). An Analysis on the Effect of Environmental Performance and the Implementation of Environmental Management System (ISO 14001) on the Issuer Financial Performance. Calitatea, 20(168), 113-117. https://www.srac.ro/calitatea/en/arhiva/2019/QAS_Vol.20_No.168_Feb.2019.pdf.

Ouma, Y. O., & Tateishi, R. (2014). Urban flood vulnerability and risk mapping using integrated multi-parametric AHP and GIS: Methodological overview and case study assessment. Water (Switzerland), 6(6), 1515–1545. https://doi.org/10.3390/w6061515

Papaioannou, G., Vasiliades, L., & Loukas, A. (2015). Multi-Criteria Analysis Framework for Potential Flood Prone Areas Mapping. Water Resources Management, 29(2), 399–418. https://doi.org/10.1007/s11269-014-0817-6

Purba, R. B., Erlina, H. U., (2020). Influence of Supply Chain Audit Quality on Audit Results through the Auditor's Ability in Detecting Corruption. Int. J Sup. Chain. Mgt Vol, 9(3), 1046. http://ojs.excelingtech.co.uk/index.php/IJSCM/article/view/4975/2526

Popescu, D., Ichim, L., & Stoican, F. (2017). Unmanned aerial vehicle systems for remote estimation of flooded areas based on complex image processing. Sensors (Switzerland), 17(3). https://doi.org/10.3390/s17030446

Saaty, R. W. (1987). The analytic hierarchy process-what it is and how it is used. Mathematical Modelling, 9(3–5), 161–176. https://doi.org/10.1016/0270-0255(87)90473-8

Saaty, T. L. (2004). Decision making — the Analytic Hierarchy and Network Processes (AHP/ANP). Journal of Systems Science and Systems Engineering, 13(1), 1–35. https://doi.org/10.1007/s11518-006-0151-5

Serbu, R., Marza, B., & Borza, S. (2016). A spatial analytic hierarchy process for identification of water pollution with GIS software in an eco-economy environment. Sustainability (Switzerland), 8(11). https://doi.org/10.3390/su8111208.

Tarmizi, HB., Daulay, M., (2017). Impact of The Economic Growth and Acquisition of Land to The Construction Cost Index in North Sumatera. IOP Conference Series : Materials Science and Engineering. 180. https://doi.org/10.1088/1757-899X/180/1/012004.

U.S. Global Change Research Program. (2018). Climate science special report: Fourth national climate assessment, volume I. U.S. Global Change Research Program, 1, 470. https://doi.org/10.7930/J0J964J6.