

Changes in the Coastline of the Wulan River Delta, Demak regency, Central Java Province during the period 2010-2025 and its Influence on the Expansion of the New Land

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Abstract

The Wulan River Delta in Demak Regency, Central Java Province as the downstream part is a unit of the Wulan River watershed system. The process for the formation of the Wulan River delta is the result of the interaction between the fluvial process in the form of sedimentation carried by the Wulan River and the marine process as the influence of currents, waves, and sea tides. The objectives of the study are (1) to map changes in coastal land in the Wulan River Delta, Demak Regency and the trend in its development direction during the 2020-2025 period. (2) to examine the effect of changes in the area of the Wulan River Delta on the expansion of new land. The method used is the interpretation of shoreline changes based on Google Earth imagery from 2010 to 2025 and assisted by field checks. The final result is in the form of a map of changes in the coastline of the Wulan River Delta and identification of newly formed land.

Keywords: Wulan River Delta; Coastline Change; Sedimentation; New Land.

1. Introduction

The River delta is one of the most dynamic coastal areas. River deltas are formed in front of the mouth of the River due to the sedimentation process brought by the River or the sediment deposition carried by currents from other places. The process that takes place in the formation of a delta is the resultant result of the process of land origin (fluvial) and the process of sea origin (marine).

The coastal area of the River delta is one of the most dynamic parts of the coast, considering that the River delta is the result of the formation process of fluvial processes of land origin that carry sediments and processes of marine origin in the form of reworking waves, currents, and tides. The world's major cities generally develop in coastal areas by relying on the existence of Rivers and a continuous supply of sediment. Examples are cities such as Cairo, Egypt which relies on the Nile River, Bangkok City, Thailand which relies on the Mekong River, Jakarta which relies on the Ciliwung River and so on. Meanwhile, the development of aquaculture areas and new settlements along the coast relies on the formation of new land which is considered to be natural marine reclamation.

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Along the northern coast of Java where large Rivers empty into the Java Sea which is relatively calm at its mouth forms a large delta. Examples can be given here of several large River deltas, including: Pemali (Brebes Regency), Comal (Pemalang Regency), Bodri (Kendal Regency), Wulan (Demak Regency), Bengawan Solo (Gresik Regency), etc.

Research on the extent of several River deltas on the north coast of Java was conducted by Hollerwoger (1964), including deltas: Cipunegara, Cimanuk, Bangkaderes, Sanggarung, Pemali, Comal, and Bodri. Setiyono (1998) researched delta changes Comal, Suseno Putri, et al. (2016) researched changes in the Wulan delta, and others.

The growth towards the enlargement of a River delta is widely used for aquaculture, in addition to fishing settlements and pond workers. This is related to the relatively newly formed and unstable nature of the land. The mangrove forests that grow along the banks of Rivers and beaches are very helpful in the stability of the newly formed land. The growth of a delta is highly dependent on the sediment supply from the upstream region and its interaction with the properties of oceanographic dynamics that occur at the end of the River estuary.

The Wulan River is one of the main Rivers resulting from the confluence of the Serang River and the Lusi River in one area of the Serang-Lusi Watershed. The Wulan River as the formation of the Wulan River Delta empties into the coastal area of Berahan Wetan Village and Berahan Kulon Village, Wedung District, Demak Regency. Based on the Minister of Public Works and Public Works Regulation no. 4 PRT/M/2015, the Wulan River is included in the Serang-Lusi watershed with a River length characteristic of 49 km, with an average water discharge of $Q_{50} = 1210 \text{ m}^3/\text{second}$. The area of the Serang-Lusi watershed is $3604,178 \text{ km}^2$ (BBWS Pemali-Juana, 2022). The Wulan River is a combined River of the Serang River headwaters in Boyolali Regency and Grobogan Regency and the Silugonggo River which flows upstream in Pati Regency.

Other Rivers on the left and right sides of the Wulan River are the Lobenner River to the south and the Serang River to the north. The distance between the Wulan River and the Lobenner River is 1500 m and the distance between the body of the Wulan River and the Serang River is 6300 m. Between Lobenner Rivers and the Serang River with the wulan River are occupied by Rivers that are affected by the tides. Tidal Rivers (*creeks*) form a network of Rivers with a dominant direction perpendicular to the coastline with at the ends forming an interconnected pattern (see Figure 1).

There are two main objectives, namely (1) to identify changes in the area of the Wulan River Delta between 2010 – 2025, and (2) to examine the effect of changes in the area of the Wulan River Delta on the expansion of land use.

2. Materials and Methods

The research location is the Wulan River Delta and the surrounding coast, including the administrative area of Babalan, Berahan Wetan, and Berahan Kulon villages, Demak Regency, Central Java, Indonesia. Geographically located on the latitude $6^{\circ}43'26'' - 7^{\circ}09'43''$ South and longitude $110^{\circ}48'47'' - 110^{\circ}27'58''$ East. The materials used include:

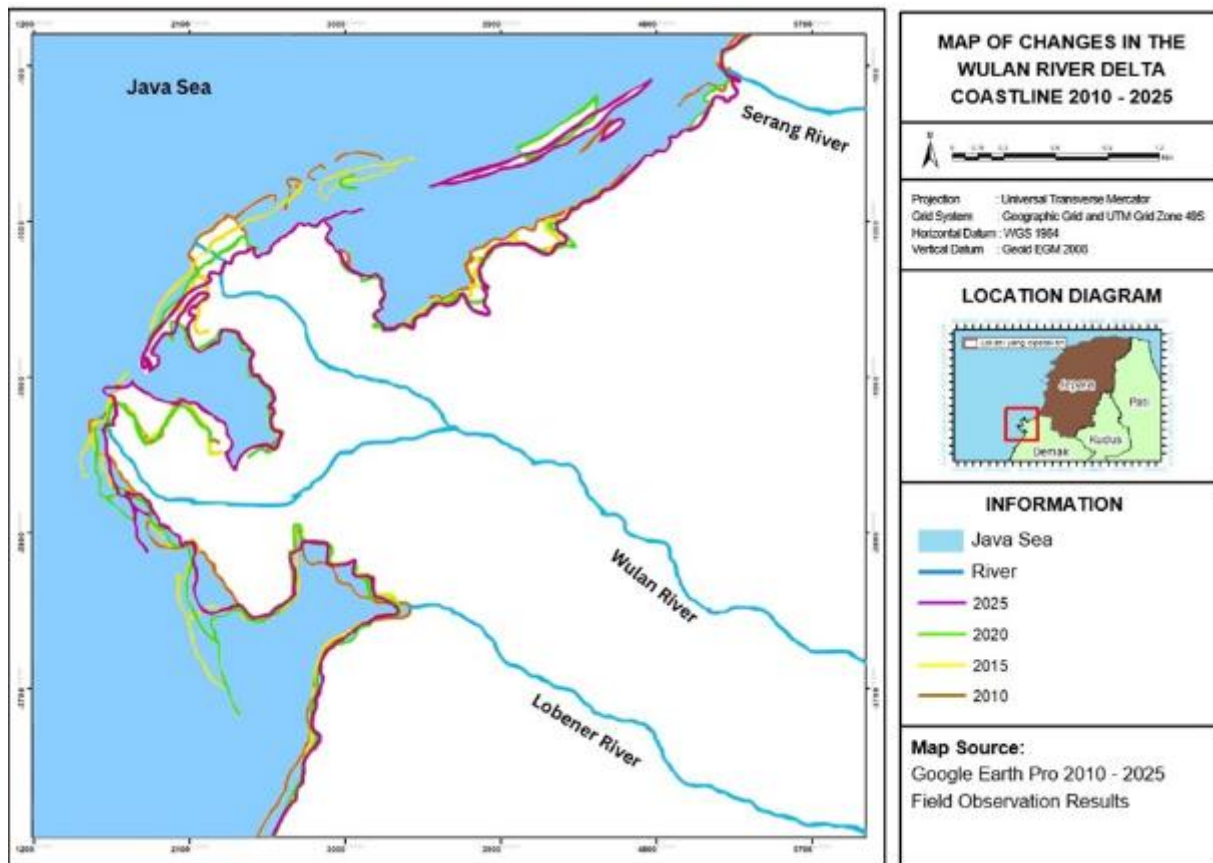
- Administrative map of Demak Regency
- Google Earth Pro imagery from 2010-2025
- DEM (digital elevation map) to find out the topographic conditions
- Land use map
- RTRW (Regional Spatial Plan) of Demak Regency, to find out the direction of regional development in the future until 2030

2.1. Methods

The method used in determining changes in the coastline is the map overlapping technique. Selected maps sourced from Google Earth Pro in 2010, 2015, 2020, and 2025. Landform analysis based on visual analysis and interpretation of recognizable shapes based on the identification of various landforms accompanied by field checks.

3. Results and Discussion

Analysis of changes in the coastline of the Wulan River delta from 2010 to 2025 or over 15 years respectively based on Google Earth imagery in 2010, 2015, 2020, and 2025. Figure 1 shows the results of the overlap (overlay) of coastline changes from 2010 to 2025. The area of each area from 2010 to 2025 is shown in Table 1. It was recorded among the area of these years that the largest was 2010, amounting to 22.90 km^2 .



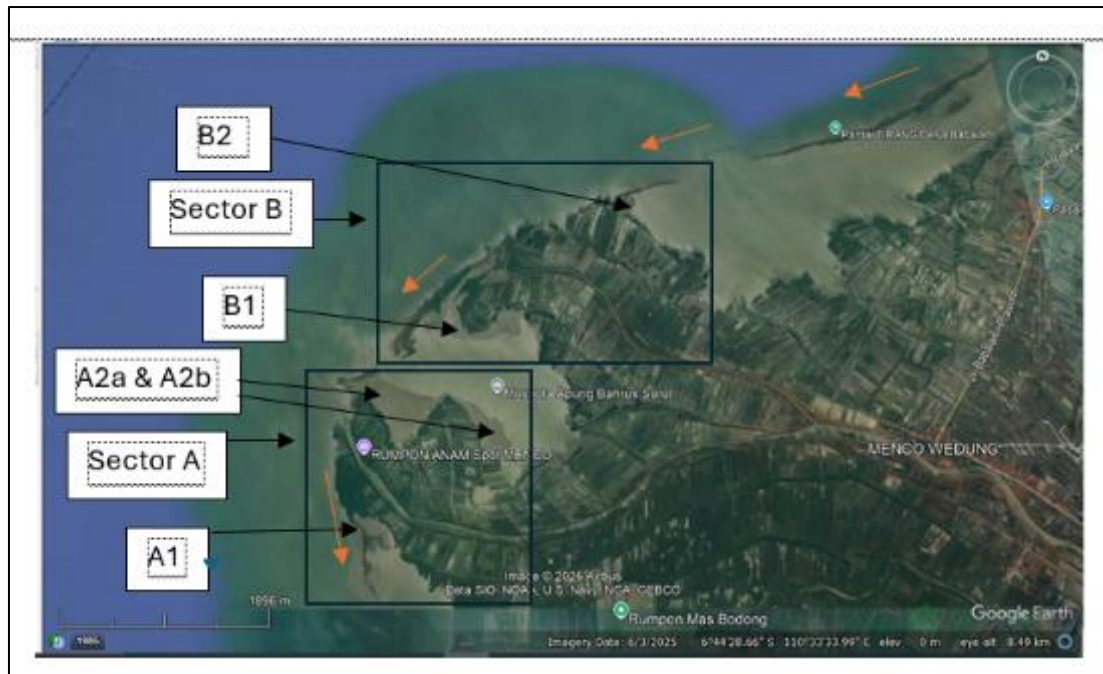
Source: Interpretation from Google Earth Pro

Figure 1 Coastline changes of Wulan River Delta from year 2010 – 2025.

Table 1 Areas of the Wulan River delta by year of satellite imagery

No	Year	Area (Km ²)	Remarks
1	2010	22.90	Start point
2	2015	21.33	decreased by 1.57 km ² from 2010
3	2020	20.67	decreased by 0.66 km ² from 2015
4	2025	21.36	increased by 0.69 km ² from 2020

Based on Google Earth Pro imagery in 2025, in several places, especially at the end of the River estuary, new land was formed as a result of sedimentation brought by the Wulan River. The formation of the new land was formed due to the flow of River branches to the side of the main River body. The new land is still labile and there are no plants growing on it. The locations of the new land are shown in the Figure 2 and the area in each sector is shown in the Table 2.



Source map: Google Earth Pro

Figure 2 Sector division for the identification of new land area**Table 2** Identification of new land (raised land) at the end of the Wulan River Delta, Demak Regency in 2025

Sector	Administrative Areas	Wide (m ²)	Remarks
A1	Village Berahan Kulon	82.295	Rivermouth Wulan left branch
A2a	Village Berahan Kulon	328.768	Rivermouth Wulan left branch
A2b	Village Berahan Kulon	208.397	Rivermouth Wulan left branch
B1	Village Berahan Kulon	118.236	Rivermouth Wulan right branch
B2	Village Berahan Wetan	52.263	Rivermouth Wulan right Branch
	Total	789.871	

Based on the visual analysis of each of the different year images, at first glance there was no significant change. Based on the analysis on the Figure 1 physical changes occur at the end of each River estuary. There is a backward shift or abrasion on the new land formation. The burns that form in front of the River mouth as a result of new sedimentation are easily changed in the form of shifting, moving, or deforming. The change is suspected to be caused by the direction of the current which is dominated from north to south. The current carries sediment shifting to the south. This is based on the shape of the cusped foreland tip that points south.

Based on Table 1 with the conditions of the beginning of 2010 to the present direction, it shows that during the 10-year period (from 2010 - 2020) there was a reduction in land area of 2.23 km². Furthermore, in the next 5 years from 2020 - 2025, the delta experienced an increase in land area of 0.69 km². Changes due to the reduction or addition of land in the Wulan River delta occur at the end of the River estuary. The change with a relatively small area within 15 years is allegedly related to the handling of River and watershed management by the competent agencies.

The Wulan River Delta is a delta with a large area, has a birdfoot type of shape. The shape of the bird's leg delta indicates that the delta has a large sediment supply, while relative oceanographic factors play a small role. The large area of the Wulan River delta makes the formation a landscape in which there is a collection of various landforms. There are several forms of land in it, including: tidal River networks, islands or bar (if still below sea level) barriers, cusped foreland (land extending out), lagoons and potential lagoons. The existence of several distinctive coastal morphological formations shows that the Wulan River delta area has a large sediment supply system that is transported through the main River.

The presence of cusped foreland at each end of the River that tends to point south shows that the dominant flow along the coast comes from the north, so that sediment is carried and deposited by these currents. In the northern part of the mouth of the Wulan River, there is a barrier island so that a lagoon will form between the mainland and the barrier island.

Based on Sunarto's (2004) research on the change in the coastline of the Wulan River delta during the period of 1931-2000, it shows that during the period of 1931-1972 for 41 years was the largest increase in area compared to the study period from 1931-2000. Originally in 1931 the coastline in the Wulan River delta was straight, then in 1972 a bird's foot delta was formed which showed that during the 41-year period there was a large sedimentation. As a result of the identification of the coastline in 2000, there was the formation of a new River branch towards the south side.

Previous research by Hollerwoger (1964) using topographic maps from the colonial period from the 1870s to 1946 showed that almost all River estuaries on the north coast of Java, including the Cimanuk River, the Bangkaderes River, the Sanggarung and Bosok Rivers, the Pemali River, the Comal River, and the Bodri River, have experienced accretion development. There was a change in the coastline and the shape of the simple delta type to the final form of the bird's foot type, which indicates that the formation of the delta was due to a large supply of sediment. Research on shoreline changes in the Comal River delta on the north coast of Central Java from 1870 to 1978 by Setiyono (1998) showed that the delta experienced the dynamics of changing coastlines and the shape of the delta getting larger.

Based on Melawani, et al. (2018) that the land delta of the Wulan River formed from advanced development through the method of identifying mollusk animals found in the sediment layer shows that the land formed is dominated by marine ecosystems. The part that has experienced advanced development, especially the one that was initially a local location in the form of the sea which experiences sediment accumulation carried by River flows.

According to Suseno Putri (2016), based on the results of map analysis in 2002 and 2010, the Wulan River Delta shows the dynamics of changes in the coastline through overlay analysis techniques. The results of the analysis of coastal changes showed that abrasion occurred on an area of 403.07 ha, while the accretion process covered an area of 217.78 ha. This shows that the area of abrasion is greater than the area of sedimentation or accretion. Meanwhile, for the period from 2010 to 2015, an abrasion area of 381.27 ha and an area of sedimentation or accretion of 87.05 ha. The general conclusion of the results of the study shows that in the period from 2002 to 2015 there was more abrasion than accretion.

The sedimentation that takes place in the Wulan River delta is related to the flow conditions brought by the Wulan River. According to Kanza, et al. (2017) the flow of the Wulan River that crosses the Demak Regency area often causes flooding. This is due to the relatively flat topographic condition of the land in the Demak Regency area so that the River flow when crossing will move slowly and if there is an abundance of water, it will be easy for the embankment to break due to flooding. The main problem faced in Demak Regency is the problem of flooding with inundation for a long time. The countermeasures, among others, through the improvement of cross-section in the Wulan watershed can be an alternative to handling the right problem for the area. The improvement of the cross-section of the Wulan River includes planning for dredging the Riverbed and River embankments.

The subsidence ranges from 0.06 to 1.15 m/year. The highest land subsidence tendency occurred in parts of Sayung, Bonang and Wedung. This tendency of land subsidence is spread in several industrial areas such as in Sayung District and dense residential areas in Bonang and Wedung Districts. Existing land use can affect land subsidence.

Most of the land at the research site is used for salt ponds. In Wedung District, there are three villages that have pond land with a total area of 621 ha. Based on monographic data of each village in 2000 with the following conditions: Babalan (pond area 153 ha, number of farmers 98), Berahan Wetan (pond area 127 ha, number of farmers 84), Berahan Kulon (pond area 108 ha, number of farmers 71) (BPS of Demak Regency, 2022).

Table 3 Area and pond area in three villages in the Wulan River Delta area

No	Village	Wide (ha)	Pond area (ha)	Area Percentage
1	Babalan	6,100	153	0.02
2	Berahan Wetan	9,230	127	0.01
3	Berahan Kulon	8,980	108	0.01

Based on Ahmad Ali's (2024) research, in all areas of Demak Regency, there has been a change in land cover, including in Wedung District. The results of the study using the research period from 2013-2023 in the Wedung District area in the mangrove forest section saw an area shrink from 121.56 ha in 2013 to 44.01 ha in 2023. For the closure of pond land in 2013, it has an area of 6100.05 ha, increasing to 6171.51 ha in 2023, which means an increase of 71.46 ha.

Coastal security measures from a legal aspect refer to the Regulation of the Minister of Public Works and Public Housing (PUPR) No. 7 of 2015 concerning Coastal Security. It is stated in Article 5 that coastal security is intended to protect and secure against: (a) communities living along the coast from the threat of waves and high tide inundation, erosion and abrasion; (b) public facilities, social facilities, areas with high economic value and historical value and national strategic value along the coast; (c) and siltation of River mouths.

The process that takes place in the Wulan River delta where there is an interplay between abrasion and accretion shows that the area is still dynamic and unstable. The handling needed in securing the coast is directed at the occurrence of siltation of the River estuary. The formation of new land usually occurs at the end of River mouths both on the main River and at the branches of smaller Rivers.

Protection and security measures for people living along the coast are not necessary considering that community settlements in the delta area (Menco hamlet which includes Berahan Wetan village and Babalan village) are located some distance from the coastline. Along the coast of the delta, mangroves are generally overgrown in groups on narrow banks, so that the banks and mangroves function to protect the farms behind them.

The dynamic development of the delta with an almost balanced abrasion and accretion process shows that the condition of the Wulan River delta is at a stagnant stage of development. This can be shown based on the data on the area of the delta per given year in the Table 1. These conditions are suspected to be related to the management of water resources by the government agency BBWS Pemali-Juana (2022), among others, in the form of: irrigation handling, the construction of embankments, barns, weirs, check dams, and flood control in the Serang and Lusi watersheds areas.

4. Conclusions

Based on the results of the research, it can be concluded as follows:

Over a period of 15 years, from 2010 to 2025 the Wulan River Delta experienced changes in the coastline, especially at the end of the River estuary. There is a change in the area of the delta but it is relatively small and the change in area occurs fluctuatingly. The conditions of the widest delta occurred in 2010 (covering an area of 22.9 km²) and the smallest in 2020 (covering an area of 20.67 km²). The change in the shape of the coastline is strongly suspected to be related to the existence of sea currents that are dominated from north to south, so that a new land expansion is formed to the south.

The Wulan River Delta for the period of 2010-2025 has no prospects for the expansion of new pond land. This is because there is no significant increase in land area, where the condition of the delta is generally in a fixed condition. Expansion of pond land can be done on newly formed land by paying attention to the stability of sediment deposits. The stability of the change in the area of the delta is suspected to be due to the success of watershed management by related agencies.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that we have no conflicts of interest.

References

- [1] Ahmad Ali, Abdul. 2024. Analysis of Critical Land Prediction on Urban Heat Island Intensity in Demak Regency. Sultan Agung Islamic University, Semarang
- [2] BBWS Pemali-Juana. 2022. Profile of the Pemali Juana River Area Center.
- [3] Badan Pusat Statistik (BPS) Kabupaten Demak. 2022. Demak Regency. Publication Number: 33210.2202
- [4] Badan Pusat Statistik (BPS) Kabupaten Demak. 2021. Wedung District. Publication Number: 33210.2102
- [5] Hollerwoger, F. 1964. The Accelerated Growth of River Deltas in Java. *The Indonesian Journal of Geography*. Vol.4, No.7, June 1964: 1-15
- [6] Kanza, R.; Ahmada,A. ; Darsono, S.; Atmodjo, P.S .2017. Flood Control of Sungai Wulan, Demak, Central Java. *Jurnal Karya Teknik sipil*, Volume 6, Nomor 4, Tahun 2017, Halaman 300-308 Online di: <http://ejournal-s1.undip.ac.id/index.php/jkts>
- [7] Malawani, M.N.; Sunarto; Handayani, T; Yoga, A.G.H. 2018. Recent Delta Evolution based on Mollusk Shell Record on Sediment in Delta Wulan, Demak, Indonesia. *Geomedia* Vol. 16 No. 2 Tahun 2018 | 81 – 87 <https://journal.uny.ac.id/index.php/geomedia/index>
- [8] Pemerintah Kabupaten Demak. Regional Regulation No. 6 of 2011 concerning the Regional Spatial Plan of Demak Regency 2011-2031.
- [9] Pemerintah Kabupaten Demak. Regional Regulation No. 1 of 2020 concerning Amendments to Regional Regulation No. 6 of 2011 concerning the Regional Spatial Plan of Demak Regency 2011-2031.
- [10] Setiyono, H. 1998. Changes in the Coastline of the Comal Delta, Pemalang from 1870 to 1981. *Majalah Penelitian*, Tahun X, no 39, september 1998, p: 46-51
- [11] Sunarto. 2004. Changes in Geomorphic Phenomena of Coastal Areas Around the Muria Volcano, Central Java (Paleogeomorphological Study). Disertasi. Fakultas Geografi UGM, Yogyakarta
- [12] Suseno Putri,Sebrine; Max Rudolf Muskananfola; dan Boedi Hendrarto. 2016. A Study of Spatial Changes in the Wulan Demak Delta in Sustainable Management of Coastal Areas. *Proceedings of the VI National Seminar on Fisheries and Marine Research Results*, Faculty of Fisheries and Marine Sciences – Center for Disaster Mitigation and Coastal Rehabilitation Studies, Semarang, November 12, 2016.