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# Rob Flood Risk Index in Medan Belawan District

Anthoni Sumuang Siahaan, Abdiyanto, Feby Milanie

*Department of Urban and Regional Planning, Universitas Pembangunan Panca Budi*

**ABSTRACT**

The flash flood in Belawan sub-district was caused by the entry of water from the Belawan and Deli rivers into the area when the sea water was at high tide. The inundation caused by the elevation of the land is below the level of the tide and river water enters through the drainage channel. Rob research in Belawan uses descriptive and qualitative methods. The distribution of inundation was analyzed using tidal analysis using the admiralty method which was the input to calculate the distribution of inundation using GIS. The flood risk index is calculated using the threat index and vulnerability index parameters. The results of this research show that the disaster risk index in Belawan sub-district is already at high risk with a risk index of 0.78.

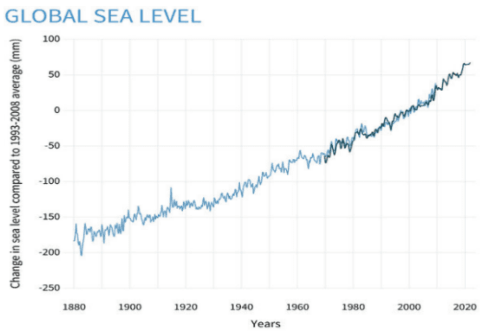
**Keywords:**

Belawan, flood risk index, flash flood

## Background

Tidal floods or tidal floods occur due to rising sea levels when the tide rises and inundates coastal areas. Flash floods can also be caused by external power factors such as water thrust, wind, or swell (waves that travel a great distance away from the generating area); storms at sea; as well as the melting of polar ice triggered by warming Global (Karana & Supriharjo, 2013) . Tides are patterns of sea level fluctuations that are influenced by the gravitational pull of celestial bodies, especially by the moon and sun on the mass of seawater in. Non-astronomical factors that affect water flow (the interval between high water and low water) and the time of arrival of high water or low water time are coastal morphology, water depth and meteorological depth as well as other hydrographic factors, so it can be said that tides in addition to the phenomenon of vertical periodic sea level movement, also horizontal periodic tidal current movements. (Fadilah *et al*. 2014).

The problem of flooding in coastal areas has become a global issue. Sea level rise and land subsidence are parameters that trigger inundation on the coast. Climate change globally, especially in coastal areas, is associated with sea level rise. This causes the tide level to increase and threatens coastal economic areas such as ports, industrial areas and settlements or housing. The record of water level rise revealed by (Maria, *et al*. 2022) that sea level rise has averaged 21–24 centimeters since 1880. The highest water level rise since the 20th century occurred in 2021 with the height of sea level rise reaching 97 mm with an acceleration of 1.4 mm per year (Figure 1.1). This has resulted in an increase of more than 300% of the potential threat of flooding in coastal areas due to high tide levels within 50 years.




Picture 1-1. Average sea level rise globally

*(Source: https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level )*

Human activities can trigger flash floods. Excessive groundwater pumping, dredging of shipping channels, and coastal reclamation are forms of human activities that trigger flash floods. Exploitation of coastal land by humans causes groundwater level subsidence, triggering land subsidence and seawater intrusion. The impact of flash floods includes various aspects of life such as changing the physical environment, decreasing environmental quality, and economic losses (Wahyudi, 2007)(Asdak, 2010)(Putra and Marfai, 2012).

Belawan is one of the areas in Medan City with high economic activity. Port activities are the mainstay of the economy of Medan City. This triggers an increase in urbanization, land change and increased regional development. Wetland areas that are land functions directly turn into strategic areas as high-economic areas and supporting areas outside the economic zone. The addition of plains such as reclamation causes the function of wetlands as flood exposure areas when sea tide is reduced.


Picture 1-2 Area and land use in Belawan

The Belawan ROB flood is currently the main problem for the northern area of Medan City. Geographically, the location of Belawan is between the Belawan River and the Lower Deli River and is directly influenced by the hydrooceanography of the Malacca Strait through the estuary. When the hydraulic behavior of the two rivers interacts with hydroscenography, the Belawan area has the potential to be flooded, considering that Belawan is a wetland area. The frequency of flash floods continues to increase, in this case, the inundation of the area has occurred two flood events in one month. This is a big impact of an economic zone.

Picture 1-3 Inundation of Areas in Belawan due to ROB

The direct physical impact faced when the tide inundates the area is physical damage to both infrastructure and infrastructure in Belawan. The Rob flood caused seawater to inundate the building. The impact of the quality of the material decreases and then becomes the main cause of damage to construction (Riki, *et al*. 2017)

Picture 1-4 Damage to building materials due to flooding

Seeing the impact caused by flash floods from rising water levels during high tide is very worrying, it is necessary to use it as a theme for research on the threat of flash floods in Belawan now and in the future.

## LITERATURE REVIEW

### Literacy and novelty of Research

The research on ROB Flood in Belawan is based on literacy entitled *The Impact of Rob Flood and Community Adaptation in Coastal Are of Medan Belawan, Medan City, North Sumatra, Indonesia* and published in the journal Geography in 2017 (Riki *et al*. 2017). The research method uses a descriptive method by conducting interviews with affected communities. The results of the research on the high flood in the residential area of Medan Belawan sub-district reached 50 – 60 cm and to mitigate from the inundation of the flood the community raised the elevation of the house above the height of the flood flood.

*Inundation Flood Mapping Againts Highest Tide In Coastal Area of Medan Belawan Sub-District, North Sumatra* was published in the journal Oceanography of Diponogoro University in 2016 (Frederick *et al*. 2016). The research discusses the potential of the tidal wave using the height of the sea level and the distribution of the Rob flood using DEM data. The method used in the study is quantitative by calculating the height of the tide using the harmonic constant of the admiralty method. To find out the distribution of ROB floods, it was analyzed using the topo to raster method. The results of the study obtained the tide height in Belawan based on MSL is 144.88 cm, HWL is 246 cm and HHWL is 232.71 cm with an inundation area of 540,398 Ha and occurred in September 2015.

*Risk and Mitigation Analysis of Tidal Flooding Disaster in Medan Belawan Sub Distri*c, Medan City and published in the journal Foundations of Civil Engineering Volume 10:2 of Sultan Sgeng Tirtayasa University in 2021 (Purnaditya, *et al*. 2021). This study discusses the potential for flood disasters in Belawan using oceanographic parameters such as tidal analysis, wave set up, wind set up, estuary water level, land subsidance and climate change. The results of the study were obtained from the flood in Belawan due to the oceanography parameters having a high risk, especially settlements along the coast of Belawan.

The thesis research entitled Risk and Vulnerability Index Due to Rob Floods in Medan Belawan District is a research with the intention of analyzing the impact of rob floods in Belawan and the risks they cause. The source of tidal water from the Malacca Strait is the main parameter in determining the duration of the tidal flood to occur. The height and duration of the tide entering the area through the Belawan River and the Deli River are the threat values that will be analyzed in the flash flood risk index. The method used quantitatively by analyzing the tidal height that causes the land area of Belawan to be flooded and the threat and vulnerability index is calculated using the value of the flood disaster index based on disaster risk index criteria such as threat index, vulnerability, economy and environment. This research was carried out in 2023 so that the data used used the latest data.

Judging from the method and use of data used in this study, this research has authenticity and there are no works that have been submitted or published.

**Flood Rob**

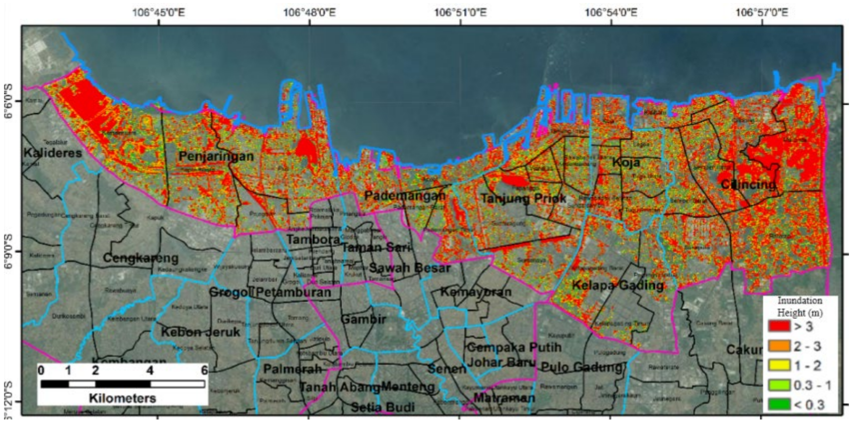
Indonesia as an archipelagic country has initiated development in coastal areas very rapidly, but it is vulnerable to the impact of climate change such as rising sea levels, changes in sea water temperature in the ocean, the threat of wave attacks and also flash floods during high tides. This threat is a serious concern for the government and the community to respond to in planning and developing coastal areas. (Zikra *et al* . 2015) .

Flash floods are a natural phenomenon, in this case seawater inundates the land when the sea water is at high tide. Seawater inundates and enters the land through rivers, drainage channels or underground streams. Rob floods generally occur due to the activity of seawater dynamics which is a form of natural behavior, but behavior due to human activities can accelerate or increase the impact of Rob floods such as excessive groundwater pumping, dredging, coastal reclamation and others, (Noson, 2000) (Wahyudi, 2007)

Rob floods occur when the tide is high during the full moon or full moon. In these conditions, the gravitational force of the moon against the earth is very strong so that the movement of sea water towards the coast is greater when compared to ordinary days. Rob occurs throughout the rainy season and dry season. If the sea water is high during the rainy season, the tidal flood will have an even worse impact.

In the last 20 years, the increase in El Nino and La Nina anomalies, sea level rise accompanied by land subsidence on the coast has caused major cities in Indonesia to experience many ROB problems. Jakarta is a city that has been categorized as threatened by the impact of the ROB flood.

Latief *et al*., (2018)conducted a study of potential threats in the North Jakarta coastal area using oceanographic elements as data stating that the high inundation optivity hitting the north coast of Jakarta until 2040 reaches 184.9 – 342.3 cm to the average sea level (MSL). The distribution of inundation hit 6 sub-districts and the area of inundation reached 7745.92 Ha




Picture 2-5 Map of the threat of ROB flood inundation in North Jakarta in 2040

(Latief et al., 2018)

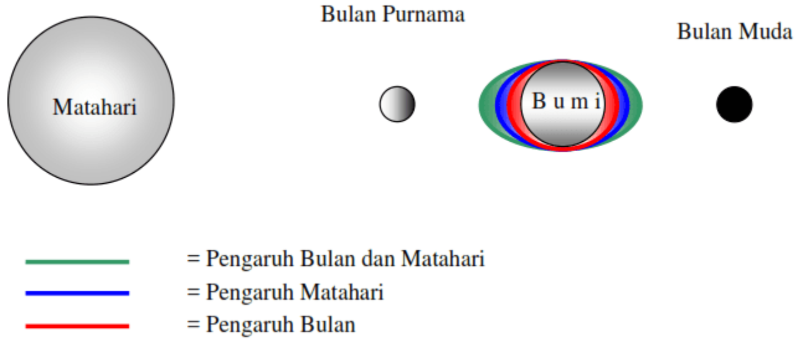
**Tidal**

Tides are events that change the water level caused by the influence of the attraction between planets. As a result, the water level changes based on time.

Changes in water levels due to tides generally occur throughout water bodies on the earth's surface, but the change in height is widely known in water bodies with a wide distribution of water, such as wide rivers, lakes, straits and oceans

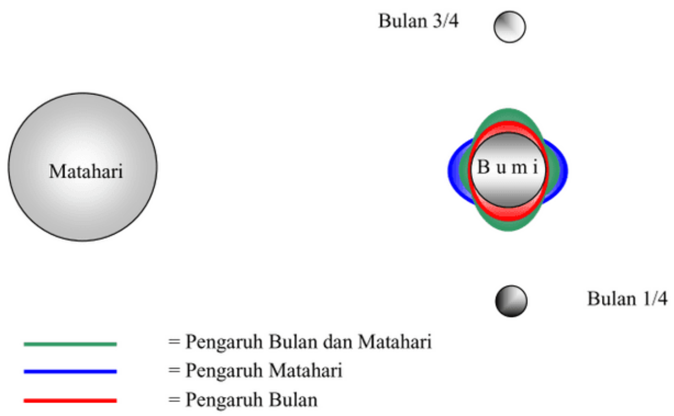
Tides are fluctuations in the water level on the earth's water bodies caused by the gravitational pull of celestial bodies. The attractive forces of attraction that affect water bodies on Earth are the Moon and the Sun. Although the Moon's period is much smaller than the Sun's period, because its distance to the Moon is much closer, the influence of the dancing attraction on the Earth is greater than the influence of the Sun. The Moon's gravitational pull that affects the tides is 2.2 times greater than the Sun's gravitational pull.

There are two positions: the position of the sun and the moon affect the water level on the earth. The first is the location of the Sun, Moon and Earth aligned in a line. Therefore, the influence of the attractive attraction of the Sun and Moon causes the water bodies on Earth to be predominantly inclined to both. As a result, the tides that occur on Earth will be superpositioned and tidal waves will be maximum. This tide is often known as *the Spring Tide*




Picture 2-6 The shape of the tidal water level on the earth is due to the influence of the position of the sun – moon – earth in one line. ( Kuswandi , 2009)

On the 7th and 21st days or (when the Moon is 1/4 and 3/4, the position of the moon forms an angle of $90^0$ to the Earth. In this condition, the tides that occur due to the influence of the Moon and the Sun are different, resulting in a relatively low tidal water level on Earth. This ebb and flow is known as *the Neap Tide* .



Picture 2-7 The Shape of the Tidal Water Table on Earth Due to the Influence of the Position of the Sun and Moon at an angle of $90^0$ to the earth. ( Kuswandi , 2009)

**Tidal type**

The shape of the tides in various regions is not the same. In an area in one day there can be one or two tides. In general, the tides in various regions can be distinguished into four types Kuswandi (2009), Triatmodjo (1999), Ongkosongo & Suyarso (1989)as follows:

a. Double Daily Tides (*Semi Diurnal Tide*)

This type of tidal occurs in one day, two tides and two tides with almost the same height and occur sequentially regularly. The value of Formzahl for the double tidal type is $F \leq 0.25$ with this tidal period being 12 hours and 24 minutes. This tidal form is found at the Equator

b. Single Daily Tides (*Diurnal Tide*)

This type of tide in one day occurs once and once in receding. The value of Formzahl numbers for the Single daily tidal type is $0.25 < F \leq 1.5$ with this tidal period being 24 hours and 50 minutes

c. *Mixed Tide Prevailing Semidiurnal*

This type of tide in one day occurs twice as high and twice as low but the height and period are different. The value of Formzahl numbers for the Mixed tidal type Leaning to Double Daily is $1.5 < F \leq 3.0$. This ebb and flow for the region of Indonesia is found in Eastern Indonesia.

d. *Mixed Tide Prevailing Diurnal*

This type of tide in one day occurs once and low but sometimes for a while there can be two high and two low tide times with different heights and periods. The value of Formzahl numbers for the tidal type of Mixed Tilt to Single Daily is $F > 3.0$.

To determine the type of tide, the Formzahl number equation is used using the tidal constant as below:

$$\Psi = \frac{O_1 + K_1}{M_2 + S_2}$$

**Admiralty method**

The Admiralty method was originally developed by A.T. Doodson in 1921, a director of the Tidal Institute in Liverpool and used for the purposes of the United Kingdom's hydrographic office, the British Admiralty. This method is appropriately used for tidal calculations with short data ranges such as 15 piantan and 29 piantan.

Table 2.1 The value of the coefficient in the calculation of the tidal constant using the admiralty method. (Ongkosongo & Suyarso, 1989)

| Second index | 0 | 2 | b | 3 | c | 4 | d |
|---|---|---|---|---|---|---|---|
| Multiplier for B ( 29 Piantan ) | -29 | -1 | 0 | -1 | 0 | -1 | 0 |
| Multiplier for B ( 15 Piantan ) | -15 | 1 | 0 | 5 | 0 | 1 | 0 |
| **Intermediate Time** *Const* | 1 | 1 | 0 | -1 | 1 | 1 | 0 |

| Second index | | | 0 | 2 | b | 3 | c | 4 | d |
|---|---|---|---|---|---|---|---|---|---|
| Multiplier for B ( 29 Piantan ) | | | -29 | -1 | 0 | -1 | 0 | -1 | 0 |
| Multiplier for B ( 15 Piantan ) | | | -15 | 1 | 0 | 5 | 0 | 1 | 0 |
| | | | 1 | 1 | -1 | -1 | 1 | 1 | -1 |
| | | | 1 | 1 | -1 | 1 | 1 | -1 | -1 |
| | | | 1 | 1 | -1 | 1 | 1 | -1 | -1 |
| | | | 1 | -1 | -1 | 1 | 1 | -1 | 1 |
| | | | 1 | -1 | -1 | 1 | -1 | 1 | 1 |
| | | | 1 | -1 | -1 | 1 | -1 | 1 | 1 |
| | | *Constant for 15 piantans* | 1 | -1 | 0 | -1 | -1 | 1 | 0 |
| | | | 1 | -1 | 1 | -1 | -1 | 1 | -1 |
| | | | 1 | -1 | 1 | -1 | -1 | -1 | -1 |
| | | | 1 | -1 | 1 | -1 | 1 | -1 | -1 |
| | | | 1 | 1 | 1 | -1 | 1 | -1 | 1 |
| | | | 1 | 1 | 1 | 1 | 1 | -1 | 1 |
| | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| | | | 1 | 1 | -1 | 1 | -1 | 1 | -1 |
| | | | 1 | 1 | -1 | 1 | -1 | -1 | -1 |
| | | | 1 | 1 | -1 | -1 | -1 | -1 | -1 |
| | | | 1 | -1 | -1 | -1 | -1 | -1 | 1 |
| | | | 1 | -1 | -1 | -1 | 1 | -1 | 1 |
| | | | 1 | -1 | -1 | -1 | 1 | 1 | 1 |
| | | | 1 | -1 | 0 | -1 | 1 | 1 | 0 |
| | | | 1 | -1 | 1 | 1 | 1 | 1 | -1 |
| | | | 1 | -1 | 1 | 1 | 1 | 1 | -1 |
| | | | 1 | -1 | 1 | 1 | -1 | -1 | -1 |
| | | | 1 | 1 | 1 | 1 | -1 | -1 | 1 |
| | | | 1 | 1 | 1 | 1 | -1 | -1 | 1 |
| | | | 1 | 1 | 1 | -1 | -1 | 1 | 1 |
| | | | 1 | 1 | 1 | 1 | -1 | -1 | 1 |
| | | | 1 | 1 | 0 | -1 | -1 | 1 | 0 |

The weakness of the Admiralty method is that it is only used for processing short-term data and relatively few calculation results only produce 9 tidal components. Because it is limited to a short range of data, this method is used in locations that have limited data, but can predict the conditions and characteristics of the tides carefully. ( Fitriana et al., 2019)

The process of calculating the paut with this method uses a supporting table containing calculation constants. Furthermore, the calculation with this method obtained 2 harmonic constants, namely amplitude (A), and phase difference ($g^o$) so that the analysis of the type of paut could be carried out. Constants – tidal constants obtained from the admiralty method are shown in the table below:

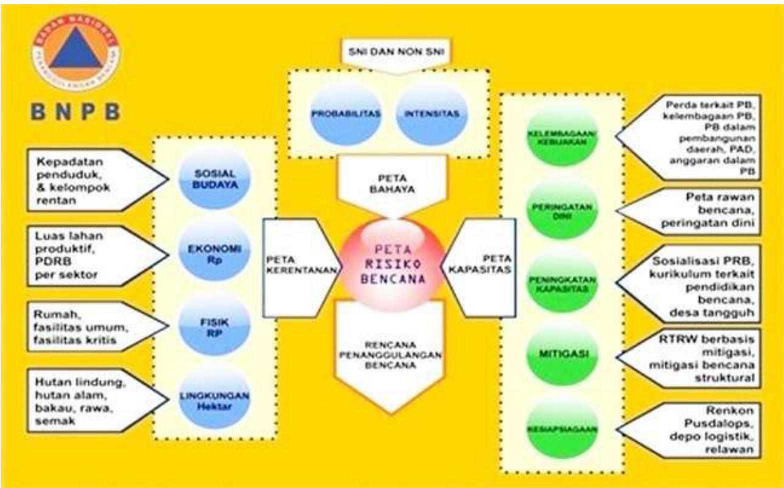
Table 2.2 Tidal Constant ( Ongkosongo & Suyarso , 1989)

| Symbol | Pasut Type | Era (Hours) | Information |
|---|---|---|---|
| M2 | Semi Diurnal | 12,42 | Main lunar semi diurnal component |
| S2 | | 12,00 | Main diesel semi diurnal component |
| N2 | | 12,66 | Lunar component due to monthly variation in moon's distance from earth |
| K2 | | 11,97 | Soil lunar constituent due to changes in declination of sun and moon troughout their orbital cycle |
| K1 | Daylong | 23,93 | Soil lunar component |
| O1 | | 25,82 | Main lunar diurnal component |
| P1 | | 24,07 | Main solar diurnal component |
| M1 | | 327,86 | Moon's biweekly component |

**ROB Flood Disaster Risk Study**

Disaster risk assessment is basically determining the magnitude of 3 (three) risk components, namely danger, vulnerability and capacity. This component is used to obtain the level of disaster risk of an area by calculating the potential for exposed lives, property losses and environmental damage. In addition, it also produces a risk map for each potential disaster in an area. This disaster risk assessment and map must be able to be an adequate basis for regions to formulate disaster management policies. The purpose of the disaster risk assessment method is to produce disaster management policies derived from the disaster risk map. Disaster risk maps are obtained from hazard map overlays, vulnerability maps and capacity maps. The hazard map is obtained from the probability and intensity components of the disaster event. In general, the methodology of disaster risk assessment is carried out by several processes, namely data collection to the presentation of the results of the disaster risk assessment in the form of spatial maps. The data taken will be processed so as to produce a disaster risk index. From the results of this index, hazard maps, vulnerability maps, capacity maps and disaster risk maps are then prepared. The summary of the mapping results will be summarized into a level that is a summary of the results of the disaster risk assessment.

Flood Disaster Risk is assessed based on the Regulation of the Head of the National Disaster Management Agency Number 02 of 2012 concerning General Guidelines for Disaster Risk Assessment. The Disaster Risk Assessment Method is summarized in the Figure below




Picture 2-8 Disaster Risk Assessment (BNPB, 2012)

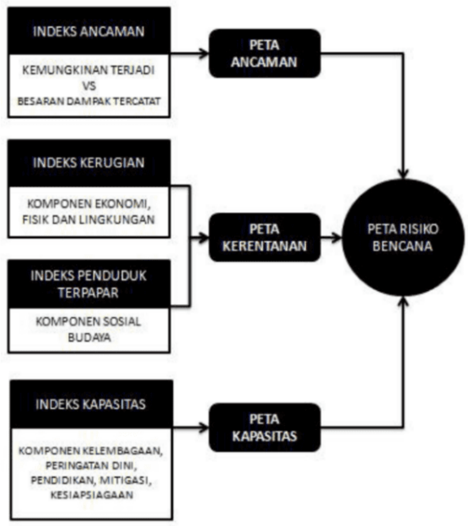
The flood disaster risk assessment is carried out to produce a disaster management policy that is prepared based on three main components, namely; (1) Threat Component; (2) Vulnerability Components; and (3) Capacity Components. The Threat component consists of two parameters, namely the intensity parameter and the probability of occurrence. Meanwhile, the Vulnerability Component consists of four parameters, namely socio-cultural, economic, physical and environmental. Furthermore, the Capacity Component is composed of five parameters, namely regulatory capacity, institutions, warning systems, skills training education, mitigation and preparedness systems. The results of the disaster risk assessment consist of 2 parts, namely:

1. Disaster Risk Map.
2. Disaster Risk Assessment Document.

The mechanism for preparing the Disaster Risk Map is interrelated with the mechanism for preparing the Disaster Risk Assessment Document. The Disaster Risk Map produces a basis for determining the level of disaster risk which is one of the components of the achievement of the Disaster Risk Assessment Document. In addition, the Disaster Assessment Document also presents a minimum disaster management policy aimed at reducing the number of exposed lives, property losses and environmental damage.

**Preparation of Disaster Risk Map**

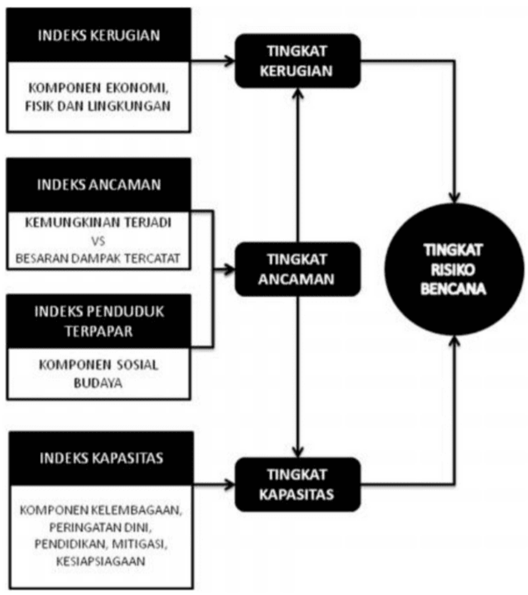
The Disaster Risk Map is an overlay (combination) of the Threat Map, Vulnerability Map and Capacity Map. The maps were obtained from various indices calculated from their own data and calculation methods. Disaster risk maps are created for each type of disaster threat that exists in an area. The calculation methods and data needed to calculate the various indices will be different for each type of threat.




Picture 2-9 Disaster Risk Mapping Method, (BNPB, 2012)

**Preparation of Disaster Risk Assessment Documents**

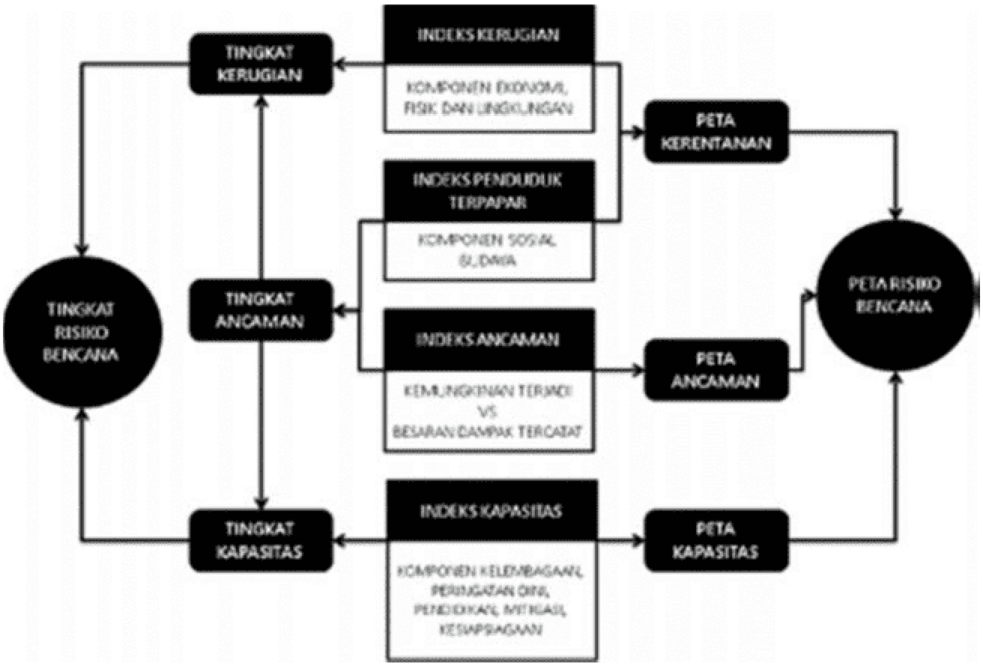
The Disaster Risk Assessment document is obtained from the same index and data as the preparation of the Disaster Risk Map. The difference is only in the order in which each index is used. This order changed because the human soul cannot be valued in rupiah. Therefore, the Threat Level, which has taken into account the Threat Index in it, is the basis for the calculation of the Loss Level and Capacity Level. The combination of Loss Level and Capacity Level is the Disaster Risk Level.




Picture 2-10 Method of Preparing Disaster Risk Assessment Documents (BNPB, 2012)

**Correlation of Map Preparation and Disaster Risk Assessment Documents**

All indices contained in the Preparation of Disaster Risk Maps and Disaster Risk Assessment Documents are correlated to see the level of disaster risk. From this correlation, the assessment of the level of disaster risk can be determined.




Picture 2-11 Disaster Risk Assessment (BNPB, 2012)

**Flood Disaster Risk Index**

**Flood Disaster Threat Index**

The Flood Disaster Threat Index is compiled based on two main components, namely the likelihood of a threat and the magnitude of the impact that has been recorded for the disaster that occurred. It can be said that this index is compiled based on data and historical records of events that have occurred in an area. In the preparation of a disaster risk map, these key components are mapped. The mapping can only be carried out after all indicator data on each component is obtained from a predetermined data source. The data obtained were then divided into 3 threat classes, namely low, medium and high. The components and indicators for calculating the Flood Disaster Threat Index are shown below.

| Information | CLASS OF THE INDEX | | |
|---|---|---|---|
| | **LOW** | **KEEP** | **TALL** |
| River Flood Height | < 1 m | 1 - 3 m | > 3 m |
| Grade grades | 1 | 2 | 3 |

| Information | CLASS OF THE INDEX |
|---|---|

| | LOW | KEEP | TALL |
|---|---|---|---|
| High inundation area | < 0.76 m | 0.76 - 1.5 m | > 1.5 m |
| Grade grades | 1 | 2 | 3 |

**Social vulnerability index**

The indicators used for social vulnerability are population density, sex ratio, poverty ratio, disability ratio and age group ratio. The social vulnerability index was obtained from the average weight of population density (60%), vulnerable groups (40%) consisting of gender ratio (10%), poverty ratio (10%), disability ratio (10%) and age group (10%). The equation and table of index classes are shown below

$$Kerentanan\ Sosial = (0.6 * Nilai\ Pddk) + (0.1\ Nilai\ Bobot\ Jk) + (0.1 * Nilai\ bobot\ Km) + (0.1 * Nilai\ Bobot\ Kc) + (0.1 * Nilai\ Bobot\ Ku)$$

| DISASTER | COMPONENTS/ INDICATORS | | CLASS OF THE INDEX | | | TOTAL WEIGHT | DATA SOURCES |
|---|---|---|---|---|---|---|---|
| | | | LOW | KEEP | TALL | | |
| Flood | Socio-Cultural (40%) | | | | | | |
| | 1 | Population Density | < 500 inhabitants/km2 | 500-1000 inhabitants/km2 | > 1000 inhabitants/km2 | 60% | Podes, Susenas, and Land use |
| | 2 | Vulnerable Groups | < 20 % | 20-40 % | > 40 % | 40% | |

**Economic vulnerability index**

To analyze economic vulnerability, the indicators used are the area of productive land in rupiah (rice fields, plantations, agricultural land and ponds) and GDP. The area of productive land can be obtained from land use maps and district or sub-district books in numbers and converted into rupiah, while GDP can be obtained from sector or district reports in numbers. To analyze the economic vulnerability index, the table and equation below are the basis for determining the economic vulnerability index assessment indicator

| Prameter | Weight (%) | CLASS OF THE INDEX | | |
|---|---|---|---|---|
| | | LOW | KEEP | TALL |
| Productive land | 60 | < 50 million | 50 -200 million | > 200 million |
| GDP | 40 | <100 million | 100 - 300 JT | > 300 million |

$$Kerentanan\ Ekonomi = (0.4 * Nilai\ Lp) + (0.4\ Nilai\ Bobot\ Lpdrb)$$

**Physical vulnerability index**

Physical Vulnerability The indicators used for physical vulnerability are house density (permanent, semi-permanent and non-permanent), availability of public buildings/facilities and availability of critical facilities. The density of houses is obtained by dividing them by built-up area or village area and divided by area (in ha) and multiplied by the unit price of each parameter.

| PARAMETERS | Weight (%) | CLASS OF THE INDEX | | | Score |
|---|---|---|---|---|---|
| | | LOW | KEEP | TALL | |
| House | 40 | < 400 million | 400-800 million | > 800 million | |
| Public Facilities | 30 | < 500 million | 500 million - 1 M | > 1 M | |
| Critical Facilities | 30 | < 500 million | 500 million - 1 M | > 1 M | Grades/Max grades |

$$Kerentanan\ Fisik = (0.4 * Nilai\ Rmh) + (0.3\ Nilai\ Bobot\ Fu) + (0.3 * Nilai\ bobot\ FK)$$

**Environmental vulnerability index**

Environmental Vulnerability Indicators used for environmental vulnerability are land cover (protected forests, natural forests, mangroves/mangroves, swamps and shrubs). The physical vulnerability index is different for each type of threat and is obtained from the average weight of the land cover type. The environmental vulnerability index conversion parameters are combined through weighting factors.

| PARAMETERS | Weight (%) | CLASS OF THE INDEX | | |
|---|---|---|---|---|
| | | LOW | KEEP | TALL |
| Protected Forest | 30 | < 20 Ha | 20 - 50 Ha | > 50 Ha |
| Natural Forest | 30 | < 25 Ha | 25- 75 hectares | > 75 Ha |
| Mangrove Forest | 10 | < 10 Ha | 10 - 30 Ha | > 30 Ha |
| Bush | 10 | < 10 Ha | 10 - 30 Ha | > 30 Ha |
| Swamp | 20 | < 5 Ha | 5 - 20 Ha | > 20 Ha |

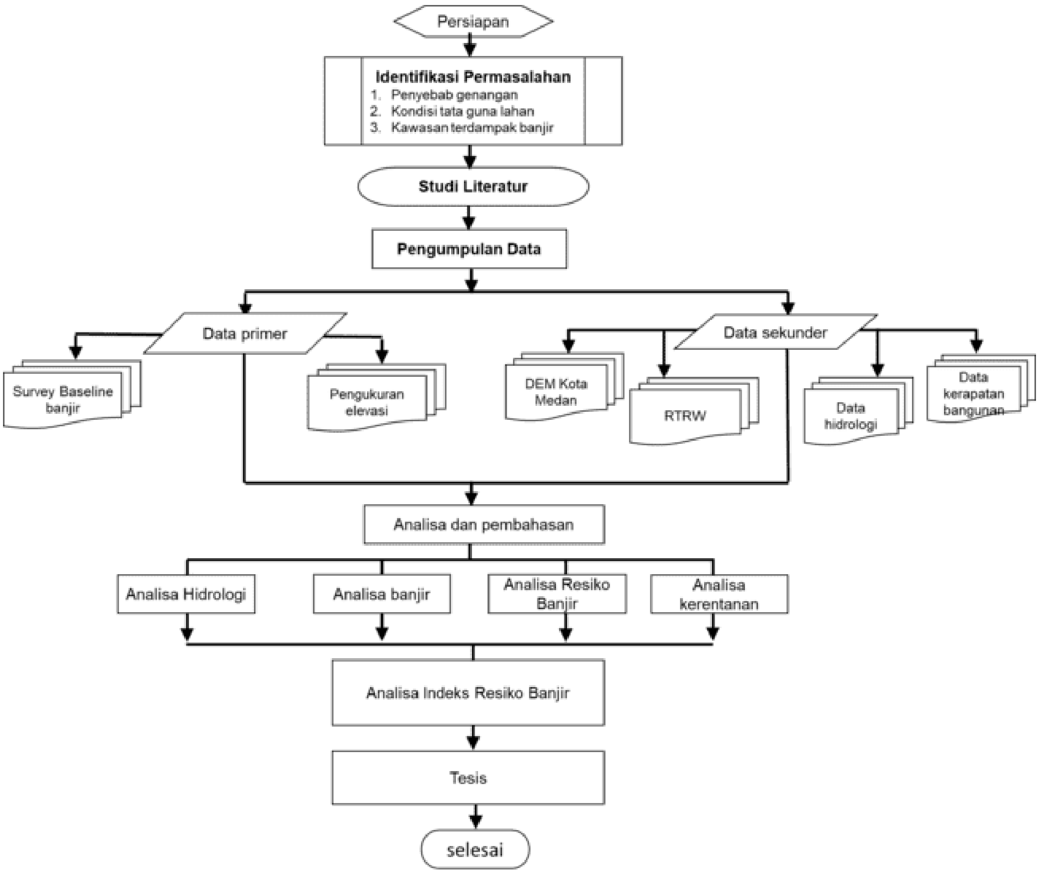
## RESEARCH METHODOLOGY

### Research Flow and Design

The research method used in this thesis is a quantitative method. The flood risk index due to sea tides can be quantitatively known for the threats, vulnerabilities and losses caused. The beginning of the problem can be identified by conducting an initial investigation of the entry of water into the area. The identification was carried out along with the digitization results of land use and an initial picture of the distribution of inundation at high tide.

At the research location, starting from the identification of problems related to flooding. In the initial activity, identify the cause of inundation or flooding due to tides. Flood-affected areas and their relationship with land use in flood-prone areas are locations that will be used to determine the flood vulnerability index from social, physical, economic and environmental aspects.

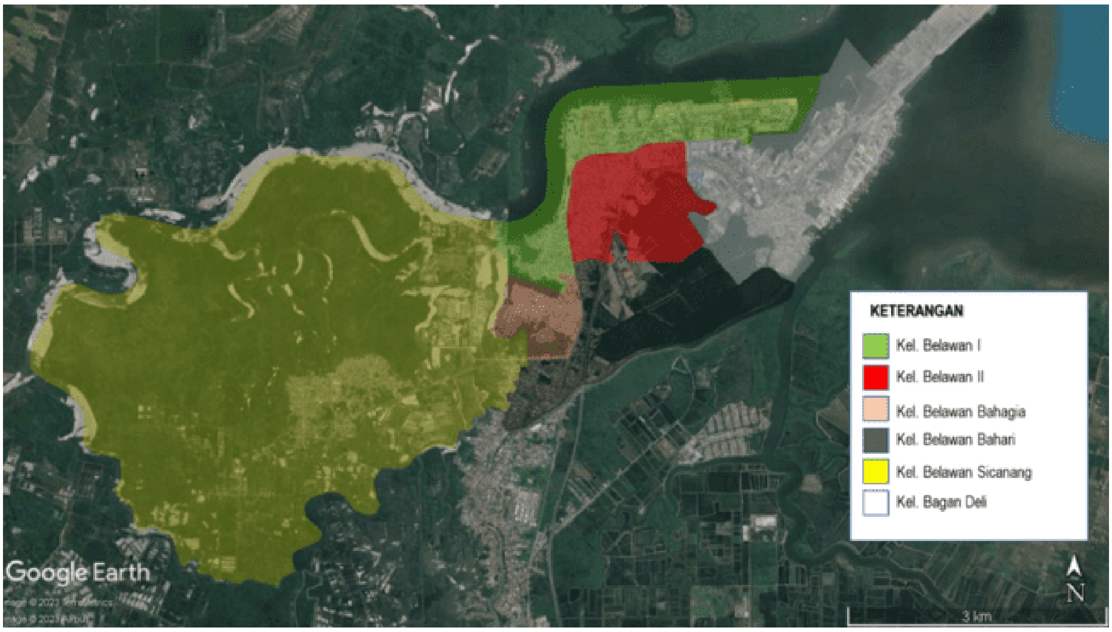
To achieve the goal, primary data and secondary data are needed as analysis materials. The primary data that will be used is flood baseline survey data and elevation strengthening, especially the elevation of drainage outlets and rivers. To get more comprehensive data, secondary data is needed such as Medan City DEM data, RTRW, hydrological data and building density. All secondary data will be the initial analysis in determining the flood disaster risk index. The analysis carried out is hydrological analysis, especially rainfall related to river and regional flooding, flood risk analysis with the knowledge of threat index values and vulnerability analysis both social, economic and environmental aspects. The entire analysis will be a parameter for assessing the flood risk index. In general, the research flow is shown in the figure below.




Picture 3-1 Disaster Risk Assessment

**Observation of Rob Flood in Belawan**

To find out the impact caused by the Rob Belawan flood, visual observation and field identification became a calibration method when analyzing the distribution of inundation and vulnerability. To observe the observation area is based on the number of villages in Medan Belawan District, namely Belawan I, Belawan II, Belawan Bahagia, Belawan Bahari, Belawan Sicanang and Bagan Deli Villages. The boundaries of each region are digitized and plotted in a map as shown in the image below.




Picture 3-2 The area of Medan Belawan District is the boundary of the research scope

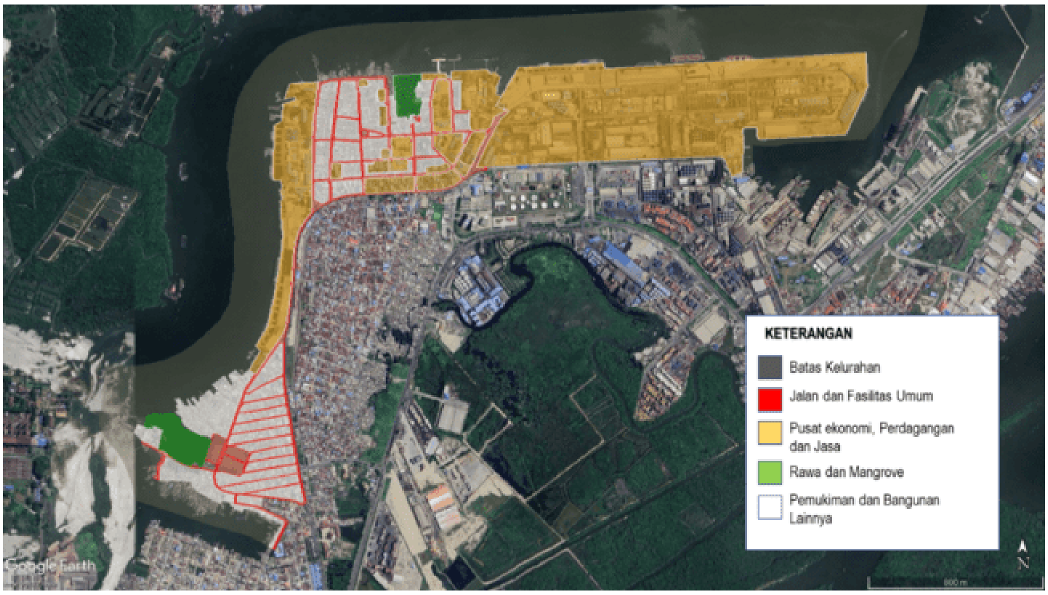
Visual observation of the tidal flood and its impact was carried out by direct observation in the field. Observing the height and distribution of inundation and the impact caused


Picture 3-3 Observation of the source of the entry of the tide that causes inundation

Flood Rob

## Digitization of Belawan Space Utilization

Digitization of space utilization such as residential areas, offices, and economic centers is an input in determining the value of vulnerability. The assessment of parameters is based on the territorial boundaries of each sub-district in Medan Belawan sub-district. The digitization method is carried out using regional shp data and generated with geographic information systems (GIS)




Picture 3-4 Digitization of boundaries and physical parameters

## DISCUSSION

### Tides and Elevation of Rob Floods

The main source of the tidal flood in Belawan is seawater inundating the area when the tide from the Malacca Strait enters through the Belawan and Deli rivers. The results of the analysis of tidal data in Belawan produced a tidal constant which further determined the type of tide and it was known that the type of tide in Belawan based on the calculation of the Fhonzal number was 0.3 which means the dominant type of diurnal tide or in one day there were two tides and two recedes

Table 4.1 Tidal constant in Belawan

| It | Constituents | Symbol | Description | Period (hour) | ω(rad/hour) | A | B | go Phase | H=Amplitude (m) |
|---|---|---|---|---|---|---|---|---|---|
| 0. | Average water level | Z0 | | - | - | | | | 1.01 |
| 1. | Main lunar constituent | M2 | Semi Diurnal | 12.42 | 0.51 | (0.43) | 0.45 | 133.56 | 0.62 |
| 2. | Main solar constituent | S2 | | 12.00 | 0.52 | (0.09) | 0.29 | 108.15 | 0.30 |
| 3. | Lunar constituent, due to Earth-Moon distance | N2 | | 12.66 | 0.50 | (0.12) | 0.04 | 163.06 | 0.13 |
| 4. | Soli-lunar constituent, due to the | K2 | | 11.97 | 0.53 | 0.11 | (0.01) | 355.43 | 0.11 |

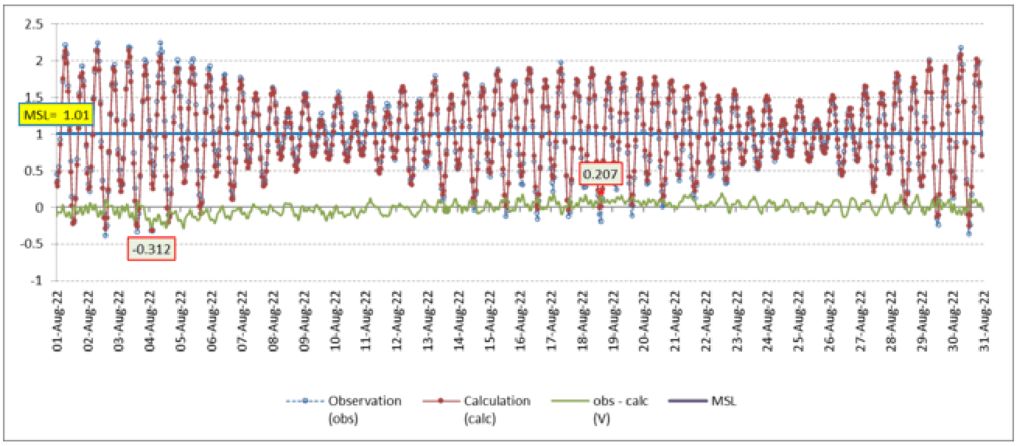
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | change of declination | | | | | | | | |
| 5. | Soli-lunar constituent | K1 | Daylong | 23.93 | 0.26 | 0.16 | (0.16) | 316.72 | 0.23 |
| 6. | Main lunar constituent | O1 | | 25.82 | 0.24 | 0.04 | (0.04) | 314.32 | 0.05 |
| 7. | Main solar constituent | P1 | | 24.07 | 0.26 | (0.08) | (0.07) | 222.95 | 0.11 |
| 8. | Main lunar constituent | M4 | Quarterly | 6.21 | 1.01 | (0.00) | 0.01 | 105.31 | 0.01 |
| 9. | Soli-lunar constituent | MS4 | | 6.10 | 1.03 | 0.00 | 0.01 | 78.42 | 0.01 |

$$F = \frac{K_1 + O_1}{M_2 + S_2} = \frac{0.23 + 0.05}{0.62 + 0.30} = 0.3$$

Flood inundation due to tidal waves in Belawan is predominantly caused by sea tides, to find out the sea level level that causes tidal floods based on tidal data obtained the water level as shown in the figure below.

Table 4.2 Water level due to tides

| Information | Symbol | Calculation | TMA (m) |
|---|---|---|---|
| Higher High Water Level | HHWL | Z0+(M2+S2+K2+K1+O1+P1) | 2.42 |
| Mean High Water Level | MHWL | Z0+(M2+K1+O1) | 1.91 |
| Mean Sea Level | M.S.L. | Z0 | 1.01 |
| Mean Low Water Level | MLWL | Z0-(M2+K1+O1) | 0.11 |
| Chart Datum Level | CDL | Z0-(M2+S2+K1+O1) | -0.19 |
| Lower Low Water Level | LLWL | Z0-(M2+S2+K2+K1+O1+P1) | -0.40 |
| Higest Astronomical Tide | HAT | Z0+(all constituents) | 2.56 |




Picture 4-5 Tide chart in Belawan

The result of the calculation of sea level height in Belawan that will be used for the simulation of tidal flood inundation is the water level based on the average sea *level*. Based on the Belawan tidal station is known to be at an elevation of + 2,274 m and the elevation of MSL to the tidal station is + 0.311 m, the height of the tide level to the elevation of the tidal station is shown in the table below.

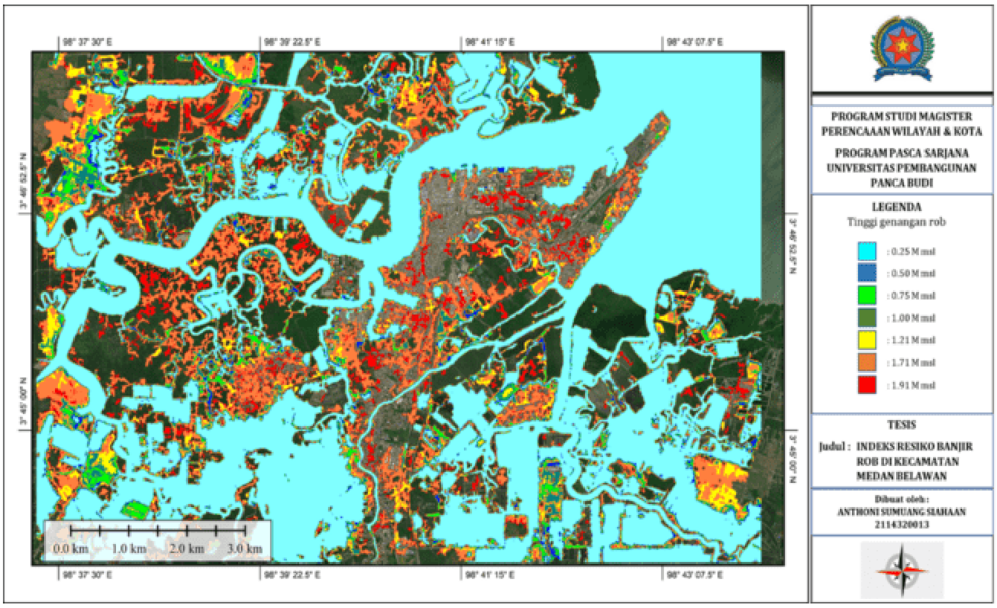
Table 4.3 Water level against the datum chart of topographic elvation of Belawan

| Information | Symbol | TMA (m) |
|---|---|---|
| Higher High Water Level | HHWL | 1.711 |
| Mean High Water Level | MHWL | 1.211 |
| Mean Sea Level | M.S.L. | 0.311 |
| Higest Astronomical Tide | HAT | 1.911 |

Table 4.3 is the water level that will be used as the input of the tide level for the simulation of inundation due to tidal flooding in Belawan. The water level used in the simulation was +0.25 m, +0.50 m, +0.75 m, +1.00 m, +1.21 m, +1.71 m and +1.91 m

**Distribution of Flood Flood Flood**

The distribution of inundation caused by seawater during high tide in Medan Belawan sub-district is very wide. The characteristics of the Belawan area are coastal ecosystem areas dominated by mangrove ecosystems so that they become wet areas. When the tide enters the Belawan River and the Deli River as well as rivers or paluh di, it provides inundation in the wetland zone. However, problems arise when inundation is in areas with human activities such as settlements, business or service areas and other areas.




Picture 4-6 Distribution of inundation in Belawan sub-district

Belawan I Village has an area of 1.10 km$^2$ and is a dominant area land use used for offices such as customs and excise offices, ports and also naval bases. Many residential areas are found in southern Bagan or adjacent to Belawan Bahagia village. The distribution of inundation due to tidal flood for tidal level variation is shown in Figure 4.3.

The picture shows that the maximum inundation (red) has entered a wider area where settlements and offices are affected by inundation. Belawan Port as the center of the economy and services also experienced inundation, which had an impact on port activities such as loading and unloading.


Picture 4-7 Distribution of inundation in Belawan I sub-district

The extent of inundation in Belawan village is not entirely caused by the overflow of Belawan river water which is affected by tides. The tidal station which is the reference for the elevation of the water level of the Belawan river is influenced by the tide has a ground surface elevation of + 1,974 m. this is interpreted at the time of the highest tide, the water of the Belawan river which is affected by the tide has not overflowed the surface of the port. However, the inundation that spreads around the port comes from the water of the Belawan river rising when the tide enters the land and the area through the regional drainage system so that the inundation easily spreads and expands into the area. Figure 4.4 shows the flood that entered Belawan I sub-district causing Kampar road. At the highest tide or simulation with a water level height of + 1,911 m, the inundation height reached 60 cm from the road body on Kampar street and rattan road, Belawan I village.


Picture 4-8 Inundation due to flash floods in Belawan I sub-district

The tidal flood inundated Belawan II village due to the tide entering the mainland through the Deli river. When the tide enters through the mouth of the Deli River, the tide does not directly face the area, but the spread of the tide is through paluhs, mangrove forests and other wetlands. However, inundation still has an impact on settlements and areas through existing drainage drainage pits.


Picture 4-9 Distribution of inundation in Belawan II sub-district

Figure 4.5 shows inundation due to tidal flooding in the field that occurred in the Pelindo passenger port area and Belawan railway station. Inundation in the railway station and passenger port areas comes from the tide that enters through drainage holes at the port pier and drainage area.

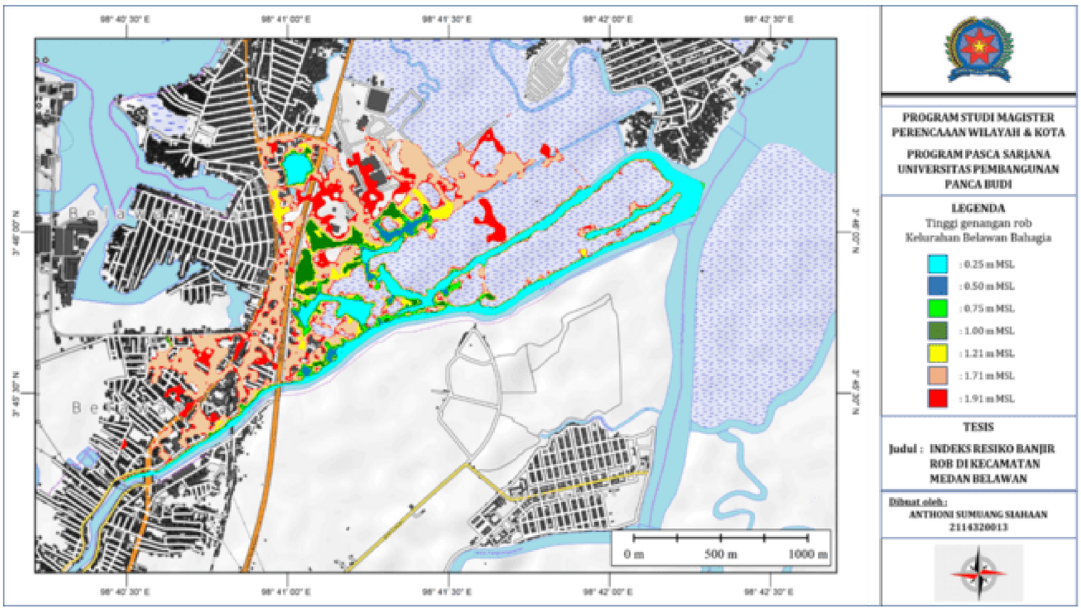

Inundation of rob in Belawan II sub-district on Yos Sudarso street in the area of the passenger port and train station

Belawan Bahagia Village is a village that directly faces the Belawan River. As a result, when the river experiences an impact due to the tide from the sea, the Belawan Bahagia village will receive the impact caused.


Picture 4-10 Distribution of inundation in Belawan Bahagia sub-district

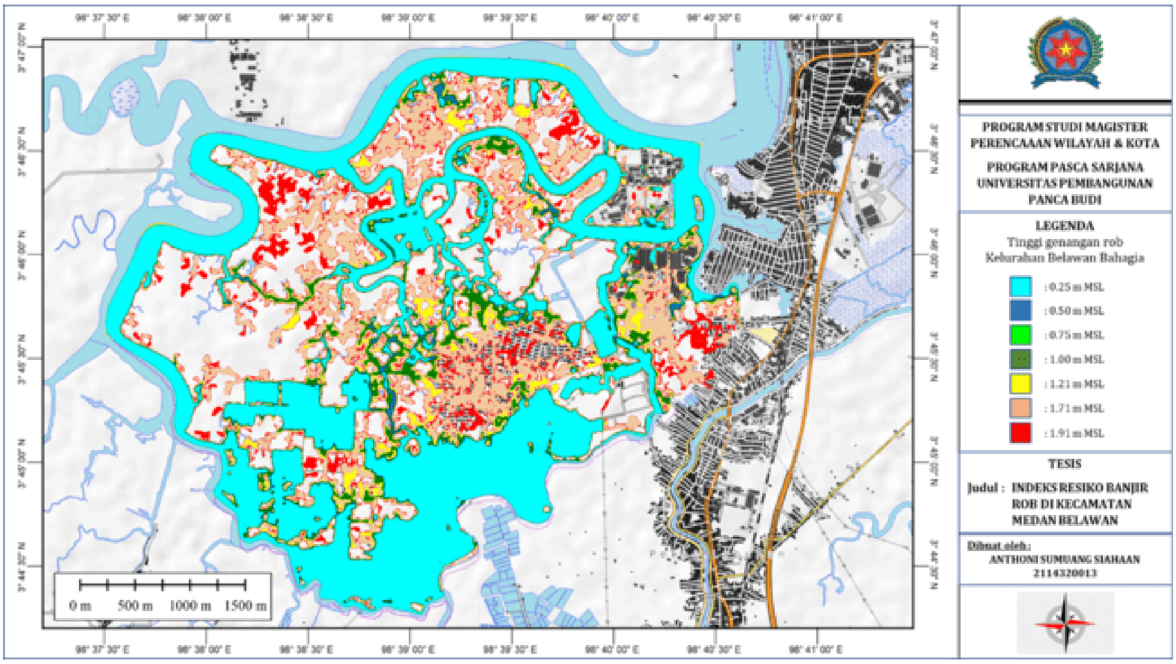
Land use in Belawan Division sub-district is dominated by community settlements. There are residential types with stilted house buildings and residential areas with housing types located on the ground. Therefore, buildings with foundations above ground level often experience inundation compared to stilt houses.

Belawan Bahari Village is a village with the original characteristics of land cover being wetlands in the form of mangrove ecosystems. However, currently wetlands have undergone significant changes with many mangrove forests turning into settlements, reclaimed land and ponds. Therefore, Belawan Bahari Village will be an area that is often flooded when the tide is high and the Deli river becomes a channel for the entry of tidal water.



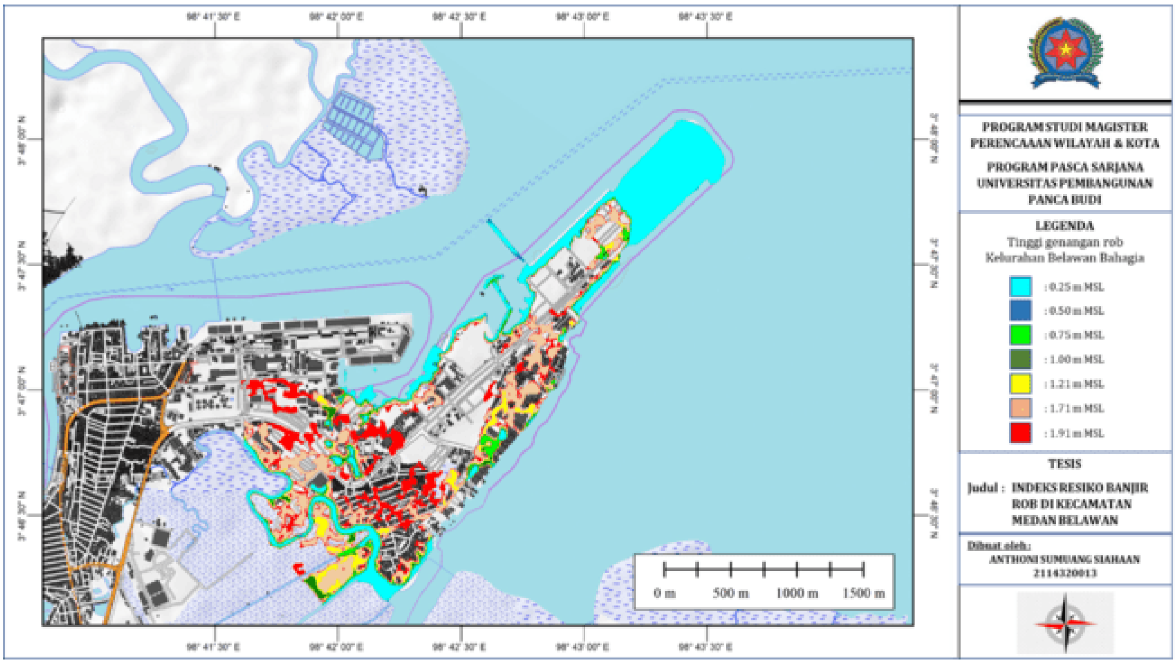

Picture 4-11 Distribution of inundation in Belawan Bahari sub-district

Belawan Sicanang Village has the same characteristics as Belawan Bahari. The flow of natural water is still often found so that it becomes a channel for the entry of tidal water from the Belawan river in the area




Picture 4-12 Distribution of inundation in Belawan Sicanang village

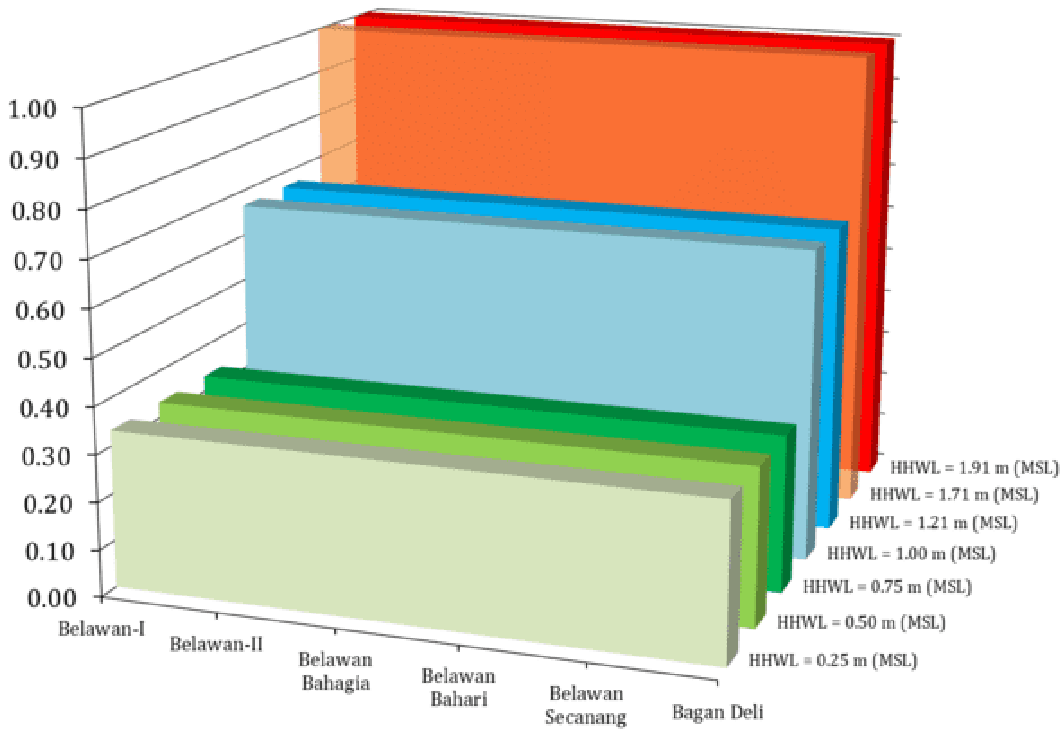
Bagan Deli Village is adjacent to Belawan Bahari Village and in the Deli area is one of the Belawan port development areas. Reclaimed land becomes an area development so that wet areas are initially flooded when the sea water is high. The type of area in Bagan Deli sub-district is a stilt house so that the dominant inundation has an impact on public facilities, offices and ports




Picture 4-13 Distribution of inundation in Bagan Deli sub-district

**Threat Index Due to Rob Flood**

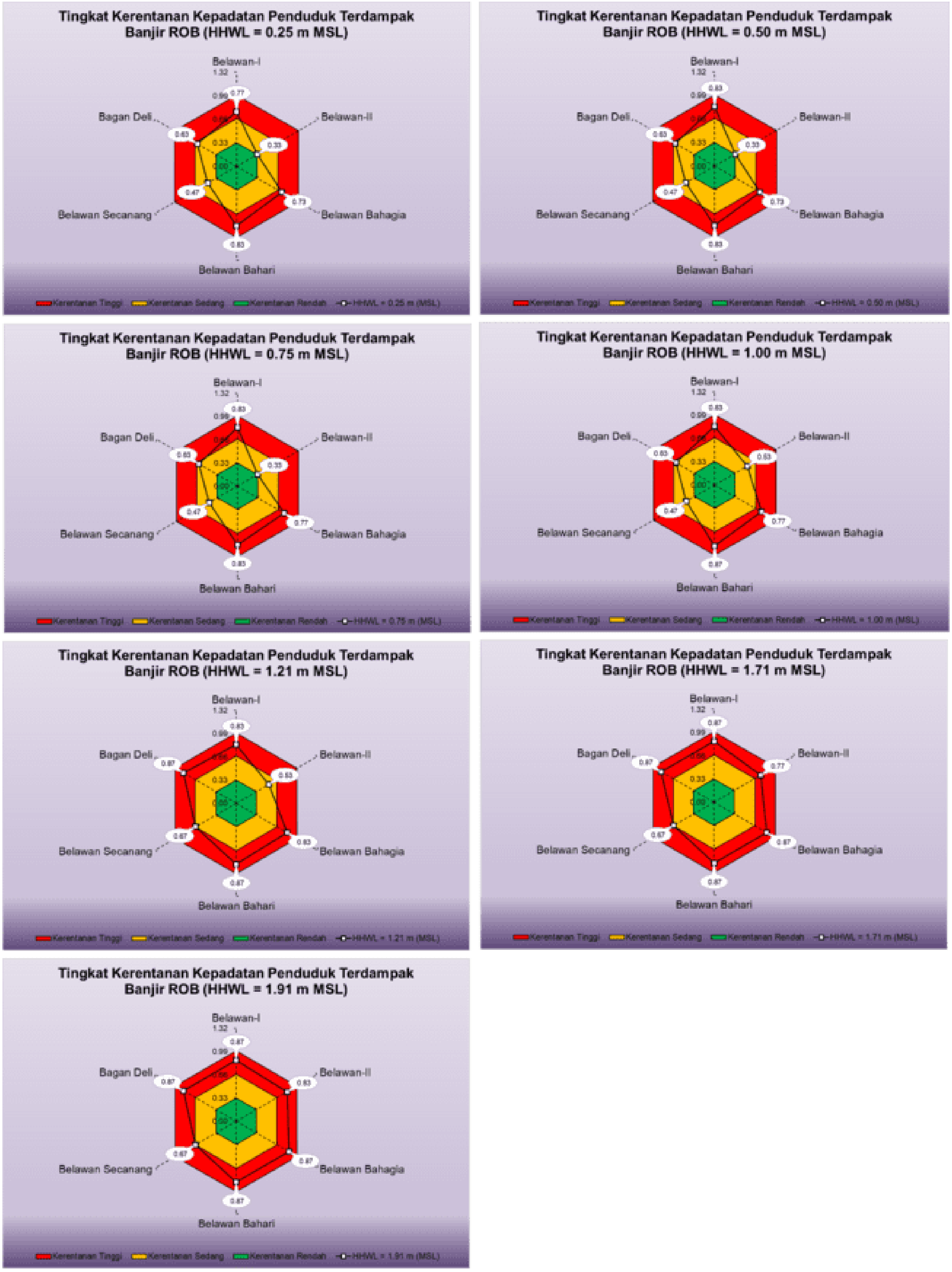
The flood disaster threat index in Belawan is assessed based on two main components: high tide levels that cause inundation in the area and the magnitude of the impact caused. The results of the inundation simulation due to the tidal flood provide three types of threats, namely when the tide occurs at the highest high tide elevation (*Highest High Water Level*) is 0.25 m from the average water level (MSL) to 0.75 m from the MSL, the threat generated in all villages in Medan Belawan District is at a low threat index. When the tide height reaches 1.00 m to 1.21 m from the MSL, the threat index due to flash floods increases to a moderate threat index.



Picture 4-14 Threat index of each village to the high tide level

**Vulnerability Index Due to Rob Flood**

The vulnerability index due to flash floods is assessed from social aspects, in this case the affected population, economic facilities, types of physical facilities (houses, office buildings and other buildings).

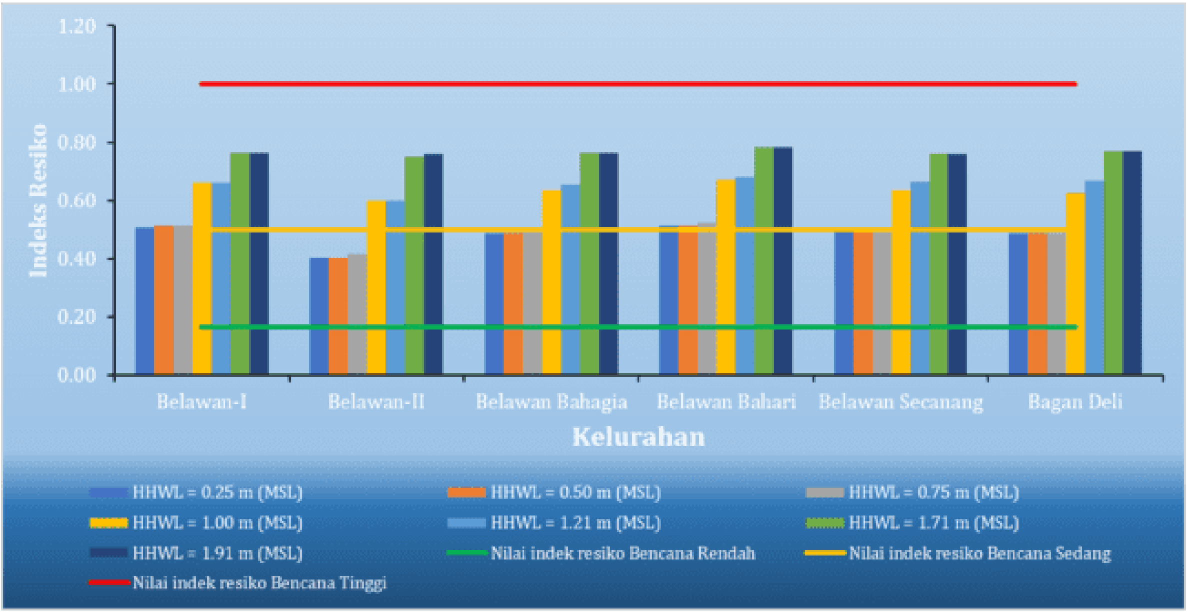



Picture 4-15The level of vulnerability of each village is high

In the image above, it shows the vulnerability of residents due to flash floods when the HHWL of 1.71 m has entered the high vulnerability category. All urban villages already have vulnerabilities above 0.667, which means that inundation has predominantly entered residential areas, offices and commercial services. Belawan I, Belawan Bahari and Belawan Bahagia Villages are villages that are in tidal conditions that have an impact on settlements.

**Flood Risk Index Due to Rob**

The flood risk index due to rob is analyzed to find out the disaster index that is the basis for mitigation so that the risk to threats and vulnerabilities can be minimized. The results of the analysis obtained the flood risk index due to rob in Belawan is already in the flood risk index due to high rob with a weight value of 0.781.




| Types of Disasters | High Tide Level Against MSL | Regency | District | Neighborhoods | 10-Year Anniversary | |
|---|---|---|---|---|---|---|
| | | | | | Risk index value | Flood Disaster Risk Index Class |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Flood | 0.25 | Medan City | Medan Belawan | Belawan-I | 0.506 | **Medium Risk** |
| Flood | 0.25 | Medan City | Medan Belawan | Belawan-II | 0.402 | **Medium Risk** |
| Flood | 0.25 | Medan City | Medan Belawan | Happy Belawan | 0.488 | **Medium Risk** |
| Flood | 0.25 | Medan City | Medan Belawan | Belawan Bahari | 0.514 | **Medium Risk** |

| Types of Disasters | High Tide Level Against MSL | Regency | District | Neighborhoods | 10-Year Anniversary | |
|---|---|---|---|---|---|---|
| | | | | | Risk index value | Flood Disaster Risk Index Class |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Flood | 0.25 | Medan City | Medan Belawan | Belawan Secanang | 0.506 | **Medium Risk** |
| Flood | 0.25 | Medan City | Medan Belawan | Deli Chart | 0.489 | **Medium Risk** |
| | | | | | | |
| Flood | 0.50 | Medan City | Medan Belawan | Belawan-I | 0.514 | **Medium Risk** |
| Flood | 0.50 | Medan City | Medan Belawan | Belawan-II | 0.402 | **Medium Risk** |
| Flood | 0.50 | Medan City | Medan Belawan | Happy Belawan | 0.488 | **Medium Risk** |
| Flood | 0.50 | Medan City | Medan Belawan | Belawan Bahari | 0.513 | **Medium Risk** |
| Flood | 0.50 | Medan City | Medan Belawan | Belawan Secanang | 0.502 | **Medium Risk** |
| Flood | 0.50 | Medan City | Medan Belawan | Deli Chart | 0.489 | **Medium Risk** |
| | | | | | | |
| Flood | 0.75 | Medan City | Medan Belawan | Belawan-I | 0.514 | **Medium Risk** |
| Flood | 0.75 | Medan City | Medan Belawan | Belawan-II | 0.416 | **Medium Risk** |
| Flood | 0.75 | Medan City | Medan Belawan | Happy Belawan | 0.500 | **Medium Risk** |
| Flood | 0.75 | Medan City | Medan Belawan | Belawan Bahari | 0.525 | **Medium Risk** |
| Flood | 0.75 | Medan City | Medan Belawan | Belawan Secanang | 0.506 | **Medium Risk** |
| Flood | 0.75 | Medan City | Medan Belawan | Deli Chart | 0.489 | **Medium Risk** |
| | | | | | | |
| Flood | 1.00 | Medan City | Medan Belawan | Belawan-I | 0.662 | **Medium Risk** |
| Flood | 1.00 | Medan City | Medan Belawan | Belawan-II | 0.598 | **Medium Risk** |
| Flood | 1.00 | Medan City | Medan Belawan | Happy Belawan | 0.636 | **Medium Risk** |

| Types of Disasters | High Tide Level Against MSL | Regency | District | Neighborhoods | 10-Year Anniversary | |
|---|---|---|---|---|---|---|
| | | | | | Risk index value | Flood Disaster Risk Index Class |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Flood | 1.00 | Medan City | Medan Belawan | Belawan Bahari | 0.673 | **High Risk** |
| Flood | 1.00 | Medan City | Medan Belawan | Belawan Secanang | 0.636 | **Medium Risk** |
| Flood | 1.00 | Medan City | Medan Belawan | Deli Chart | 0.624 | **Medium Risk** |
| | | | | | | |
| Flood | 1.21 | Medan City | Medan Belawan | Belawan-I | 0.662 | **Medium Risk** |
| Flood | 1.21 | Medan City | Medan Belawan | Belawan-II | 0.598 | **Medium Risk** |
| Flood | 1.21 | Medan City | Medan Belawan | Happy Belawan | 0.654 | **Medium Risk** |
| Flood | 1.21 | Medan City | Medan Belawan | Belawan Bahari | 0.680 | **High Risk** |
| Flood | 1.21 | Medan City | Medan Belawan | Belawan Secanang | 0.666 | **Medium Risk** |
| Flood | 1.21 | Medan City | Medan Belawan | Deli Chart | 0.667 | **Medium Risk** |
| | | | | | | |
| Flood | 1.71 | Medan City | Medan Belawan | Belawan-I | 0.762 | **High Risk** |
| Flood | 1.71 | Medan City | Medan Belawan | Belawan-II | 0.750 | **High Risk** |
| Flood | 1.71 | Medan City | Medan Belawan | Happy Belawan | 0.762 | **High Risk** |
| Flood | 1.71 | Medan City | Medan Belawan | Belawan Bahari | 0.781 | **High Risk** |
| Flood | 1.71 | Medan City | Medan Belawan | Belawan Secanang | 0.761 | **High Risk** |
| Flood | 1.71 | Medan City | Medan Belawan | Deli Chart | 0.768 | **High Risk** |
| | | | | | | |
| Flood | 1.91 | Medan City | Medan Belawan | Belawan-I | 0.762 | **High Risk** |
| Flood | 1.91 | Medan City | Medan Belawan | Belawan-II | 0.761 | **High Risk** |

| Types of Disasters | High Tide Level Against MSL | Regency | District | Neighborhoods | 10-Year Anniversary | |
|---|---|---|---|---|---|---|
| | | | | | Risk index value | Flood Disaster Risk Index Class |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Flood | 1.91 | Medan City | Medan Belawan | Happy Belawan | 0.762 | **High Risk** |
| Flood | 1.91 | Medan City | Medan Belawan | Belawan Bahari | 0.781 | **High Risk** |
| Flood | 1.91 | Medan City | Medan Belawan | Belawan Secanang | 0.761 | **High Risk** |
| Flood | 1.91 | Medan City | Medan Belawan | Deli Chart | 0.768 | **High Risk** |

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