International Journal of Architecture and Urbanism Vol. 09, No. 01 (2025) 25 – 33

International Journal of Architecture and Urbanism

Journal homepage: https://talenta.usu.ac.id/ijau

Coastal Morphological Characteristics and Their Impact on Spatial Structure in Medan Belawan District

Bima Hazril Prasetyo*[1]

[1]*Bachelor of Urban and Regional Planning, Faculty of Infrastrucuture and Regional Technology, Institut Teknologi Sumatera, Lampung Selatan, 35365, Indonesia*

*Corresponding Author: bimahazrilp@gmail.com

ARTICLE INFO

Article history:
Received 14-11-2024
Revised 5-3-2025
Accepted 17-3-2025
Available online 31-03-2025

E-ISSN: 2622-1640
P-ISSN: 2622-0008

How to cite:
Prasetyo, H. B. Coastal Morphological Characteristics and Their Impact on Spatial Structure in Medan Belawan District. International Journal of Architecture and Urbanism. 2025. 9(1):25-33.

http://doi.org 10.32734/ijau.v9i1.18861

ABSTRACT

This research explains the morphological characteristics that occur in the coastal area of Belawan District. The Belawan coastal area experienced morphological changes in the form of changes in the coastline due to reclamation carried out in 2017, resulting in various phenomena such as abrasion and accretion on the Belawan coast. Reclamation development forms new land which can change sea current patterns, thereby making tidal flood disaster intervals in Belawan District occur more frequently. The tidal flood disaster had an impact on the spatial structure of Belawan District, such as damage to road and residential infrastructure, and business location selection patterns that avoided areas that had a high potential for flood disasters. This research aims to observe the morphological characteristics of the Belawan coast in terms of the spatial structure in the Belawan sub-district. In this research, the analysis was carried out using spatial analysis using GIS and descriptive analysis. To produce analysis, secondary data needed to be obtained from websites, regulations, and related research. The results of this research show that the characteristics of the Belawan coastal area are experiencing changes originating from a combination of human and natural activities which have a negative impact on the spatial structure of Belawan District. This negative impact cannot continue to be ignored and there is a need for a management approach that pays attention to coastal natural resources, management based on disaster mitigation, and sustainable management of coastal areas.

Keywords: coastal area, morphology, spatial structure

1. Introduction

Coastal areas are areas that are vulnerable to changes in shape caused by natural processes such as natural disasters and other natural events or changes caused by human development. Coastal areas have attractiveness both in terms of tourism, industry warehousing, and services which cause an increase in population and urban spatial physical growth such as increasing the area of built-up land and decreasing the area of that land. as vegetation and undeveloped land [1]. The characteristics of urban space growth in each region vary based on the type of growth in developed, developing, and underdeveloped countries. This urban spatial growth pattern will show differences resulting from social, economic, environmental, and spatial interactions [2].

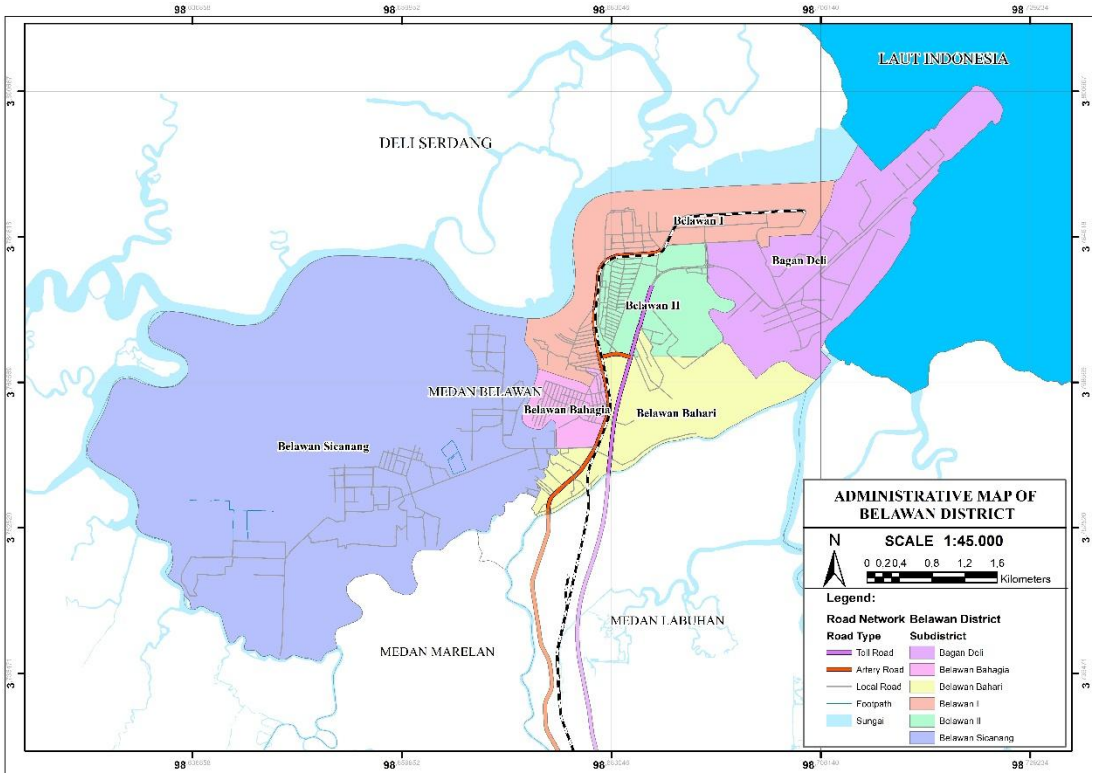


Figure 1 Administrative map of Belawan District

Belawan District is located on the north coast of Medan city. The area of Belawan District is 33.27 km2 with a population of 110,238 people [3]. Belawan District has 6 sub-districts, namely Belawan I District with an area of 2.69 km2, Belawan II District with an area of 1.88 Km2, Belawan Sicanang District with an area of 17.7 Km2, Belawan Bahagia Village with an area of 0.74 Km2, Belawan Bahari District with an area of 2, 97 Km2, Bagan Deli District 2.97 Km2, Bagan Deli District covering an area of 2.97 Km2, the area is 6.81 Km2 (Figure 1). Belawan is a sub-district that is synonymous with port areas, industrial and warehouse areas, mangrove-protected areas, and coastal residential areas. According to the Medan City Regional Spatial Plan for 2022-2042, Belawan District is designated as a City Center Service Sub Area (SPPK) which functions as a center for sea transportation services, loading and unloading, and a center for export-import activities, defense and security services. Activity centers, industrial activity centers, and fisheries activity centers [4]. As a Medan City SPPK, Belawan District is experiencing significant morphological transformation dynamics. Apart from having great potential, Belawan District is also very vulnerable to changes originating from development and natural disasters. The high utilization of natural resources in coastal areas causes the development and exploitation of natural resources in coastal areas without prioritizing and considering the ecology, thus causing damage to coastal ecosystems [5].

There are development events and natural disasters that occur which have a negative impact on the Belawan coastal area. Reclamation construction was carried out in 2017 by PT. Pelindo 1 to expand its territory to increase its container capacity. This reclamation received support from the Decree of the Ministry of Transportation of the Republic of Indonesia Number KM 193 of 2020 which has now been changed to the Decree of the Minister of Transportation of the Republic of Indonesia Number KM 92 of 2021 concerning Approvals to PT. Pelindo 1 to carry out reclamation activities in Belawan[6][7]. The reclamation development has caused problems that have had a huge impact on Belawan District. The impact of this reclamation is damage to the ecology of coastal areas and loss of existing natural resource potential. The construction of this reclamation also causes the Belawan sub-district to experience tidal floods more frequently because reclamation can change the coastline due to changes in sea currents which are diverted by the formation of reclaimed land. This results in areas outside the reclamation receiving more water overflow so that these areas experience abrasion due to flooding that occurs [8]. This development destroys the balance of the coastal environmental ecosystem and disrupts the spatial structure in the Belawan District.

The flood disaster affected the condition of residential infrastructure and the distribution pattern of slum settlements which emerged due to increasingly poor environmental quality. Apart from that, flood disasters

also have an impact on damage to infrastructure, facilities, and utilities in the sub-district and influence people's behavior in determining business locations and residential locations [9][10]. This research is very important to carry out and aims to find out how changes in morphology in the Belawan subdistrict due to development and natural disasters have an impact on the spatial structure of the Belawan subdistrict. It is hoped that the results of this research will provide an overview of the impacts of development that does not pay attention to the surrounding ecosystem, resulting in losses in the form of natural disasters, so that it can become input and evaluation material in development planning and management of coastal areas.

2. Method

This research aims to determine the morphological characteristics of the Belawan coastal area and its impact on the spatial structure in the Belawan District using quantitative research methods. Quantitative research methods are research methods used to study things that are definite and can be explained based on logic [15]. The scope of the research object is to look at morphological changes in Belawan District and their impact on the spatial structure of the district. The analytical method used in this research is descriptive analysis, namely describing and identifying problems in the research. Researchers also used spatial data analysis using Geographic Information Systems (GIS) to see morphological changes that occurred in Belawan District. Researchers used Landsat satellite imagery in 2010, 2017 and 2024. In this research, researchers also looked at changes in coastlines during reclamation construction and after reclamation in 2017 and 2024 using the method DSAS.

The data collection technique in this research is secondary data collection. Secondary data collection is collecting data from existing documents and using the data in these documents. In this research, spatial data was collected via websites and from related agencies such as the Regional Disaster Management Agency (BNPB), data collection from regulatory documents, and related research that had been carried out previously. In this study, researchers also made observations through Google Earth And Google Street Maps.

3. Result and Discussion

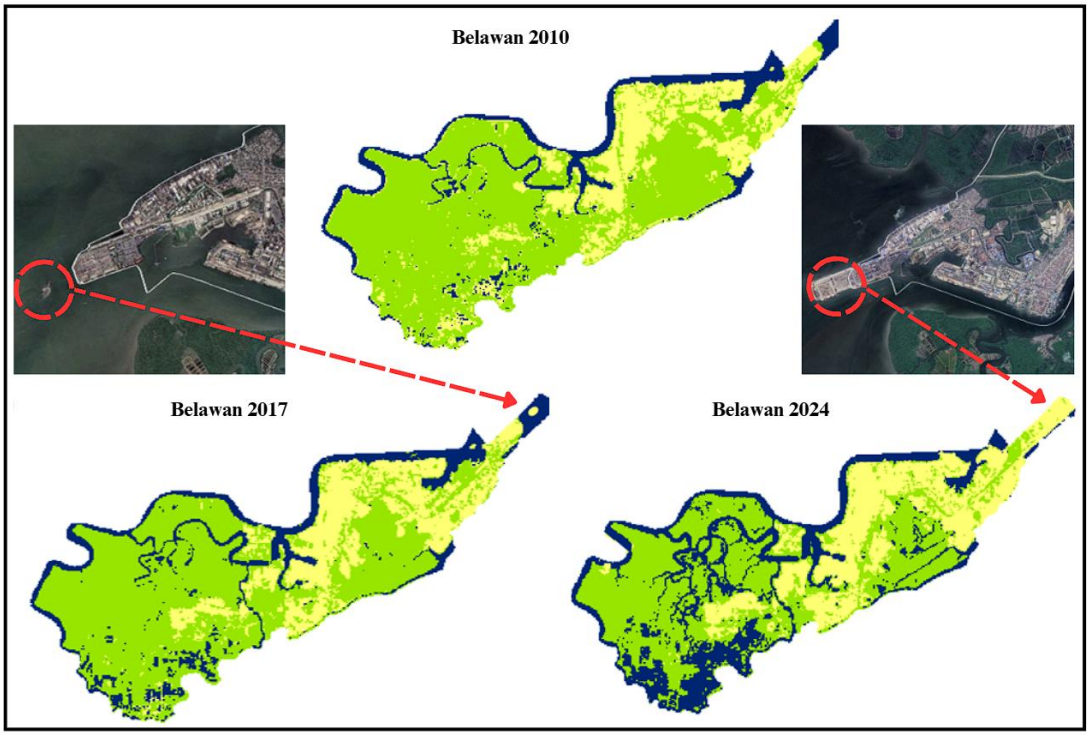


Figure 2 Morphological Map of Belawan District and Reclamation Locations

From 2010 to 2024 very significant changes occurred in Belawan District. Where the reduced vegetation area is replaced by built-up land in the form of residential areas, trade services, industrial areas, ports, and warehouses. This was shown in 2017 (Figure 2), there was a reclamation process carried out by PT. Pelindo 1 is a company that operates in the field of shipping goods by ship. PT. Pelindo 1 carried out reclamation to

expand the port for container storage. Reclamation carried out by PT. Pelindo has an impact on the coastline of the Belawan sub-district which is experiencing an accretion process, namely changing the coastline through the addition of land in the coastal area. Reclamation development carried out by PT. Pelindo makes the Belawan sub-district experience more frequent tidal floods because the reclamation process requires the formation and addition of new land on the coast which can change sea current patterns. Abrasion often occurs in open areas directly adjacent to the sea. This is due to the open position of the area without natural or artificial protection so it is very easily eroded by waves when the waves hit land. The longer and more frequently a land experiences erosion, the smaller the land will become, making it easier for seawater to enter the land [11]. Changes in coastlines are caused by abrasion and accretion which can cause problems in the form of increasing the interval of natural disasters such as tidal floods. The tidal flood phenomenon occurs because land conditions are no longer the same, which can change current and wave patterns in the surrounding area [12]. According to [16] changes in current patterns are capable of eroding coastlines (abrasion) in other areas through the abundance of water flowing from changes in currents due to the addition of new land. The following coastline changes will occur in Belawan District in 2017 and 2024:

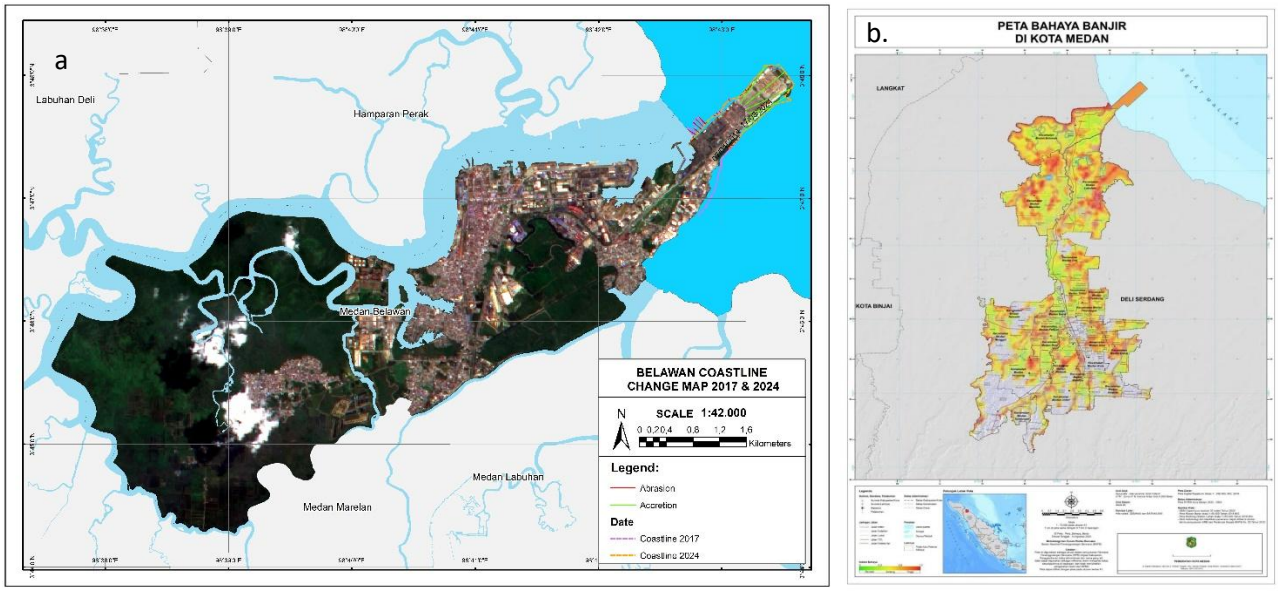


Figure 3 (a) Coastline Change Map (b) Flood Hazard Map in Medan City

Based on the author's analysis, the area that experienced abrasion between 2017 and 2024 experienced changes and the land was reduced by 0.1 Ha, which is a residential area. Meanwhile, the area that experienced accretion in 2017 and 2024 experienced changes and additional land due to reclamation covering an area of 0.39 Ha (Figure 3 a**)**. The accretion phenomenon due to reclamation creates new problems in the form of tidal flood phenomena which occur due to land conditions that are no longer the same, which can change current and wave patterns in the surrounding area. According to [8] in the 80s, before reclamation was carried out, Belawan District only experienced one tidal flood which was caused by the phenomenon of a lunar eclipse which caused tidal waters to rise into settlements, causing tidal floods. On the map from the Medan city government, the Belawan District is included in several classes prone to tidal flood disasters, ranging from low to medium. The color transition from green to red indicates the risk classes from low to high (Figure 3 b).

Tidal floods cause damage to residential environments, resulting in a lack of availability of clean water for the community, exacerbated by drainage that is not functioning properly, which makes residential areas increasingly slum. It is stated in Government Regulation Number 14 of 2016 Article 108 which states that the criteria for a settlement to be considered a slum can be seen from the aspects of building construction, environmental roads, drinking water supply, residential environmental drainage, sanitation management, waste management, and fire protection [17]. Meanwhile, regarding the drainage system, Belawan slum settlements are often unable to channel water runoff, resulting in tidal puddles.

This puddle occurs due to continuous subsidence of the land surface, giving rise to puddles called tidal flood puddles. If this waterlogging continues to occur, it will cause a decline in groundwater quality [18]. According to [19], another impact of tidal floods can be that areas that are continuously inundated by tidal floods will

cause an increase in salt levels in the soil which can damage the soil structure and reduce porosity, thereby inhibiting water filtration. The higher level of soil salinity can reduce the activity of microorganisms whose role is important in the process of decomposition and humus formation, which leads to a reduction in the soil's ability to absorb water [19]. This is certainly not good for residential areas if this happens, which will reduce the quality of the residential environment and could give rise to new slum areas.

In the 2020 Housing and Settlement Area Development Plan (RP3KP) document, it is stated that the total area of slum settlements in 6 Belawan sub-districts is 81.21 Ha [20]. Based on Law No. 1 of 2011 concerning Housing and Settlements To prevent the spread of slum settlements, prevention can be carried out by carrying out supervision and control regarding permits, improving the quality of slum areas by developing, rejuvenating, and restoring housing infrastructure, facilities and utilities (PSU) [21]. It is also important to maintain the facilities, infrastructure, and utilities provided by the government and the community. There is a direction for residential area development in the 2020 RP3KP document that in Belawan District, housing development is directed at site and vertical development as well as PSU development [20].

The following are field findings regarding the impact of tidal flooding on residential environments that have led to deteriorating housing conditions (Table 1**)**.

Table 1 Findings of The Impact of Tidal Flooding on Resedential Areas

Research Findings	**The Impact of Rob Floods on Residential Areas**
  **Figure 4** (a) Drainage Conditions (b) Settlement Conditions	It was found that almost all sub-districts in Belawan sub-district have a drainage system that is not functioning properly, where the drainage is unable to drain standing water because it is not properly maintained and many drainage conditions require repair (Figure 4 a). The drainage system should work well so that standing water can flow. According to research, the Belawan sub-district has low drainage capacity and is vulnerable to tidal flood disasters, because it is on a slope of 0-2%, which indicates that drainage takes quite a long time to drain water runoff [13]. The consequences of drainage that does not function optimally will impact the residential environment, causing slums (Figure 4 b).
 **Figure 5** (a) Belawan Sicanang Subdistrict Road Network in 2015 (b) Belawan Sicanang Subdistrict Road Network in 2024	A program for the development and arrangement of slum settlements, usually called the City Without Slums Program (KOTAKU), is starting to emerge in the Belawan Sicanang Village and Belawan Bahari Village, which is being implemented by the PUPR Ministry in collaboration with the Medan City Government. By arranging roads in residential areas, maintaining drainage quality (Figure 5), providing waste facilities, renovating uninhabitable houses, and overcoming tidal floods by building infrastructure in the form of embankments [22].

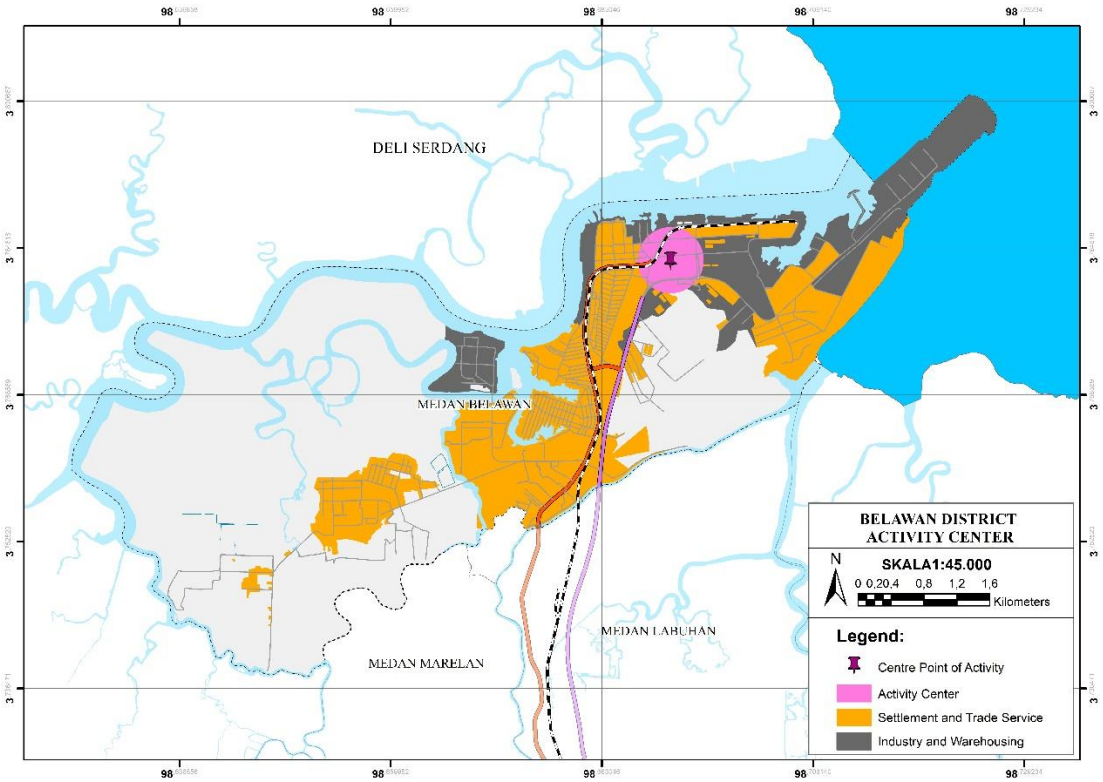


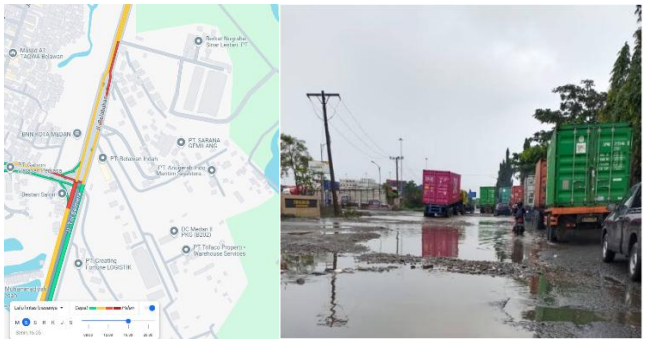
Figure 6 Peta Map of Belawan District Activity Center

Urban morphology due to changes in the coastline causes tidal floods which have an impact on the spatial structure of the city. One of the impacts of tidal flooding that was felt was that which occurred in the trading area Urban morphology due to coastal line changes leads to tidal flooding that affects the spatial structure of the city. One impact of tidal flooding is that which occurs in the trade area located at the center of the district's activities (Figure 6). The trade area is a vital area for economic activity in the Belawan sub-district, which if it is continuously disturbed by tidal floods will cause sub-district income and community income to decrease. This is supported by research [9] that activity centers such as trade areas which are located in areas vulnerable to tidal floods and are often affected will affect the economic activities within them. This is influenced by the reduction in the number of visitors coming so that the amount of income decreases [9]. Apart from disrupting economic activity, this can also change the perception of people's mindset about choosing business locations that are not vulnerable to tidal floods. So it can also trigger many business actors to move their business locations to relatively safer areas.

With the policy of Belawan sub-district as SPPK for Medan City in the 2022-2042 Medan City RTRW, these things must be taken into account and must also be supported by increasing good traffic circulation in supporting Belawan Sub-district as a Sub-City Service Center (SPPK). The development of the road network in the Belawan sub-district focuses more on developing road functions such as the Belmera toll road, primary and secondary arterials, primary and secondary collectors, and local roads. The construction of this road helps support the Belawan sub-district as a City Service Sub-Center to improve road accessibility from port, industrial, warehouse, and trade areas to sub-districts in Medan City or Deli Serdang district.

The following are the field findings of the impact of the flash flood on activity centers that disrupt transportation mobility which is detrimental to the active community and to the warehousing and industrial sectors (Table 2).

Table 2 Findings of The Impact of Tidal Flooding on Activity Centers

Research Findings	Impact of Rob Floods on Activity Centers
 **Figure 7** (a) Map of Port Road Congestion Locations (b) Damaged Road Conditions	One of the problems with accessibility and road quality occurs on Jalan Pelabuhan which functions as a primary arterial road. In the picture, it is known that 6 companies are operating in the industrial and logistics sector. This often causes traffic jams on Port Road due to the circulation of container trucks coming in and out on operational days and hours (Figure 7 a). This is of course detrimental to many parties, from people whose activities are disrupted due to traffic jams or losses to logistics service companies that need additional time to deliver their logistics to their destination. Problems also occur in the same location, namely problems with damaged road infrastructure. Quoted from alert.id This road damage was caused by company waste that pooled around Jalan Pelabuhan overflowed due to drainage not functioning as a result of the sluice gate construction project carried out by the PUPR Service (Figure 7 b). The construction of this water gate construction project is one of the government's efforts to overcome tidal floods in Belawan District [23].

Based on the findings and analysis above, there is a need for spatial restructuring in the Belawan coastal area so that the management of the area becomes better by paying attention to existing natural resources and disaster mitigation. The right approach for this management is Integrated Coastal Management (P2T) which requires a lot of involvement stake stakeholders so that its implementation can run well. In research [14] which specifically discusses the Integrated Coastal Management (P2T) approach in managing tidal floods, there are several management workflows for implementing the Integrated Coastal Management (P2T) framework that can be implemented in Belawan sub-district. This research explains that the role of cooperation and responsibility in each sector is crucial in carrying out each target, such as preventing and managing damage caused by nature or humans; managing clean water needs and use; and ecosystem management and restoration. Each of these targets will later produce framework output in the form of programs or analyses that attempt to overcome problems and manage coastal areas that are more resilient to face various environmental challenges and are more sustainable.

4. Conclussion

The morphology of the Belawan Coastal area has experienced significant changes. Changes in the morphology of the Belawan Coast are marked by changes in the coastline in 2017 and 2024. These changes are caused by reclamation construction carried out by PT. Pelindo 1 for container storage expansion needs. The reclamation development causes changes in current patterns which result in eroding coastlines (abrasion) in other areas. This abrasion causes seawater tides to easily enter land areas and the overflow water inundates the land which is called tidal floods. Tidal floods cause damage to the environment and residential infrastructure, resulting in the potential for the emergence of new slum settlements. The impact of tidal floods was also felt in trade areas and influenced the perception of people's mindset in determining business locations. Thus, changes in morphology in coastal areas have a big impact on the spatial structure in Belawan District. There is a need for an integrated coastal area management (P2T) approach to pay attention to coastal natural resources, disaster mitigation, and sustainable coastal management so that the Belawan coastal area is more resilient to face various environmental challenges in the future.

5. Acknowledgment
This study is a study that discusses the morphological characteristics that occur in the coastal area of Belawan District which has undergone changes in the form of coastline which has resulted in the increasingly frequent occurrence of the phenomenon of flash floods in the district which affects the spatial structure in Belawan District. The author would like to thank the Department of Architecture, Faculty of Engineering, University of North Sumatra and all parties who have assisted in research on morphological characteristics in coastal areas and their impact on spatial structure in Medan Belawan District.

6. Conflict of Interest
The authors whose names are listed below certify that the manuscript does not have a conflicto of interest.

Bima Hazril Prasetyo

This statement is signed by all the authors to indicate aggreement that the above information is true and correct (a photocopy of this form may be used if there are more tan 10 authors):

Author's name (typed)	Author's signature
Bima Hazril Prasetyo	

References

[1] Mcgranahan, Gordon, Deborah Balk Dan Bridget Anderson. The Rising Tide: Assessing Therisks Of Climate Change Andhuman Settlements In Lowelevation Coastal Zones. Sage Journals; 2007. Vol 19 (1): 17-37.
[2] Scott, Allen J. Dan Michael Storper. The Nature Of Cities: The Scope And Limits Of Urban Theory. International Journal Of Urban And Regional Research 39 (1); 2014. Hal: 1-15.
[3] Badan Pusat Statistik. Kecamatan Belawan Dalam Angka Tahun 2024; 2024.
[4] Pemerintah Kota Medan. Peraturan Daerah Kota Medan Nomor 1 Tahun 2022 Tentang Rencana Tata Ruang Wilayah Kota Medan Tahun 2022-2042. 2022
[5] Djunaedi, Ahmad Dan M Natsir Basuki. Perencanaan Pengembangan Kawasan Pesisir. Jurnal Teknologi Lingkungan; 2022. Hal: 225-231.
[6] Menteri Perhubungan Republik Indonesia. Keputusan Menteri Perhubungan Republik Indonesia Nomor KM 193 Tentang Persetujuan Kepada PT Pelabuhan Indonesia I (Persero) Untuk Melaksanakan Kegiatan Kerja Reklamasi Yang Berlokasi Di Dalam Daerah Lingkungan Kerja Dan Daerah Lingkungan Kepentingan Pelabuhan Belawan Provinsi Sumatera Utara; 2020.
[7] Menteri Perhubungan Republik Indonesia. Keputusan Menteri Perhubungan Republik Indonesia Nomor KM 193 Tentang Perubahan Atas Keputusan Menteri Perhubungan Nomor Km 193 Tahun 2020 Tentang Persetujuan Kepada PT Pelabuhan Indonesia (Persero) Untuk Melaksanakan Kegiatan Kerja Reklamasi Yang Berlokasi Di Dalam Daerah Lingkungan Kerja Dan Daerah Lingkungan Kepentingan Pelabuhan Belawan Provins! Sumatera Utara; 2021.
[8] Saragi, Sismawati. Manajemen Konflik Terhadap Kasus Banjir ROP Akibat Reklamasi Pelabuhan Belawan. Jurnal Publik Perform Vol:10 No.2; 2023.
[9] Kurniawati, W., & Suwandono, D. Pengaruh Bencana Banjir dan Rob Terhadap Ketahanan Ekonomi Kawasan Perdagangan Johar di Kota Semarang. *Ruang*, Volume 1 Nomor 4; 2015. Hal: 371-380.
[10] Gjimedan. *Kisah Masyarakat Pesisir Belawan: Bertahan di Tengah Banjir Rob Akibat Perubahan Iklim*. Diambil kembali dari Green Justice Indonesia: https://gji.or.id/2024/05/kisah-masyarakat-pesisir-belawan-bertahan-di-tengah-banjir-rob-akibat-perubahan-iklim/; 9 May, 2024.

[11] Fithor, Alin, Joko Sutrisno Dan Agus Indarjo. Mangrove Ecosystem Management Strategy In Maron Beach Semarang. Ilmu Kelautan Vol 23 (40); 2018. Hal: 156-162.
[12] Mahinsha, Amryl Naufal Ilham, Muhammad Helmi Dan Aris Ismanto. Analisis Dampak Rencana Perluasan Reklamasi Akibat Perubahan Karakteristik Arus Dan Gelombang Di Perairan Kota Semarang, Jawa Tengah . Indonesian Journal Of Oceanography (Ijoce); 2023. Vol. 05 No. 03: 165 - 175.
[13] Charmelia P, Brigita. Kaitan Antara Daya Dukung Lingkungan Berbasis Kemampuan Lahan dengan Kerentanan Bencana Banjir ROB di Kecamatan Belawan, Kota Medan. Bandar Lampung: UPA Perpustakaan Institut Teknologi Sumatera; 2023.
[14] Christian, Y., Afandy, A., Yonvitzer, & Ahmadi, N. Pendekatan Integrated Coastal Management (ICM) dalam Pengelolaan ROB dan Banjir. *Scientific Journals of IPB University Vol. 5 No. 1*; 2023. Hal: 474-481.
[15] Sugiyono P. D. Metode Penelitian Kualitatif Kuantitatif Dan R&D. Bandung: ALFABETA, CV; 2013.
[16] Edyanto, C. H. Faktor - Faktor Yang Berpengaruh Dalam Proses Reklamasi Untuk Mengantisipasi Bencana Di Lingkungan Pantai. *Jurnal Sains dan Teknologi Mitigasi bencana Vol. 11, No. 1;* 2016.
[17] Pemerintah Indonesia. Peraturan Pemerintah No. 14 Tahun 2016 Tentang Penyelenggaraan Perumahan Dan Kawasan Permukiman Pasal 108; 2016.
[18] Musarofa, Siswanti, Y. D., & A-Rosyid, L. M. Analisis Pengaruh Banjir Rob Terhadap Kualitas Air Tanah Di Kawasan Pesisir Selatan Puger Kabupaten Jember. *Journal of Mechanical Engineering Vol:1, No:1*; 2024. Hal: 52-59.
[19] Pujiastuti, R., Suripin, & Syafrudin. Pengaruh Land Subsidence terhadap Genangan Banjir dan Rob di Semarang Timur . *Jurnal MKTS Volume 21, No. 1*; 2015.
[20] Pemerintah Kota Medan. Review Rencana Pembangunan dan Pengembangan Perumahan dan Kawasan Permukiman (RP3KP) Kota Medan; 2020.
[21] Pemerintah Indonesia. Undang-Undang Nom 1 Tahun 2011 Tentang Perumahan dan Kawasan Permukiman; 2011.
[22] Angel dan Muhammad Arifin Nasution. Kolaborasi Pemerintah Dengan Stakeholders Dalam Program Kota Tanpa Kumuh Di Kelurahan Belawan Sicanang Kota Medan. Jurnal Komunikasi & Administrasi Publik; 2023. Hal: 69-76.
[23] Tirtayasa, Andi Aria. Limbah Perusahaan Penyebab Jalan Pelabuhan Raya Belawan Rusak Parah. https://www.waspada.id/medan/limbah-perusahaan-penyebab-jalan-pelabuhan-raya-belawan-rusak-parah/; 13 September 2024.