Analysis of Factors Affecting Potential Tidal Flooding in the Northern part of Medan City (Logistic Regression Analysis Approach)

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Abstract: This study aims to analyse the factors that influence the potential for tidal flooding in the northern part of Medan City. This research was conducted in the northern part of Medan City in 3 sub-districts, namely Medan Belawan District, Medan Marelan District and Medan Labuhan District, which are potentially prone to tidal flooding. Determination of the sample in this study is to use the technique of purposive sampling. In this study, interviews were conducted with 211 respondents, all of whom were sub-village heads in each affected village. Data analysis was performed using logistic regression analysis. Based on the results of the tests carried out, the variables that have a significant effect on the dependent variable (potential tidal flooding) are elevation, slope, distance from the sea, distance from rivers, land-use, and drainage density. Medium that does not have a significant effect is the aspect, rainfall and soil type.

Keywords: Tidal Flooding, Logistic Regression, Medan City.

1. Introduction

Climate change is a phenomenon of changing the physical conditions of the earth's atmosphere, including temperature and distribution of rainfall, slowly but continuously, which has a broad impact on various sectors of human life (U.S. Global Change Research Program, 2018). The main factor causing this change is global warming. One of the impacts of global warming is sea level rise, which poses serious risks, especially in the coastal zone. Deteriorating coastal habitat and resources is a problem that many coastal communities face in developing countries (Wood, Jones, Schelling, & Schmidtlein, 2014) . In a special report by the intergovernmental panel on climate change (IPCC), sea level rise ranged from 22 cm to 34 cm between the 1990s and the 2080s. This is mainly due to the thermal expansion of the oceans and, to a lesser extent, the melting of glaciers. Predicted sea level rise of 38 cm will increase five times the number of people affected by flooding due to storm surges. Not only that, accelerated sea level rise will exacerbate pressure on coastal areas, causing flooding in coastal lowlands, coastal erosion, and destruction of urban structures (U.S. Global Change Research Program, 2018).

One of the disasters that occur in coastal areas is a flood disaster (Popescu, Ichim, & Stoican, 2017). The problem of tidal flooding has a broad impact on various aspects, both in terms of government services and community life. Therefore, efforts to overcome them must be an inseparable part of various development activities in order to improve the welfare of the community.

In the northern area of Medan City, there are 3 sub-districts that are often affected by tidal flooding, namely Belawan District, Labuhan District and Marelan District. Belawan sub-district is the most severely affected by flooding, while Marelan sub-district is the least vulnerable. Floods due to high tides (rob) also have an impact on the destruction of environmental facilities and infrastructure. Since 2010 until now, tidal flooding has been repeated continuously so that it interferes with human activities in terms of physical, economic, social and environmental factors.

Table 1. Tidal Flood Incidents in the Northern Medan Region

Location/District/Sub-district	Date	Observation Area	Sources
Belawan I, Belawan II, Belawan Bahari, Belawan Bahagia, Belawan Sicanang, Bagan Deli	October, 9 - 2010	Belawan District	https://www.republika.co.id
Belawan I, Belawan II, Belawan Bahari, Belawan Bahagia, Belawan Sicanang, Bagan Deli	May, 6 - 2012	Kecamatan Belawan District	https://daerah.sindonews.com
Nelayan Indah dan Sei Mati	May, 8 - 2012	Labuhan District	https://www.republika.co.id
Kantor Pelindo I Belawan dan seluruh Kelurahan	June, 24 - 2013	Belawan District	http://www.globalsumut.com
Belawan I, Belawan II, Belawan Bahari, Belawan Bahagia, Belawan Sicanang, Bagan Deli	April, 17 - 2014	Belawan District	http://www.tribunnews.com
Belawan	April, 27 - 2017	Belawan District	https://news.detik.com
Belawan I, Belawan II, Belawan Bahari, Belawan Bahagia, Belawan Sicanang, Bagan Deli	2018	Belawan District	https://sumutpos.com

Source: Online media

Belawan city is located between 2 (two) river mouths, namely the Belawan river and the Deli river. Naturally, this port has problems with hydraulic and environmental aspects. From the hydraulic study, it was identified that the sediment content in the river contributed as much as 17% of the total material in the inlet to the estuary (Neale & Weir, 2015). This sedimentation is caused by waves that carry mud from the coast to the seabed, causing siltation and accelerating seawater entering the land during high tides.

Based on the calculation of the average tidal height from 2011-2015, (U.S. Global Change Research Program, 2018) showed that sea level rise occurred in Belawan Port of approximately 1.042 cm/year. The increase is relatively large when compared to the average global sea level rise.

2. Method

2.1. Research sites

This research was conducted in the northern part of Medan City in 3 sub-districts. The selection of 3 sub-districts was carried out based on the consideration that the northern part of Medan City, especially in the Medan Belawan District, Medan Marelan District and Medan Labuhan District, was potentially prone to tidal flooding.

2.2. Population, Sample and Respondents

Determination of the sample in this study is to use the technique of purposive sampling. This technique aims to take respondents really understand the condition of the area. According to (Sekaran & Bougie, 2016), the use of this technique is to determine the research sample with certain considerations aimed at making the data obtained more representative. In this study, interviews were conducted with 211 respondents, all of who were Heads of Environment in each affected villages.

2.3. Research Flowchart

Research will run well and systematically if the research conducted is well designed. The design of this research is illustrated in Figure 1. below.

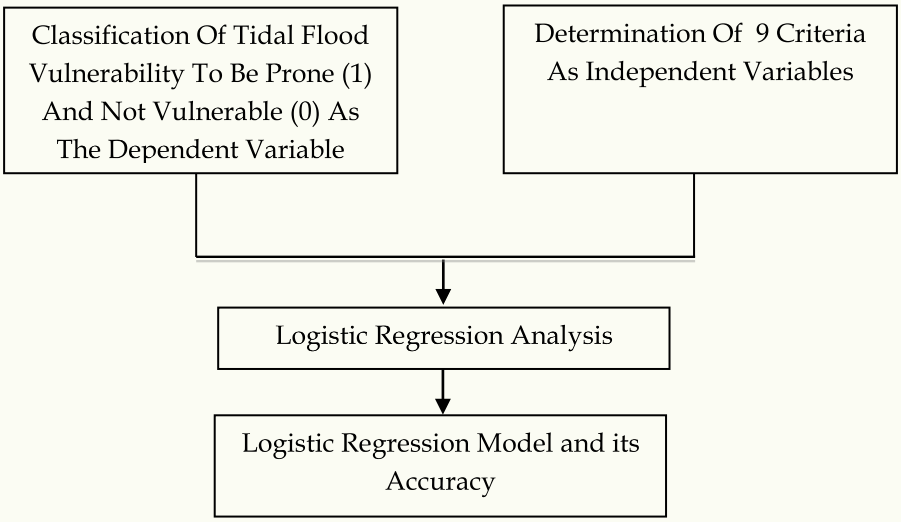

Figure 1. Research Flowchart

2.4. Data analysis

Logistic regression analysis is a regression method used to find the relationship between categorical response variables on a nominal, ordinal scale and one or more continuous and categorical explanatory variables. In binary logistic regression, the response variable consists of two categories (Hair JR, Black, Babin, & Anderson, 2010).

Logistic regression model is used to estimate how likely a certain event will occur. In addition, the logistic regression model is also used to calculate changes that occur in the log odds ratio value of the response variable, not changes in the response variable directly. If there are k predictor variables, then the probability of getting a 'success' result (y = 1) is expressed by $P\left(Y = \frac{1}{x}\right) = \pi(x)$, while the probability of getting a 'failed' result (y = 0) is expressed by $P\left(Y = \frac{0}{x}\right) = 1 - \pi(x)$, where x is a predictor variable and can be qualitative, for example x = 0 dan x =1. In general, the equation of the logistic regression function with k predictor variables is as follows.

$$\pi(x) = \frac{\exp(\beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n)}{1 + \exp(\beta_0 - \beta_1 x_1 + \cdots + \beta_n x_n)} \quad (1)$$

Where π(x) is the probability of a successful event with a probability value of 0 ≤ π(x) ≤ 1 and j is a parameter value with j = 1,2,…p. π(x) is a nonlinear function, so it is necessary to transform it into logit form to obtain a linear function so that the relationship between independent and dependent variables can be seen. By performing the transformation of logit $\pi(x)$, a simpler equation is obtained, namely:

$$g(x) = \frac{\pi(x)}{[1-\pi(x)]} = \beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n \quad (2)$$

with $\beta = (\beta, \beta, \beta, ..., \beta)^T$ dan $\boldsymbol{x} = (1, x, x, ..., x)^T$

In this research, tidal flood vulnerability is the dependent variable, which is categorical (nominal) data. If it affects it is given a value of 1 and if it does not affect it is given a value of 0.

2.4.1. Model Significance Test

Testing of model parameters is carried out to examine the role of explanatory variables in the model. According to (Hair JR et al., 2010), to determine the role of all explanatory variables in the model together, the G-test statistic is used, namely the maximum likelihood ratio test (likelihood ratio test). The G Test statistic is defined as:

$$G = -2 \ln \left[\frac{L_0}{L_p}\right] \quad (3)$$

Where :

L_0 = Likelihood value without independent variable

L_p = Likelihood value with all independent variables

The tested hypotheses are:

$H_0 : \beta_1 = \beta_2 = ... = \beta_p = 0$

H_1: there is at least one $\beta_i \neq 0$, i =1,2,...,p

If H_0 is true, the G-test statistic will follow the distribution of X^2 2 with degrees of freedom p and H_0 will be rejected if the value of G > X^2 (p, α). (Hair JR et al., 2010).

2.4.2. Partial Test (Wald Test)

Partial logistic regression testing was carried out by including all independent variables and dependent variables. The results of this test can help us determine the effect of each independent variable on the dependent variable. This test was carried out using the enter method with a significance level of 5%. The basis for making the decision is if the significance value is <0.05, the hypothesis which states that the independent variable affects the dependent variable is accepted. This test can be done with the Wald test (Bethlehem, 2009) The hypothesis in Wald's test is as follows:

$H_0 : \beta_0 = 0$ (j-th predictor variable has no significant effect on response).

$H_1 : \beta_0 \neq 0$ (j-th predictor variable significantly affects the response) for $j = 1, 2, \ldots, p$ with the following test statistics:

$$w = \left(\frac{\hat{\beta}_i}{SE(\hat{\beta}_i)}\right)^2 \quad (4)$$

Where :

$\hat{\beta}_i$ = Logistic regression coefficient value for the j variable

$SE(\hat{\beta}_i)$ = Standard error value for the j variable

The hypothesis will be rejected if $p - value < \alpha$ which means that the predictor Xj partially significantly affects the response Y.

2.4.3. Testing the Conformity of the Model (Goodness of Fit)

This test explains how much the behavior of the independent variable is able to explain the behavior or variations of the dependent variable. The value of the coefficient of determination is between 0 (zero) and 1 (one). The small value of Nagelkerke R Square means that the ability of the independent variables in explaining the variation of the dependent variable is very limited.

A value close to one means that the independent variables provide almost all the information needed to predict the variation of the dependent variable. This measurement explains the goodness of fit of the model where the closer the value to 1, the more goodness of fit the model is, while the closer to 0 the model is not goodness of fit (Cooper, Schindler, & Sun, 2006).

2.4.4. Hosmer and Lemeshow's Goodness of Fit Test

Hosmer and Lemeshow's goodness of fit test is used to prove the empirical data is suitable or in accordance with the model. There is no difference between the model and the data so that the model can be said to be fit. If the Hosmer and Lemeshow goodness of fit statistic is equal to or less than 0.05, then the null hypothesis is rejected, which means that there is a significant difference between the model and its observation value, so that the goodness fit model is not good because the model cannot predict the observed value. However, if the Hosmer and Lemeshow goodness of fit statistic is greater than 0.05, then the null hypothesis cannot be rejected and means that the model is able to predict the observation value or it can be said that the model can be accepted because it matches the observation data.

2.4.5. Omnibus Tests of Model Coefficients

After testing the logistic regression partially with the wald test, then the logistic regression test will be carried out simultaneously (together). Simultaneous logistic regression testing is called the Omnibus Test of Model coefficient. In this test all independent variables are tested together. This test aims to see whether the independent variables jointly affect the tidal flood vulnerability. The basis for making the decision is if the significance value is greater than 0.05 then Ho is accepted while if the significance value is less than 0.05 then Ho is rejected.

The method is optional for original research articles. This method is written in descriptive and should provide a statement regarding the methodology of the research. This method as much as possible to give an idea to the reader through the methods used. This Method are optional, only for original research articles.

3. Research Findings

This study uses 9 (nine) criteria that can affect the potential for tidal flood vulnerability. To get the influential criteria, then by using statistical analysis using logistic regression. This regression analysis is used to explain the relationship between the response variables in the form of dichotomous/binary data with the independent variables in the form of interval or category scales.

3.1. Model Identification of Potential Tidal Flood (Z)

The identification of this model is to explain the influence of the dependent variable in the form of tidal flood-prone potential (Z) with the independent variable being the occurrence of criteria that affect tidal flooding (X).

Table 2. Variable Output Results on the Potential of Tidal Flood Prone

	B	S.E	Wald	df	Sig.	Exp(B)	95% C.I.for	
							Lower	Upper
Elevation (X1)	1.631	.653	6.243	1	.012	5.111	1.422	1.631
Slope (X2)	4.429	.998	19.707	1	.000	83.872	11.866	4.429
Aspect (X3)	.834	.932	.801	1	.371	2.303	.371	.834
Distance from Sea (X4)	1.922	.684	7.890	1	.005	6.832	1.787	1.922

Distance from River (X5)	.607	.274	4.899	1	.027	1.834	1.072	.607
Land use (X6)	-.784	.328	5.695	1	.017	.457	.240	-.784
Drainage Density (X7)	-1.394	.564	6.103	1	.013	.248	.082	-1.394
Rainfall (X8)	-.816	.630	1.674	1	.196	.442	.129	-.816
Soil Type (X9)	.478	.573	.696	1	.404	1.613	.525	.478
Constant	-24.078	7.184	11.233	1	.001	.000		-24.078

Regression model:

$$\text{Ln}\,\frac{p}{1-p} = -24.078 + 1.631X_1 + 4.429X_2 + 0.834X_3 + 1.922X_4 + 0.607X_5 - 0.784X_6 - 1.394X_7 - 0.816X_8 + 0.478X_9$$

From a series of tests that have been carried out, the odds ratio obtained can be interpreted as follows:

1. Elevation (X_1) = 5.111

   This means that every increase in the elevation variable increases by 1 unit, the ratio of the likelihood of experiencing tidal flooding is 5,111 times, with the value of other variables remaining constant.

2. Slope (X_2) = 83.872
   This means that every increase in the slope variable by 1 unit will increase the tendency to be threatened by 83,872 times, with the value of other variables remaining constant.
3. Aspect (X_3) = 2.303
   This means that each additional aspect variable of 1 unit will increase the tendency to be threatened by 2,303 times, with the value of other variables remaining constant.
4. Distance from sea (X_4) = 6.832
   This means that each increase in the distance to the sea variable by 1 unit will increase the tendency to be threatened by 6,832 times, with the value of other variables remaining constant.
5. Distance from river (X_5) = 1.834
   This means that each increase in the distance variable from the river by 1 unit will increase the tendency to be threatened by 1,834 times, with the value of other variables remaining constant.
6. Landuse (X_6) = 0.457
   This means that every increase in the landuse variable by 1 unit will increase the tendency to be threatened by 0.457 times, with the value of other variables remaining constant.
7. Drainage Density (X_7) = 0. 248

This means that every increase in the drainage density variable by 1 unit will increase the tendency to be threatened by 0.248 times, with the value of other variables remaining constant.

8. Rainfall (X_8) = 0.442
   This means that each increase in the rainfall variable by 1 unit will increase the tendency to be threatened by 0.442 times, with the value of other variables remaining constant.
9. Soil Type (X_9) = 1.613
   This means that each increase in the soil type variable by 1 unit will increase the tendency to be threatened by 1,613 times, with the value of other variables remaining constant.

Table 3. Results of the Model Output on the Potential of Tidal Flood Prone

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	87.326a	0. 470	0.723

In table 3. above, it is explained that Cox & Snell R Square is a measure that tries to imitate the size of R Square in multiple regression which is based on the likelihood estimation technique with a maximum value of less than 1 so it is difficult to interpret. Therefore, the Nagelkerke R Square which is a modification of Cox & Snell R Square where the value varies from 0 - 1, will be easier to interpret as the interpretation of R Square in multiple regression or Pseudo R-Square in multinomial logistic regression.

Nagelkerke R Square in the table above shows a value of 0.723 or 72.3%. This means that the variability of the dependent variable can be explained by the variability of the independent variables of 72.3%. That is, all independent variables affect the dependent variable simultaneously in the range of 72.3%, while the other 27.7% are influenced or explained by variables not included in this study. However, this value is only an approximation because in logistic regression the coefficient of determination cannot be calculated like linear regression, so what needs more attention is how much we can predict correctly which is reflected in the classification table value (see Table 4).

Table 4. Results of Classification of Potential Tidal Flood Prone

Observed		Predicted		
		Tidal Flood Prone		Percentage Correct
		Not Threatened	Threatened	
Tidal Flood Prone	Not Threatened	33	13	71.7
	Threatened	10	155	93.9
Overall Percentage				89.1

From Table 4 above, it is found that from a sample of 211 environmental heads that filled out the questionnaire as many as 46 neighbourhoods were declared to have no effect on tidal flood proneness. There are 33 environments that really don't have a significant effect and those that shouldn't have a significant effect on tidal flood-prone but have an effect of 13 environments. Then the number of environments that affect the tidal flood prone as many as 165 neighbourhoods. The ones that really have a significant effect are 155 environments and those that should have an effect on tidal flood-prone but not as much as 10 environments.
In the logistic regression interpretation, the overall percentage value is 89.1%, meaning that the logistic regression model used is quite good because it is able to correctly guess 89.1% of the conditions that occur.

3.2. Test of Model Suitability (Goodness of fit) to Potential Flood Prone to Rob

This test is used to determine whether the independent variables affect the dependent variable.

Table 5. Results of the Omnimbus Test Output against the Potential of Robt Flood Prone

	Chi-square	df	Sig
Step	133.961	9	0
Block	133.961	9	0
Model	133.961	9	0

Based on Table 5. above, to get a model that is suitable for use, hypothesis testing in ANOVA is used, namely the overall test. Here's the analysis:

1. Hypothesis
   $H_0 : \beta_1 = \beta_2 = \ldots \beta_p = 0$ (the model is feasible to use / there is no effect of the independent variable on the dependent variable).
   H_1 : *ada* $\beta_1 \neq 0$, dimana $i = 1,2,\ldots,$ p (the model is feasible to use/there is an effect of the independent variable on the dependent variable).
2. Significance Level (risk level)
   The significance level (α) = 5% = 0.05, so the confidence interval used is 95%.
3. Critical area
   Reject H_0 if:
   P-Value $< \alpha$
   Chi-Square > *Chi- Square* tabel (df = 9)

   133.961 > 16,119
4. Model Test Statistics : : *p-value* (0.000) $< \alpha$ (0.05)

5. Decision to reject H_0
6. Conclusion
   By using α of 5%, the decision rejects H_0, meaning that there is an influence of the independent variable (criteria) on the dependent variable prone to tidal flooding.

3.3. Partial Test of Potential Tidal Flood Prone

From the output results in Table 2. above to display the t-test used in partially testing the parameters, in other words to find out whether the independent variable (X) has a significant (significant) effect on the dependent variable (Z). The results are tabled in Table 6. below.

Table 6. Partial Significance Test Results of the Model on the Potential of Robt Flood Prone

Variable	*p-value*	α	Sig. test	Decisions
Elevation (X1)	0.012	0.05	0.012 < 0.05	Rejected H_0
Slope (X2)	0.000	0.05	0.00 < 0.05	Rejected H_0
Aspect (X3)	0.371	0.05	0.371 > 0.05	Accepted H_0
Distance from Sea (X4)	0.005	0.05	0.005 < 0.05	Rejected H_0
Distance from River (X5)	0.027	0.05	0.027 < 0.05	Rejected H_0
Land use (X6)	0.017	0.05	0.017 < 0.05	Rejected H_0
Drainage Density (X7)	0.013	0.05	0.013 < 0.05	Rejected H_0
Rainfall (X8)	0.196	0.05	0.196 > 0.05	Accepted H_0
Soil Type (X9)	0.404	0.05	0.404 > 0.05	Accepted H_0

With = 0.05, it can be concluded that the variables Elevation (X1), Slope (X2), Distance from the Sea (X4), Distance from River (X5), Land use (X6) and Drainage Density (X8) have a significant effect on the dependent variable (prone to tidal flooding) while the Aspect (X3), Rainfall (X7) and Soil Type (X9) variables have no significant effect on the dependent variable (tidal flood-prone).

3.4. Model Parameters

Test the model parameters with data (Hosmer and Lemeshow test), this test is to measure whether the predicted probabilities match the observed probabilities. However, this test can be carried out when it is certain that the model obtained is representative-using Table 7. below.

Table 7. Results of the Hosmer and Lemeshow Test Model Output against the Potential of Tidal Flood Prone

Step	Chi-square	df	Sig.
1	7.269	8	0.508

1. Hypothesis

   H_0 = the model fits the data or there is no difference between the model and the data so it can be said to be fit.

   H_1 = the model does not match the data or there is a difference between the model and the data so that it can be said to be fit (the probability of the original data and the probability of the predicted data being equal or appropriate).
2. Significance level : = 0.05
3. Critical Area

   p-value < , then reject H_0

   p-value > , then accept H_0
4. Test statistics

   p-value =0.508
5. Decision

   Because the value of *chi square* value 7.269 < 15.507 *chi square* table for df 8 with a significance of 0.05. The significance value of *p-value* (0.508) > (0.05) then *p-value* 0 is accepted.
6. Conclusion

Because the *p-value* is significant, the predicted probability corresponds to the observed probability.

4. Discussion

Sea level rise is one of the most profound consequences of anthropogenic climate change. As coastal ecosystems and their communities worldwide are widely recognized to be vulnerable to MPAs (Agarwal, Agarwal, Garg, & Garg, 2013). Sea level rise due to the greenhouse effect is 60 cm per hundred years. This publication is the first assessment report conducted by the IPCC (Intergovernmental Panel on Climate Change) on climate change (U.S. Global Change Research Program, 2018), sea level rise (KML) imposes an increased risk of flooding in low-lying coastal communities due to higher exposure to high-wave conditions and storm surge (U.S. Global Change Research Program, 2018).

The phenomenon of tidal flooding that occurs almost throughout the year, both in the rainy season and in the dry season. This shows that rainfall is not the main factor that causes the tidal phenomenon. The moon's gravity is the main generator of tides. Although the mass of the sun is much larger than the mass of the moon, but because the distance of the moon is much closer to the earth than the sun, the moon's gravity has a greater influence (Papaioannou, Vasiliades, & Loukas, 2015).

According to (Chabuk, Al-Ansari, Hussain, Knutsson, & Pusch, 2017) elevation is the vertical difference between two points or the distance from a predetermined reference plane to a certain point along a certain line. For a country, usually the average sea level is used as a reference plane, and then the extension to the mainland is called the geoid. The distance measured from the surface of the geoid to a certain point is called elevation. The higher the location of the area in the coastal area, the safer the area from inundation due to rising sea levels. Elevation of the coastal area refers to the size of the altitude in a particular area that is above the average sea level. The study of coastal elevation is very important to be studied in depth to identify and estimate the land area threatened by the impact of sea level rise in the future. Based on the results of research analysis using logistic regression that the elevation variable based on the significance test value is 0.012 < 0.05, meaning that elevation has a significant effect on the potential for tidal flooding. The higher the elevation, the more protected from tidal flooding and the easier the flow of water to flow to a low place. Vice versa, the lower the ground level, the easier it is to flood. This is as explained (Marfai et al., 2008) that tidal floods inundate parts of the coastal land or places that are lower than the high water level. As in (Ouma & Tateishi, 2014), states that DEM (Digital Elevation Model) is data that provides information on elevation and topographic characteristics of a landscape. Then according to (Melgarejo & Lakes, 2014) also explains that altitude has an influence on the occurrence of floods. Based on the nature of water that flows following the force of gravity, namely flowing from high areas to low areas. Where areas that have higher elevations are less likely to flood. Meanwhile, areas with low elevations have greater potential for flooding. According to (Melgarejo & Lakes, 2014) higher areas are safer areas, while areas that are low and flooded during sea level rise are areas that are vulnerable or unsafe.

Slope based on the significance test, the value is 0.000 < 0.05, meaning that the slope has a significant effect on the potential for tidal flooding. Based on the DEM, the soil slope conditions in the 3 sub-districts of the research location are categorized as relatively sloping so that tidal flooding is easier to enter settlements. As in the study (Papaioannou et al., 2015), that the slope shows the magnitude of the slope angle in per cent or degrees. In addition to increasing the amount of runoff, the steeper the slope also increases the velocity of runoff. The direct inland slope is one of the most important factors that must be considered in estimating the impact of sea level rise on a beach (Papaioannou et al., 2015).

The distance from the sea and the distance from the river based on the significance test were 0.005 < 0.05 and 0.027 < 0.05, respectively. This means that the distance from the sea and the distance from the river have a significant effect on the potential for tidal flooding. In general, one of the main impacts caused by sea level rise is the occurrence of tidal flooding (Popescu et al., 2017) and the same thing according to (Marfai et al., 2008) Semarang City is the capital city of Central Java Province which has a coastal area in the northern part is clearly heavily affected by sea level rise. That this condition is also not much different in the coastal areas of the northern part of Medan City where the closer the plains to the sea or rivers adjacent to the sea, the more potential the land has the potential to be prone to tidal flooding.

While the aspect variable, based on the significance test of the p-value = 0.317 > = 0.05, it means that the aspect does not significantly affect the tidal flood proneness. (Papaioannou et al., 2015) assessing aspect criteria by looking at the position of the river and the direction of the storm that causes flooding that often occurs in the area. The storm blows from the north, causing areas with positions 157.5° - 202.5° south to have a high potential for flooding due to the storm. The criteria for this aspect are technical matters that are closely related to the slope and elevation criteria. However, in the comparison of criteria, the aspect has the lowest importance in terms of elevation and slope. For the North Medan area, the position of the sea is in the north and the area with a slope direction has the lowest level of risk of being affected by tidal flooding from the sea.

According to (McAneney, McAneney, Musulin, Walker, & Crompton, 2016) land use is an effort in planning land use in an area, which includes the division of areas to specialize in certain functions, for example the function of settlement, trade, industry, and others. In this study, land use based on the significance test has a significant effect on tidal flood prone where p-value = 0.017 < = 0.05. In these various land uses are vulnerable to tidal flooding, especially those in coastal areas and directly adjacent to the coast. Very high development growth urges the existence of rivers and drainage channels, and the water catchment area becomes smaller, so that it has an impact on low water absorption capacity, as a result of land cover will be wider pavement. So that the potential for puddles that accumulate to become floods.

Extreme weather events in recent decades have emphasized the importance of climate and weather-related hazards, such as high temperatures or flooding after intense rainfall (Melgarejo & Lakes, 2014). Rainfall factor as one of the predictors of the cause of flooding, rain will cause flooding if the intensity is high enough and falls in a relatively long time (Udmale et al., 2015).From the results of the significance test p-value = 0.196 > = 0.05, it means that based on the rainfall criteria, it does not significantly affect the tidal flood proneness.

Drainage density based on the significance test has a significant effect on tidal flood hazard where the significance value is p-value 0.013 <0.05. The results of this test as conducted by (Johannessen et al., 2014) that another direct impact is the increase in coastal water levels and obstructed drainage. (Wirasatriya, 2006) stated that land subsidence is the most dominant factor causing the relative sea level rise in Semarang, in addition to global warming factors, changes in land use and poor drainage systems.

Meanwhile, for the type of soil on the coast, the significance value is p-value 0.404 > = 0.005, meaning that the criteria for soil type do not significantly affect the occurrence of tidal flood prone. This occurs because the soil type in the area studied is more dominant in the wet swamp category. This means that the land does not affect flood conditions because it is a soil that naturally contains water. This is different from what was stated (Serbu, Marza, & Borza, 2016), the finer the texture of the soil, the more difficult it is for surface runoff water from rain or river overflow to seep into the ground, resulting in inundation. As in (Chowdary et al., 2013) soil texture also determines the water system in the soil in the form of infiltration speed, penetration and water binding ability by the soil and is the only physical property of soil that is permanent and cannot be easily changed by human hands if it is not added from other places. The amount of soil infiltration rate on non-vegetated land will never exceed the rate of rainfall intensity, while in vegetated land areas, the magnitude of the infiltration rate will never exceed the rate of effective rainfall intensity (Melgarejo & Lakes, 2014) (Udmale et al., 2015).

5. Conclusion

Based on the results based on a partial test that has a significant effect on the dependent variable (potential tidal flooding) are elevation, slope, and distance from the sea, distance from the river, land use, and drainage density. Medium that does not have a significant effect is the aspect, rainfall and soil type. Tidal flood management actions can be prioritized in areas according to the tidal flood prone zone map and the tidal flood vulnerability map in this study. In areas with moderate to very high levels of vulnerability and vulnerability, it is necessary to disseminate information from the local government to the local community about losses due to tidal flooding so that local people can better protect the environment and not act that can increase the risk of tidal flooding in the area. It needs very serious attention from the Government regarding the vulnerability and vulnerability of this tidal flood, especially in the City of Belawan and it can be predicted that if this problem is not immediately addressed, then in 2100 the City of Belawan will be completely inundated. This research can be continued by adding soil subsidence and climate factors.

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