

ENVIRONMENTAL PARAMETERS AND COASTAL ECOTOURISM POTENTIAL OF AMBON BAY

PARAMETER LINGKUNGAN DAN POTENSI EKOWISATA PANTAI TELUK AMBON

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ABSTRACT

Ambon Bay is one of the waters in Maluku Province that has the potential for ecotourism, but the quality of the waters needs to be considered because over time it changes and experiences changes to the point of coastal damage from various natural events and human activities, especially on Wayame Village Beach, Galala Village Beach, and Passo Village Beach. This study aimed to determine the environmental parameters of Ambon Bay waters as an ecotourism area. This study measured salinity, pH, dissolved oxygen, temperature, and changes in the coastline using Sentinel 2 Imagery. The results of the study showed that the three locations had DO values of 2.8 mg/L, 3.1 mg/L, and 1.4 mg/L; salinity at 32 ppt, 34 ppt, and 33 ppt; pH ranging from 7.6 to 8.6; and temperatures ranging from 27°C to 29°C, and within a period of 4 years (2018-2022) there have been changes in the coastline. The results of the inventory found several tourist areas that can be revitalized and developed to help the economy of coastal communities. This research can be a reference for village communities and the government in making regulations and activities to prevent damage and handle it appropriately.

Keywords: coastline, hydro-oceanography, inventory

ABSTRAK

Teluk Ambon adalah salah satu perairan di Provinsi Maluku yang berpotensi sebagai kawasan ekowisata, namun perlu diperhatikan kualitas perairannya karena seiring berjalannya waktu berubah dan mengalami perubahan sampai pada kerusakan pantai dari berbagai kejadian alam dan aktivitas manusia khususnya pada Pantai Desa Wayame, Pantai Desa Galala, dan Pantai Desa Passo Tujuan penelitian ini adalah untuk mengetahui parameter lingkungan perairan Teluk Ambon sebagai kawasan ekowisata. Penelitian ini dilakukan dengan mengukur salinitas, pH, oksigen terlarut, suhu dan perubahan garis pantai menggunakan Citra Sentinel 2. Hasil penelitian menunjukkan pada ketiga lokasi memiliki nilai DO yaitu 2,8 mg/L, 3,1 mg/L dan 1,4 mg/L, salinitas pada 32 ppt, 34 ppt, dan 33 ppt pH berkisar 7,6-8,6, dan suhu berkisar 27°C-29°C dan dalam kurun waktu 4 tahun (2018-2022) sudah mengalami perubahan garis pantai. Hasil inventarisasi ditemukan beberapa kawasan wisata yang dapat diperbaharui serta dikembangkan untuk membantu ekonomi masyarakat pesisir pantai. Penelitian ini dapat menjadi acuan bagi masyarakat desa, pemerintah dalam membuat regulasi, dan kegiatan pencegahan kerusakan maupun penanggulangan secara tepat.

Kata kunci: garis pantai, hidrooseanografi, inventarisasi

INTRODUCTION

Ambon Bay is one of the waters that play a role in the eastern Indonesian region and consists of two parts, namely Outer Ambon Bay and Inner Ambon Bay. The Ambon Bay is currently experiencing a decline in function due to pollution, waste, and uncontrolled human activities (Pattipeilohy 2014), including the reduction of mangrove forest ecosystems (Suyadi 2012), changes in residential land use (Selanno *et al.* 2015), and damage to coastal areas (Hiariey and Baskoro 2011). The impact of unsustainable use of resources can hinder the development of the potential of Ambon Bay in the fisheries and marine sectors. Opportunities in the fisheries and marine sectors that can be improved include the fields of nature tourism (Pattipeilohy 2014), deep-sea fisheries, diving tourism, white-spotted rabbitfish, mangrove forests, fisheries businesses, and in the fields of industry and trade (Latuconsina *et al.* 2012).

The water quality in Ambon Bay waters was one of the best waters in Eastern Indonesia (Gemilang *et al.* 2017) because it had superior and abundant coastal and marine ecosystems, which had crucial ecological roles and functions for the sustainability of biological resources as a whole. However, its quality has decreased along with the increase in activities around the coastal area, such as being surrounded by residential areas, industrial sectors, shopping centers, and regional and inter-island sea transportation activities. Various impacts that have been identified from these activities are increasing the amount of sediment, changes in temperature and salt content, and excessive eutrophication.

The lack of waste disposal facilities and public awareness has resulted in increased eutrophication. These piles of waste are visible on the surface of the seawater in Ambon Bay. Oil spills from the disposal of companies and ports around, as well as the activities of vessel transportation, have an impact on the water quality in Ambon Bay. Some of them are Wayame Village Beach, Galala Village Beach, and Passo Village Beach, all of which have the potential to develop ecotourism in the waters of Ambon Bay. Knowing the quality of the waters is an important step in supporting the development of ecotourism in an area. Clean and healthy waters attract tourists and support the sustainability of the ecosystem, which is the main attraction of

the ecotourism concept. Good water quality reflects a well-maintained environmental condition, while polluted waters can reduce tourist interest and hurt the lives of marine biota. In addition, monitoring water quality also plays a role in detecting damage to the coastline, which is often caused by abrasion, industrial activity, or climate change. By understanding the condition of the waters and coastline, conservation measures can be implemented to maintain the balance of the ecosystem and support the sustainability of ecotourism in the area.

Based on Supiyati (2005), handling coastline damage effectively needs accurate information about the oceanographic conditions in the area, which is provided through hydrooceanography analysis. The causes of coastline damage that are often the focus of research can be categorized into 2 factors, namely natural and human (Yuwono 2004; Triatmodjo 2012). The nature that influences the position of changes in the coastline is various hydro-oceanographic processes that occur, such as waves, changes in flow patterns, tides, and weather changes. Meanwhile, changes in the coastline due to human activities include changes in the use of coastal retaining land that disrupts and changes sediment movement and sand mining that triggers changes in flow and current patterns (Halim *et al.* 2016). Therefore, this study was conducted to determine the environmental parameters of the waters of Ambon Bay as an ecotourism potential in Maluku.

According to Hakim (2012), coastal development strategies require strengthening in many areas, especially increasing ecological conservation as a whole so that natural resources can be well maintained. Efforts to prevent and overcome damage in coastal areas that have the potential as natural tourism destinations must be carried out through cooperation between the government and the community. Knowing the environmental parameters of Ambon Bay Waters is an important step in understanding the dynamics of the aquatic environment and is a benchmark in assessing the level of water degradation in the area. Factors that need to be considered, such as temperature, salinity, water quality, and changes in the coastline, play a crucial role in determining the condition of the aquatic ecosystem. If there is a significant change in environmental parameters, such as increased pollution or decreased dissolved oxygen levels, this can be an early indicator

of degradation of the aquatic environment. It is expected that regular monitoring and early detection of these changes will lead to more effective intervention strategies, helping to prevent further damage. With good monitoring, preventive measures can be taken immediately to minimize negative impacts, such as pollution and decreased quality of marine habitats. Appropriate conservation and management measures will greatly support the development of Ambon Bay as a sustainable ecotourism area so that the beauty and balance of its ecosystem are maintained for the long-term benefit of the community and the environment.

METHODS

The study was conducted from May 1 to August 28, 2022, in the waters of Ambon Bay. The three locations studied were Passo Village Beach, Galala Village Beach, and Wayame Village Beach (Figure 1). The determination of sampling location was determined using the purposive sampling method, namely, the location was selected with the assumption that it could represent the surrounding area with certain considerations, which was apart from being within the scope of the inner Ambon Bay. It also has good accessibility and shows the potential for interference from human activities such as settlements, fisheries, and tourism activities, which can affect the condition of the aquatic environment. This is by the definition of purposive sampling, according to Sugiyono (2016), namely that samples are selected based on criteria that have been determined by the researcher and must meet previously established requirements. The considerations that are used as requirements are areas that have tourism potential that can be developed to improve the community's economy.

Data collection and analysis

This study is a descriptive study with observation (interviews and direct observation) and pure experimental (testing of ecological parameters and coastlines). Primary data for this study were obtained from interviews, direct observations in the field, and laboratory testing. The environmental parameters seen in this study are ecological parameters testing (salinity, temperature, pH, and dissolved oxygen), which was carried out for 1 month, namely August-September

2022. The average calculation was then analyzed, and a picture of the differences in coastlines in 2018 and 2022 was taken using satellite imagery, namely Landsat 8 Satellite Imagery. The collection of data on coastline changes in this study over 4 years is based on data on the rate of sedimentation in the inner Ambon Bay, increasing from 0.6 cm per year in the period 1987-1996 to 2.4 cm per year in 2008, which means a four-fold increase.

This increase in sedimentation causes the shallowing of the waters, which in turn can affect the dynamics of the coastline. For this reason, researchers took a 4-year time span where it can be proven that in a short period, factors such as increased sedimentation, unplanned coastal reclamation, and coastal ecosystem degradation are likely to contribute to changes in the coastline during that period. To see changes in the coastline, image data from Landsat 8 satellite imagery is used to see changes in the coastline, which offers several advantages, namely being able to monitor a large area (Kasim 2012). The method of analyzing changes in the coastline of Ambon Bay Waters using Landsat 8 satellite imagery is carried out using a remote sensing approach and geographic information systems (GIS) with normalized difference water index (NDWI) analysis to distinguish land and water, and the shoreline change detection method to detect changes in the coastline from year to year. After the data description is obtained, a comparison is made. The rate of change in the coastline is not seen in this study, but will be carried out in further research. Secondary data and information from relevant places and literature are then analyzed descriptively as alternative materials for development.

RESULTS AND DISCUSSION

Hydro-oceanography

Characteristics of environmental parameters

Measurement of environmental parameter characteristics in hydro-oceanography is carried out to understand the dynamics of waters and their interactions with marine ecosystems. The main parameters measured include temperature, salinity, pH, dissolved oxygen (DO), turbidity, and currents and tides. Temperature and salinity are measured using CTD (conductivity,

temperature, and depth), which provides a vertical profile of water conditions (Figure 2a). pH and dissolved oxygen are analyzed using a pH meter and DO meter to assess water quality for marine life (Figure 2b). These measurements are important in hydroceanography to understand changes in the aquatic environment, identify potential degradation, and support sustainable coastal ecosystem management.

In general, salinity, pH, dissolved oxygen content, and temperature are part of

the oceanographic chemical parameters that play an important role in waters. According to Gang-ji (2007), salt concentration and dissolved oxygen are the main parameters in determining water quality. Dissolved oxygen plays an important role in decomposing organic matter by microorganisms, then used by organisms for the respiratory process, and becomes one of the main supporting factors for the life of biota and one of the main indicators in indicating the fertility of waters.

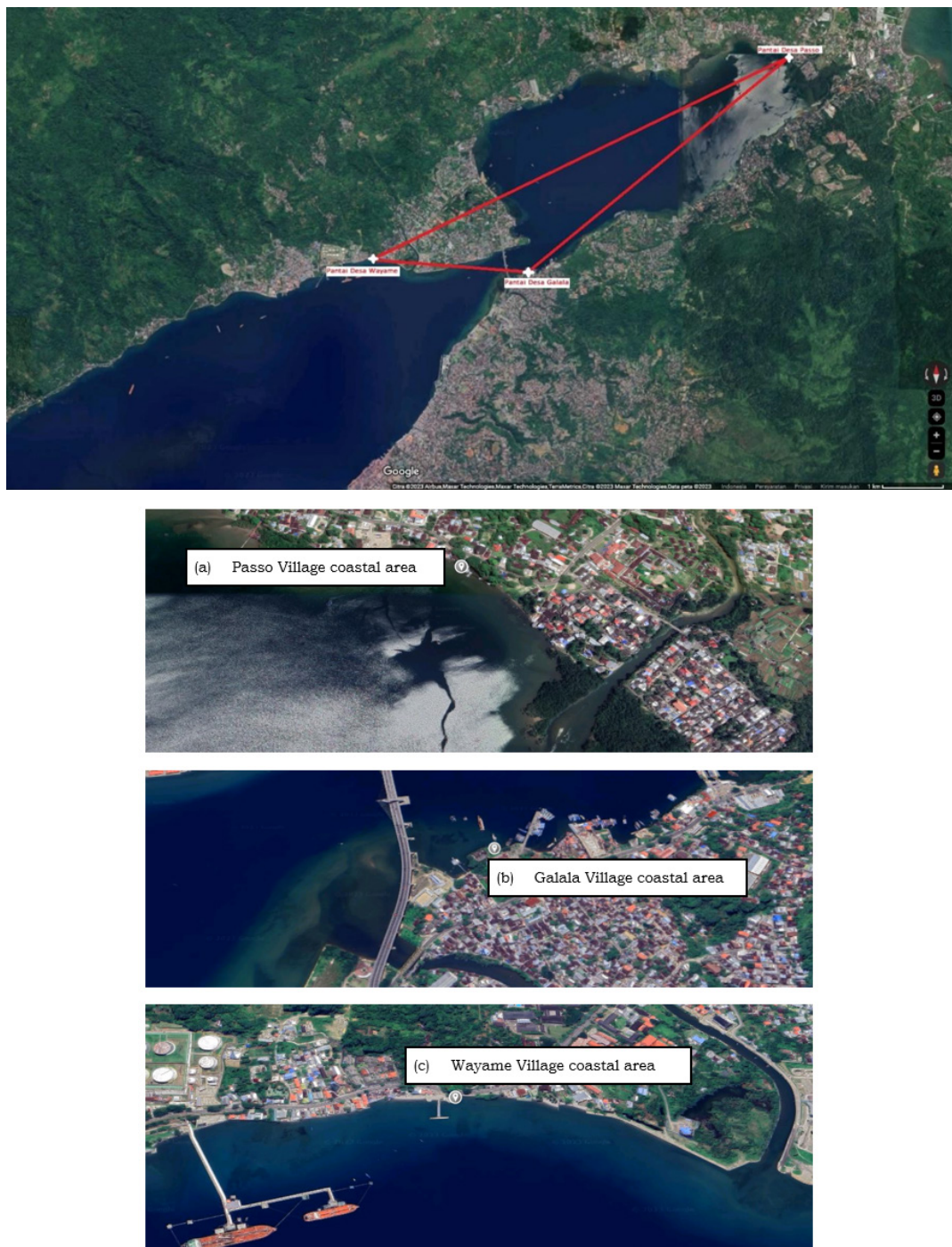


Figure 1. Research location in Ambon Bay waters.

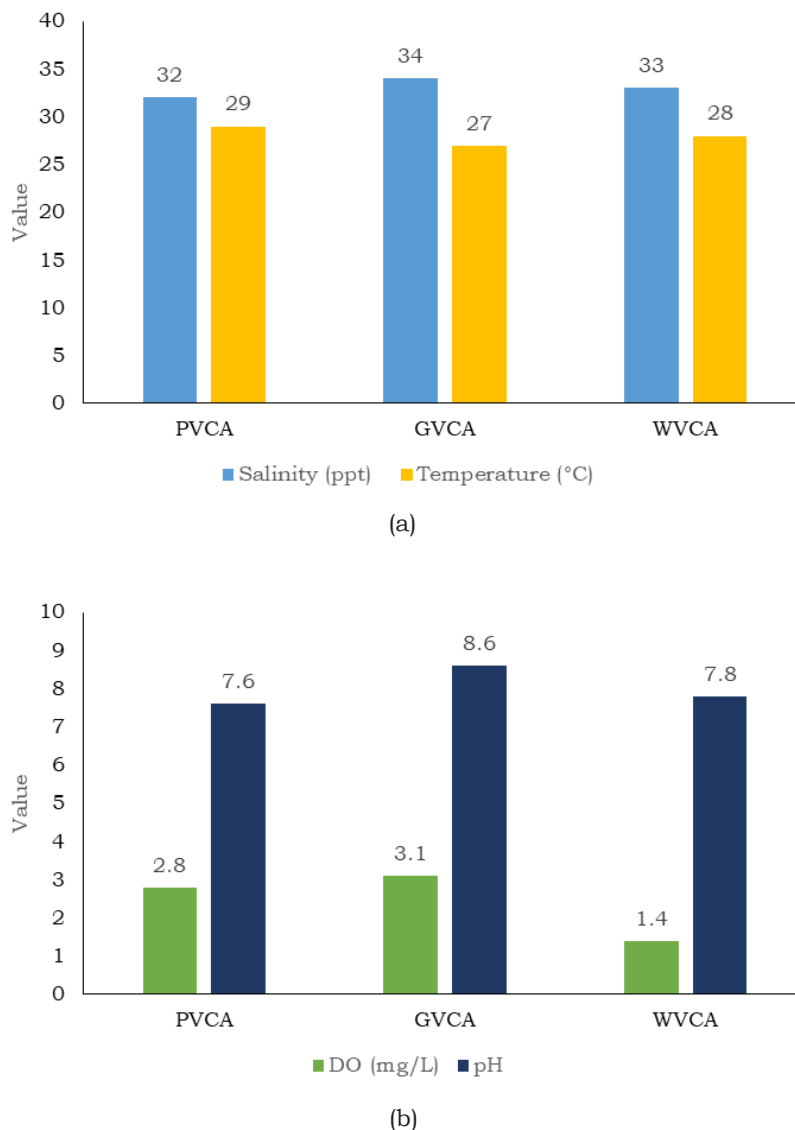


Figure 2. Measurement of environmental parameter characteristics at 3 research locations. (a) Salinity and temperature measurement, (b) pH and DO measurement.

The optimal dissolved oxygen level, according to Subarijanti (2005) in Kadim *et al.* (2017), is between 3 and 7 mg/L. However, when compared with the results of the DO values on the 3 beaches in this study, namely 2.8 mg/L, 3.1 mg/L, and 1.4 mg/L, it indicates that the beaches of Passo Village and Galala Village have low DO values, so it can be said that the waters are exposed to waste. The DO value in water is related to the degree of pollution, type of waste, and amount of organic matter in water. The low DO value is caused by several environmental factors around the research location, such as the presence of industries located near the coast, waste disposal activities, and drying areas. In addition, the low DO value indicates that the photosynthesis process is

not optimal. Salinity on the coast of Passo Village, Galala Village, and Wayame Village has a value of 32 ppt, 34 ppt, and 33 ppt, respectively; this condition is classified as poor salinity. This was also stated by Wulandari *et al.* (2015), that the salinity conditions to support the growth of marine biota stated that the appropriate salinity range for the growth of marine biota is 30 ppt.

The standard pH level in waters that is classified as stable is 7.7-8.4 (Verawati 2016). This range supports the life of marine organisms because these conditions are ideal for physiological processes, including the growth and reproduction of biota. A stable pH also reflects the chemical balance of waters that are free from significant acid or base contamination. The results of pH

measurements at three locations showed interesting variations. Passo Village Beach has a pH value of 7.6, which is slightly below the stable range and may indicate the influence of local activities or the natural properties of its waters. In contrast, Galala Village Beach recorded a pH of 8.6, slightly above the stable range, which may indicate the presence of biological processes or waste that increases alkalinity. Meanwhile, Wayame Village Beach showed a pH of 7.8, within the stable range, reflecting environmental conditions that support the ecosystem. The variation in pH at these three locations indicates the presence of different environmental factors, such as pollution levels, human activities, or natural processes. Further monitoring is needed to identify the causes of these differences and ensure that the aquatic ecosystem remains balanced. By understanding the factors that influence pH, coastal area management can be carried out sustainably to maintain the sustainability of the marine ecosystem. According to Megawati *et al.* (2014), pH levels are a determinant in seeing the dominance of phytoplankton, which influences the main production level of waters where the presence of phytoplankton is supported by the availability of nutrients. Changes in pH values to a basic state are influenced by the entry of river loads and the results of population activities.

The results of temperature measurements at the research location were 29°C, 27°C, and 28°C, if following the Sea Water Quality Standards according to the Decree of the Minister of Environment No. 51 of 2004, namely 24°-32°C. This range provides optimal conditions for ecological processes, such as phytoplankton photosynthesis, coral reef growth, and the sustainability of the food chain. The results of temperature measurements at the research location showed variations that remained within the quality standard limits. The temperature of 29°C recorded at Passo Village Beach indicates warm waters and is ideal for many tropical species. The temperatures of 27°C and 28°C at Galala Village Beach and Wayame Village Beach also indicate stable conditions and support ecosystem sustainability. These three locations have temperatures that reflect the characteristics of tropical waters, which are generally warm throughout the year. If there is a change in temperature above the optimal temperature, this will affect the physical, chemical, and biological processes

in the water column, where, according to Koniyo (2020), an increase in temperature can reduce the solubility of oxygen in water, directly affect fish activity, and increase the toxicity of pollutants to other aquatic organisms, with one of the causes being seasonal changes (Ayuniar 2018).

Coastline

Coastal areas are areas that can change. Coastline changes are one form of change that occurs continuously. Coastline changes that occur include coastal erosion and coastal addition (sedimentation or accretion). Figure 3 uses Sentinel 2 Imagery at the Faculty of Agriculture, Universitas Pattimura. This method provides data on coastal areas regarding coastline changes and changes in land use in large areas (Prameswari *et al.* 2014). Figure 3 shows the difference in coastlines between 2018 and 2022. The magnitude of the coastline change in this study was not calculated because it only looked at whether or not there was a change in the characteristics of physical and chemical properties, and the description of the coastline at 3 locations.

Coastline changes not only affect coastal ecosystems but also have an impact on human life, such as loss of residential land, reduced productive land, and disruption of infrastructure. Therefore, understanding the pattern of coastline changes through monitoring and analysis of spatial data is very important for sustainable coastal area planning and management. Mitigation approaches such as mangrove reforestation, breakwater construction, or controlling human activities in coastal areas can help minimize the negative impacts of these changes.

The difference in coastlines between August 2018 and August 2022 shows changes in coastal dynamics that can be influenced by various natural factors and human activities. The coastline is a very dynamic boundary between land and water, influenced by tides, waves, ocean currents, and sediment. These changes can be in the form of abrasion (coastal erosion) or accretion (land addition due to sedimentation), which often reflect natural geomorphological processes and the impacts of human activities. One of the main causes of coastline changes is abrasion, which is often triggered by rising sea levels due to climate change and increased wave intensity. Human activities, such as coastal

development, sand mining, or mangrove deforestation, can also accelerate the erosion process. Conversely, accretion can occur due to sediment deposition from rivers or reclamation projects carried out to expand land. These changes can be seen from a comparison of coastline maps at two different times, such as August 2018 and August 2022, which show a shift in the location of the coastline.

Coastline changes over a short period are an indicator of significant environmental dynamics, both due to natural processes and human activities. Naturally, coastlines can change due to erosion, sedimentation, and changes in land elevation due to earthquakes or tectonic activity. In addition, tidal phenomena, storms, and high waves also contribute to shifts in the position of the coastline. These factors reflect the complex interactions between the atmosphere, land, and sea. Coastline changes can occur from changes and reductions in sediments that basically experience changing positions according to the position at high tide, the influence of waves, and ocean currents due to the accumulation of land sedimentation and deposition on the seashore through river

mouths (Wibisono 2011). Coastline changes are a continuous process, be it erosion or the addition of material to the coastline caused by the movement of material, waves, and human activities on land (Arief *et al.* 2011 in Siregar *et al.* 2015).

Angkotasari *et al.* (2012) stated that in the process of coastline changes, ocean waves play an important role because the size of the waves has a major impact on changes in the coastline, including tides and wind movements. In addition, there will also be continuous changes in the ebb and flow of seawater, the movement of material in rivers, ocean waves, and currents that move along the coastline so that over time, the coastline changes (Purnaditya *et al.* 2012). Within a period of 4 years (2018-2022), there were extreme climate and weather changes. This could also be a natural factor for changes in the coastline shortly. This is in line with Opa (2022), who stated that these changes occur from time to time on a seasonal or annual scale, depending on the strength of the coast in terms of topography, rocks, and characteristics of waves, tides, and wind. Arief *et al.* (2011) added that the decline in the coastline is caused by erosion

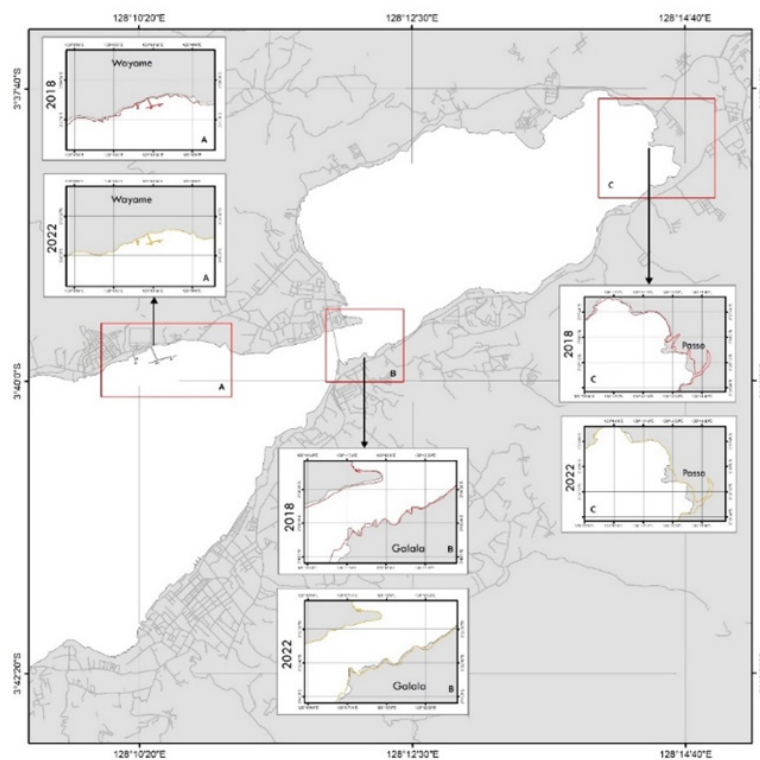


Figure 3. Coastline changes. a) Wayame Village Beach, b) Galala Village Beach, c) Passo Village Beach.

due to wave energy.

The results of observations and mapping show that in the three research locations, river flows were found to be one of the factors causing changes in the coastline, namely accretion. This is in line with Sardiyatmo *et al.* (2013), who stated that accretion causes the river mouth to close, causing flooding. In addition, if the conditions coincide with high rainfall, flooding will often occur. The increase in changes in the coastline is caused by the accumulation of sediment that is quite rapid in coastal areas near rivers and material that continues to settle to form new soil and increase the area of existing land (Muryani 2010). The area that most often experiences this situation is Galala Village.

Not only naturally, but changes in the coastline can also be influenced by anthropogenic or human activities. Human activities such as coastal infrastructure development, land reclamation, and sand mining also accelerate changes in the coastline. Exploitation of coastal resources can reduce the stability of the ecosystem, making the land more susceptible to erosion. In addition, global climate change, which causes sea level rise due to melting ice at the poles, is also a major factor accelerating abrasion in various coastal areas. Rapid changes in the coastline can have a significant impact on the environment and society. From an ecological perspective, this can damage important habitats such as mangroves, coral reefs, and seagrass beds that function to protect the coast. Meanwhile, socially and economically, coastal communities can lose land, infrastructure, and sources of livelihood. It can be said that both natural and anthropogenic are related to seeing changes in the coastline.

Various efforts have been made by the government and the community, such as planting mangroves and making embankments, but they are still ineffective. This is because even though there are prevention efforts, coastal land use for development is still occurring. Based on field observations, on the coast of Galala Village, Wayame Village, and Passo Village, changes in the use of coastal areas were found for infrastructure development (bridges, offices, hospitals, and industry), settlements, and land clearing, which are thought to cause increased sedimentation from upstream areas during high rainfall. This is in line with Suhana *et al.* (2016), which states

that one of the coastlines can also change due to sedimentation influenced by human activities such as landfilling and expansion of sea areas for community settlements.

Ecotourism inventory

Water quality plays a crucial role in determining the ecotourism potential of an area, especially in coastal and marine areas. Clean and healthy waters support the sustainability of marine ecosystems, including coral reefs, seagrasses, and mangroves, which are the main attractions of nature-based ecotourism. Water quality parameters such as clarity, temperature, dissolved oxygen, pH, and pollution levels greatly affect the survival of marine biota that are tourist attractions, such as fish, coral reefs, and marine mammals. If water quality decreases due to pollution or eutrophication, the appeal of ecotourism will also decrease because the ecosystem is damaged and biodiversity decreases. Conversely, good management of water quality, such as waste control and ecosystem conservation, can increase tourist attractions, attract more visitors, and support the local economy. Therefore, monitoring water quality is very important in the planning and management of sustainable ecotourism areas.

Ecotourism adopts an environmentally conscious tourism model, which is connected with nature conservation efforts, tourism experiences, ecological education, and other functions to achieve harmonious integration between development and protection (Xia 2020). From the observation results, the development of Passo Village, Galala Village, and Wayame Village into ecotourism areas can be done by developing existing potential. Researchers conducted an inventory that can be used as a reference for the development of the three research locations. This is in line with Monecke *et al.* (2015), namely that development efforts can be carried out by ensuring regional readiness to identify and inventory potential resource opportunities that can be developed for the prosperity of the people. With the inventory, the community and government will better understand the conditions and will also demand participation and seriousness in determining the direction of development in coastal areas.

Measuring environmental parameters such as salinity, temperature, pH, DO

(dissolved oxygen), and shoreline changes are important steps in understanding the condition of coastal ecosystems. Salinity and temperature affect the presence of marine flora and fauna that are the attractions of ecotourism, such as coral reefs and other marine biota. The pH and DO values indicate water quality, which is important for maintaining a healthy ecosystem and supporting ecotourism activities. Shoreline changes also affect the accessibility and aesthetic appeal of beaches, so it is important to monitor these changes to maintain the competitiveness of tourist destinations.

These measurements are relevant to determine the potential for ecotourism based on biodiversity and environmental sustainability at Galala Village Beach, Passo Village Beach, and Wayame Village Beach. These beaches have different characteristics, which are influenced by these environmental parameters. For example, beaches with stable salinity and high DO tend to support rich underwater life, making them attractive for activities such as snorkeling or diving. Stable temperatures are also a determining factor for tourist comfort in their activities. With an ecotourism inventory based on environmental data, tourism management can be carried out in a more focused and sustainable manner. The results of environmental parameter measurements can be used as a basis for designing tourism activities that do not damage the ecosystem, such as regulating the number of visitors or protected areas. In addition, good coastline management can anticipate the impacts of climate change, such as abrasion or rising sea levels, which can threaten the attractiveness and sustainability of ecotourism on the three beaches. From the results of the inventory, some findings can be developed at each research location.

There is a cafe near the beach and a mangrove planting area in the Passo area, which can be used as a medium for learning at school or as a place for students to conduct research. Furthermore, in Galala Village, most of the residents work as skipjack tuna fishermen (*Katsuwonus pelamis*) and sell their catch to collectors and then to traditional fish processors, such as smoked fish processors. Galala Village is known for its smoked fish products, which can also be souvenirs when visiting Ambon. In addition, there is one famous area, namely the "boat place" managed by the Galala boat rowers, which can be developed into a beach tourism spot for recreation using boats to

see the coastal area, mangroves, and the scenery under the red and white bridge. In addition, a simple cafe can be developed on the beach to enjoy seafood dishes. There is a bridge decorated in color that is made for taking pictures with the background of the sea and the charm under the amazing bridge. Around Galala Beach, there is a soccer field that can be an attraction for young people and parents to do sports, and also the Galala Smoked Fish Souvenir Center. Wayame Beach offers a beautiful panorama at night, the sparkling lights of Ambon City, and fresh air blown by a gentle breeze. Wayame Beach is 25 kilometers from the center of Ambon City, with a travel time of about 30 minutes (Salampessy and Kaisupy 2020). The coast of Wayame Village has beautiful sea potential and can be a marine tourism destination, presented with stunning and calming coastal views because it is surrounded by many coconut trees and various other types of plants. In addition, the bright blue seawater adds to the appeal of the beauty of Wayame Marine Park.

However, if it is associated with supporting factors, including DO quality, temperature, pH, and salinity according to this study, the three locations must be improved and carry out real mitigation activities to become ecotourism areas. Seeing the reality that occurs visually, there is still a lot of plastic waste found and also contaminated oil on the beach, which can be said to be polluted because it does not comply with optimal standards. Furthermore, if we pay attention to changes in the coastline over close to 4 years, this can be a useful guide and information for implementing coastal water protection measures to support the sustainability of coastal ecosystems.

CONCLUSION

Based on the results of DO and salinity measurements, the three beach locations are classified as polluted. The study using Sentinel-2 imagery showed significant changes in the coastline at Galala Village Beach, Passo Village Beach, and Wayame Village Beach from 2018 to 2022. This is due to dynamics such as erosion, sedimentation, and climate change, as well as human activities such as infrastructure development (bridges, offices, hospitals, and industry), settlements, and land clearing at the 3 research locations that occurred within 4 years. The inventory

can be a reference for the government and community in understanding conditions, carrying out development, and proper coastal management to become ecotourism areas.

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