The Socioeconomic Effect of Changes in Coastal Areas: A Case Study of Coastal Areas in Surabaya

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Abstrak

Selama beberapa tahun terakhir pemantauan dengan citra satelit menunjukkan kondisi garis pantai Surabaya mengalami perubahan signifikan, hal ini dikarenakan fenomena erosi, akresi dan antropogenik. Fenomena tersebut dapat menjadi ancaman terhadap lingkungan pantai Surabaya dimana masyarakat pesisir (nelayan) bergantung langsung terhadap hasil pantai dan tambak. Penelitian ini bertujuan untuk mengetahui adanya dampak sosial ekonomi akibat perubahan tutupan lahan khususnya area tambak. Metode yang dilakukan adalah penginderaan jauh dengan analisis metode maximum likelihood dan metode statistik deskriptif. Hasil penelitian menunjukkan bahwa pada tahun 2011-2017, area tambak mengalami penurunan sebesar 8,66 km^2 .Berkurangnya area tambak dan jumlah produksi ikan tambak (air tawar), tidak memberikan dampak signifikan terhadap nilai Produk Domestik Regional Bruto (PDRB) kategori A. Hal ini dikarenakan produksi ikan tidak hanya berasal dari tambak (air tawar) tetapi juga dari produksi ikan laut. Nilai PDRB kota Surabaya selama 3 tahun terakhir mengalami naik turun dikarenakan dampak pandemi COVID 19. Namun pada tahun 2021, nilai PDRB kota Surabaya mulai menunjukkan dampak positif. Perlu adanya pendampingan dari pemerintah terhadap nelayan tambak dan aturan pengelolaan kawasan pesisir. Diharapkan kawasan tambak dapat secara optimal memproduksi ikan air tawar dengan tujuan memberikan tambahan nilai lebih terhadap PDRB kota Surabaya kedepannya.

Kata kunci: *Citra Satelit, Penginderaan Jauh, Pesisir Surabaya, Produk Domestik Regional Bruto (PDRB), Tambak.*

Abstract

Over the last few years, satellite imaging data shows that the condition of coastal lines in Surabaya has significantly changed. Several factors can contribute to this issue, such as erosion, accretion, and anthropogenic phenomena. These factors are a threat to the environment of Surabaya because many coastal communities (fishermen) are relying on beach and pond products. This research aims to better understand the socioeconomic effect of changes in land cover, especially in pond areas. To collect data, the research used remote sensing tools. The data were then analyzed using maximum likelihood and descriptive statistics methods. Results indicated that between 2011 – 2017, the pond areas declined by 8.66 km^2. However, the decline of the pond areas and pond fish quantities (freshwater fish) does not have a significant impact on the value of the Gross Regional Domestic Product (GRDP) category A. One of the reasons is that fish production is not only taken from the pond (freshwater) but also from the sea. The value of Surabaya's GRDP in the last three years is volatile due to the Covid-19 outbreak. However, in 2021, the GRDP has shown an increase. The government should play their roles by providing assistance to pond fishermen and regulating the management of coastal areas. Hopefully, pond areas can increase freshwater production in order to give an additional contribution to the GRDP of Surabaya.

Keywords: *Satellite images, Remote sensing, Surabaya coastal areas, Gross Regional Domestic Product (GRDP), Pond*

1. INTRODUCTION

Coastal areas refer to land and water areas affected by biological and physical processes of sea waters and land. Generally, they are used for natural resource management purposes. Thus, the delineation of this coastal area can differ depending on administrative, ecological, and planning aspects. [11]

The biological resources of coastal waters are units of life (living organisms) that are interconnected and interact with their non-living (physical) environment. This connection then creates a system, known as the ecosystem of coastal and marine areas. Some of the main ecosystems in the coastal areas have the following characteristics [17], such as:

- containing habitats and ecosystems, such as estuaries, coral reefs, and seagrass beds that provide goods (such as fish, minerals, and petroleum) and services (such as natural protection from storms and tidal waves, recreation areas) for coastal communities,
- marked by competition of space and resource management by many stakeholders. This competition often creates conflicts and damages towards functional integrity of resource systems,
- is considered the economic backbone of coastal countries where the majority of Gross National Product (GNP) depends on activities such as shipping, oil and gas mining, beach tourism, and the like,

- usually has a dense population and become a preferred destination for urbanization

The coastal areas of Surabaya have a mangrove forest ecosystem. They are located in Pamurbaya (Surabaya East Coast) and Panturbaya (Surabaya North Coast). Pamurbaya covers 916,743 hectares or approximately 82.68% of the total estimated mangrove forest in Surabaya City [13]. Based on the Surabaya City Spatial and Regional Plan Number 12 of 2014 [25], Pamurbaya is decided as a protected area. Unfortunately, this area is one of the areas indicated to be damaged in Indonesia. Damage to the mangrove ecosystem continues to occur in Pamurbaya as a result of changes in land use, for example, housing and apartment constructed by property developers [3].

Pamurbaya has mangrove tourism and economic diversification, such as syrup raw materials, food ingredients, and medicines. In addition, the local community promoted Wonorejo mangrove ecotourism by providing boat ecotourism, fishing grounds, and monitoring posts [1]. The designation of the Wonorejo mangrove ecotourism as a strategic area is based on four aspects, such as economic aspects, functions and carrying capacity of the environment, socio-culture, and high technology [24]. In other words, the formulated policy shows that the development of mangrove tourism is directed to increase tourist attractiveness and local community income while keeping the mangrove forests intact.

Surabaya's land cover has changed in the last 24 years due to population growth. Thus, some areas of the land have been converted. Besides mangrove forests, ponds and urban areas become a factor that causes area changes in Surabaya's coastal area. The land cover in pond areas tends to decline from 45,4626 km^2 in 1994 to 39,0924 km^2 in 2018 [28]. The decline is caused by land conversion in the coastal areas. It also affects the livelihood of the people who live there. People who worked as shrimp farmer in the past has now changed to become tourism service providers in the mangrove forest. Ponds that are not very productive are left alone by the fishermen.

As a coastal city, fish production should become one of the main sources of income for Surabaya. The decline of fish production is one factor that makes the fish should be imported from the neighboring city. Moreover, many fishermen do not have enough capital to sail; to buy fuel and a charter boat. In addition, the fishermen need assistance and financial support from the government (for example loans) [27].

For that reason, Surabaya's coastal areas have socioeconomic effects on the surrounding community. People who live in the ecotourism areas, mangrove forest become their main source of income (for example in Wonorejo mangrove forest). This economical advantage can be obtained as many tourists visit this destination, especially during the weekend. The local people can earn additional income, for example, by providing boat services at the entrance gate and running small stalls along the coast [21]. In addition, ponds that are no longer productive are allowed to dry up and then converted into fishing tourism areas. This provides additional economic value for coastal communities.

With changes in land cover that have an impact on the socio-economic life of coastal communities, monitoring land cover in coastal areas is very important for environmental sustainability, including in mangrove areas and ponds in Surabaya. To date, plenty of research has proven the significance of monitoring and mapping mangrove forest ecosystems through remote sensing [12; 16; 18; 19; 29; 31]. Remote sensing can support the analysis of large areas with high accuracy and low cost compared to conventional methods without having to go directly to the area [20; 22]. With this technique, data collection is performed using imagery, one of which is satellite imagery. Remote sensing can be used to monitor mangrove vegetation on two important properties, for example, green leaf substance (chlorophyll) and where it grows in coastal areas [30]. This tool also supports the monitoring of pond areas which have a reflectance value that is almost the same as mangrove forests.

Remote sensing is one of the alternatives to determine coastal lines and temporary changes in land cover. Using satellite imagery for monitoring land cover and changes in coastal lines is highly suggested because data collected through satellite-based remote sensing provides a more dynamic result. In addition, this technique has a time that is close to real-time compared to data collected through observation. In short, remote sensing provides a more efficient analysis of land cover and coastal line changes [26].

Based on the above explanation, this research aims to identify the results of monitoring the land that causes changes in coastal areas and affects the socio-economic life of people there. With this monitoring, data about the land cover are obtained and linked to several effects, for instance, the amount of fish catch, the number of fishermen, and the value of the Gross Regional Domestic Product (GRDP) of Surabaya City. The results of this research can serve as a basis for the local government and stakeholders to formulate better policies on coastal area management in Surabaya. In addition, the government of Surabaya must identify areas that experience an extreme change in land cover (accretion or erosion/abrasion).

2. RESEARCH METHODOLOGY

In 2021, Safitri conducted research on changes in land cover in Surabaya coastal areas. She used data on land cover changes that occurred in 1994, 2003, and 2017. The current research attempts to enrich her data by incorporating additional data from Landsat satellite imager in 2011, 2012, 2013, 2014, 2015, 2016, and 2017. The data satellite imagery using the maximum likelihood analysis method with ENVI 5.0 software (Exelis Visual Information Solutions). Furthermore, the number of areas of land cover change for each class is calculated each year using ArcGIS 10.8 software. (Safitri et al, 2021) [28]. The analysis produced the value of changes in each class every year. After obtaining land cover data, socio-economic analysis was carried out using statistical data from Statistics Indonesia between 2011-2017 (descriptive statistical method). The research focused on the socioeconomic effect of land cover

changes in pond areas, such as the amount freshwater fish catch, the number of fishermen, and the value of the GRDP of Surabaya City.

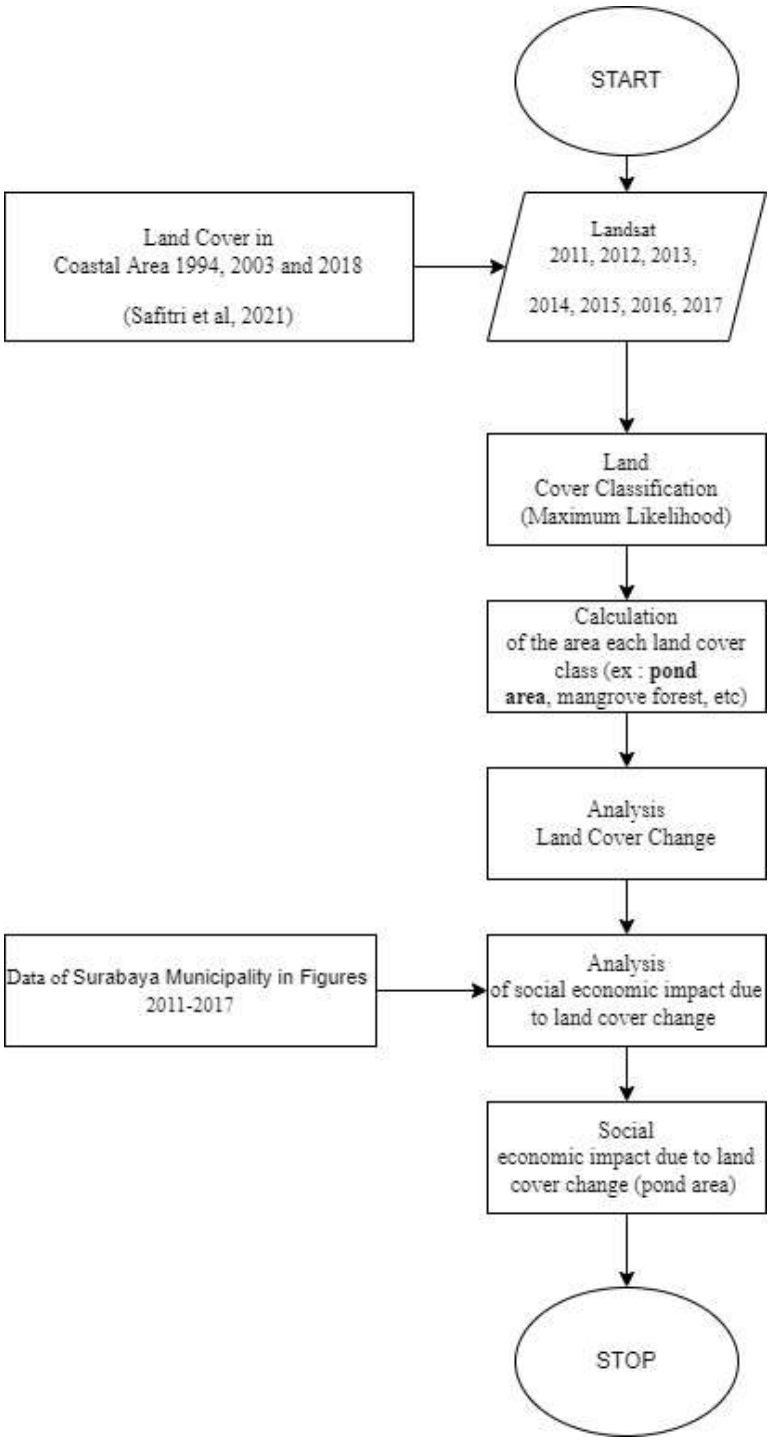


Figure 1. Research Flow Chart
(Source: processed by researchers)

3. FINDINGS AND DISCUSSION

The Conditions of Land Cover in Surabaya's Coastal Areas

The land cover in Surabaya's coastal areas has drastically changed over the last two decades. Safitri et al., (2021) [28] mention that in the last 24 years, the changes in land cover were caused by various factors, one of which was the economic factor. Surabaya is a destination for finding jobs for people who live outside the city. Therefore, the migration from village to city is inevitable and makes the demand for permanent housing in the coastal areas of Surabaya increase, for example in Kelurahan Keputih and Wonorejo. As a result, the areas that were initially vegetation and ponds changed to urban areas that were intended as housing and office areas. As shown in Table 1, the urban areas have increased by 2.88 km^2 in the last 24 years. This increase then causes the decline of vegetation and pond areas.

Table1. Land Cover Changes in Surabaya's Coastal Areas

Class	1994 (km^2)	2003 (km^2)	2018 (km^2)	The change over 24 years (1994 – 2018) (km2)
Urban area	28.6038 (31%)	25.8939 (27%)	31.4892 (31%)	2.8854
Vegetation	11.9304 (13%)	10.4166 (11%)	5.2182 (5%)	-6.7122
Mangrove	4.5621 (5%)	7.398 (7%)	8.6301 (8%)	4.068
Pond	45.4626 (49%)	49.6476 (51%)	39.0924 (38%)	-6.3702
Bare land	1.5588 (1%)	1.9503 (2%)	9.3492 (9%)	7.7904
Water Bodies	0.7326 (1%)	2.0358 (2%)	8.6454 (9%)	7.9128

Sources : Safitri et al (2021) [28]

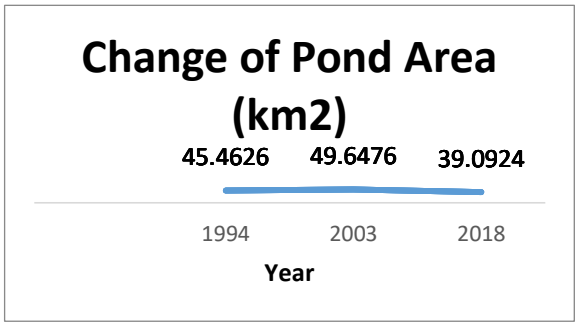


Figure 2. The trend of Pond Area Changes

To see the annual changes in pond areas, observations were carried out from 2011 to 2017. Table 2 shows that, during the period, the trend of pond area changes in Surabaya has increased and decreased. However, in 2017, the pond area decreased significantly compared to 2011. The changes in land cover classes are associated with land function conversion, from ponds to mangroves or new housing. The number of ponds in East Surabaya, for example in Kelurahan Dukuh Suterojo, Kalisari, Keputih, Wonorejo, Medokan Ayu, and Gunung Anyar. Based on the Landsat images, the classes of ponds, mangroves, vegetation, and water bodies are located next to each

other and have almost the same reflectance values. Hence, the classification process is sometimes difficult

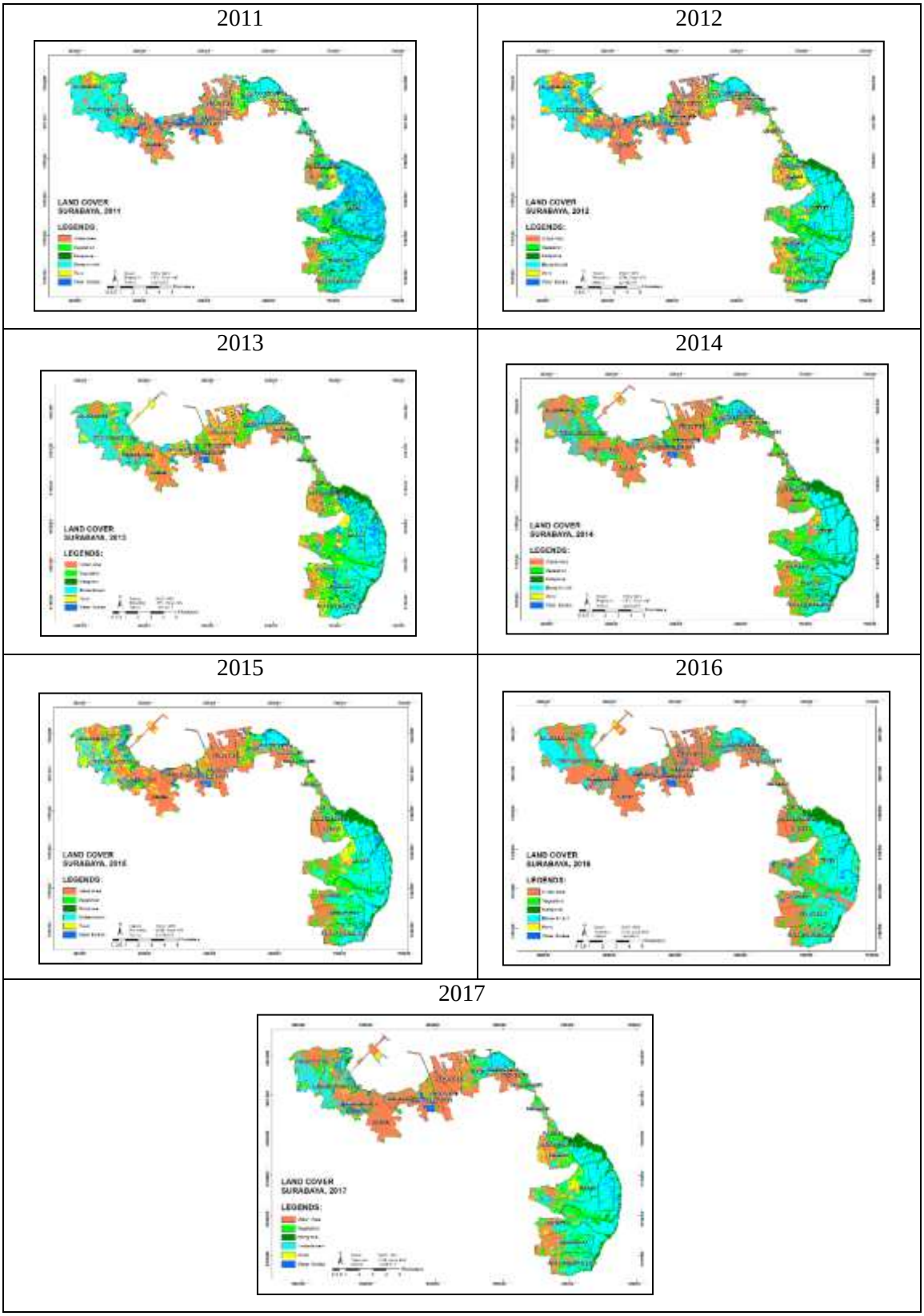


Figure 3. Land Cover of Coastal Areas in Surabaya between 2011-2017
(Source: Processed by Researchers)

Because the number of ponds was declining, the production of pond fish in Surabaya also decreased. From 2011 – 2017, for example, the number of fishermen decreased by 85 people. Similarly, the fish production from the ponds also decreased by 1125.16 tons. So far, the fish ponds were managed traditionally. The fishermen had inadequate skills to cultivate pond fish. Additionally, other problems include the lack of stock of fish seeds, and the high cost of various pond equipment to support pond production management. These problems eventually make the utilization of pond areas decrease. These things also make many fish ponds have their functions changed. For example, fishermen prefer to change the function of fish ponds to become fishing ponds or salt ponds to earn extra money rather than having the ponds not generate any money at all.

Table 2. Socioeconomic Relationship with Pond Areas in Surabaya

Year	The total area of ponds in the coastal area (km^2)	The number of Pond Fishermen	Total Fish Production (ton)
2011	38,6289	2.351	7923.84
2012	30,1842	2.276	7593.18
2013	28,9224	2.293	6906.10
2014	24,4008	2.029	6542.09
2015	26,9631	2.017	6785.15
2016	27,8505	2.266	6915.03
2017	29,9646	2.266	6798.68
Total of Changes 2011-2017	8,6643	85	1125.16

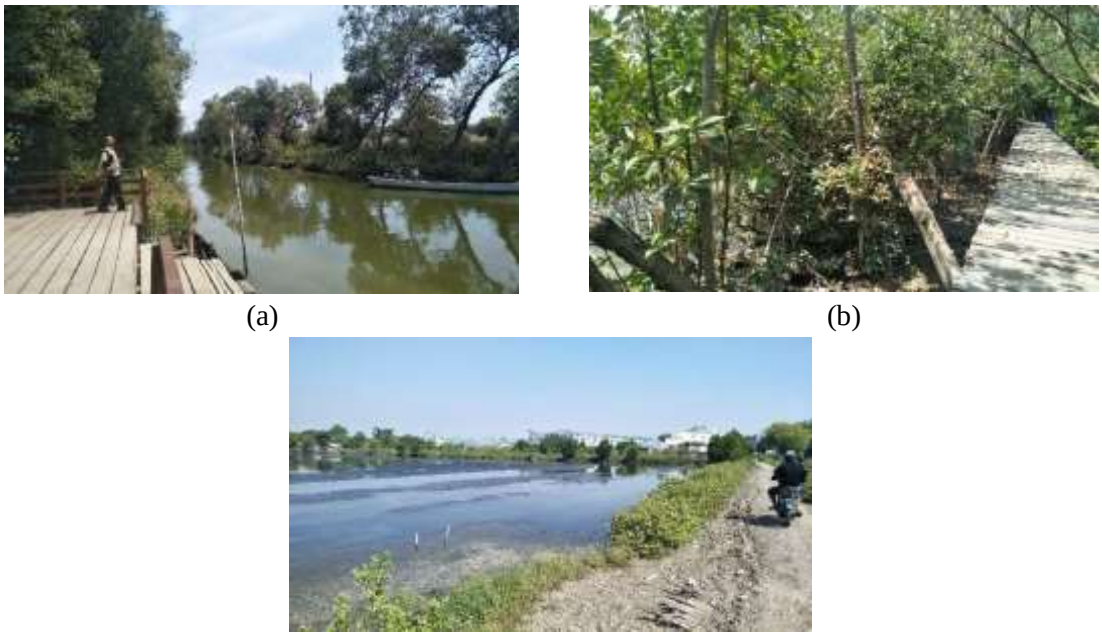
(Sources: Processed by Researchers and Statistics Indonesia of East Java and Surabaya City [4;5;6;7; 8; 9])

The Conditions of Mangrove Forest and Ponds in Surabaya's Coastal Areas

Based on Regional Regulation no. 12 of 2014 concerning Regional Spatial Planning, mangrove areas on the East Coast of Surabaya (Pamurbaya) are put in the development unit areas III and IV. Marine area development unit III belongs to marine areas which are in the waters of the northeastern part of the city, around the Tambak Wedi and Kenjeran areas in the Kenjeran and Bulak Districts. The main function of marine area development unit III includes promoting marine tourism, developing the management of natural and non-natural development, fishing, and aquaculture areas, and providing the flows of fishing boats. Meanwhile, marine area development IV refers to marine areas in the waters of the eastern part of the city, around the east coast in Mulyorejo District, Sukolilo, Rungkut, and Gunung Anyar Districts. The main functions of this marine areas IV cover the protection and rehabilitation of the marine environment, the establishment of natural tourism, and as a place for fishing and cultivation.

Meanwhile, the mangrove areas on the North Coast of Surabaya (Panturbaya) include Area Development Units I and II. Unit I can be defined as marine areas which

are in the waters of the Northern Part of the city, in the Lamong Bay area in the Benowo District, Tandes District, and Asemrowo District. This unit is mainly responsible for developing ports and large shipping lanes. Further, the development unit of marine areas II is the areas which are located in the waters of the Northern Part of the city, in the Tanjung Perak Port area in Krembangan District, Cantian Customs District, Semampir District, and Kenjeran District. The main responsibility of this unit is to ensure ports and crossing transportation, naval defense and security bases, the shipping industry, and large vessel lanes [12].



(a) (b)

(c)

Figure 4 (a) Boat tourism destination in the mangrove forest in Kelurahan Gunung Anyar.
(b) Jogging track in the mangrove forest di Kelurahan Wonorejo;
(c) The condition of ponds in Kelurahan Keputih
(Source: Personal documentation, 2019 and 2020)

Mangrove areas on the East Coast of Surabaya (Pamurbaya) and the North Coast of Surabaya (Panturbaya) provide socioeconomic effects for the surrounding society. For instance, in Wonorejo, the mangrove forest can be used for ecotourism and economic diversification such as syrup raw materials, food ingredients, and medicines. In addition, the local community creates mangrove ecotourism in an effort to maximize tourism. Some of the forms include boat ecotourism, fauna, and flora monitoring post, a fishing place, and going jogging in the mangrove areas. Other communities, furthermore, used the mangrove forest to express their hobbies.

Human activities (anthropogenic) contribute the largest towards the damage to mangrove forests in Indonesia. The ecosystem of mangrove forests is complex. This sort of forest is filled with vegetation and is also a habitat for a variety of animals and aquatic biota. In addition, it is also dynamic in its ability to grow and develop

continuously and experience succession following changes in its natural habitat. unfortunately, these forests are usually unstable (easily damaged by disturbance and difficult to recover) [2]. Indonesian mangrove forest has been long known as the widest in the world. However, it systematically and gradually decreases as a result of anthropogenic where the average degradation reaches 14% annually [15]. Anthropogenic activities refer to activities such as fishing, planting, farming, cultivating, housing, industry, legal and illegal logging, and mining. This activity greatly contributes to the degradation and loss of mangrove forests in Indonesia. The impacts of this degradation are coastal line abrasion, siltation and the formation of new land (accretion), seawater intrusion, decreased biodiversity, decreased fishing and crab yields, and increased incidence of malaria [14].

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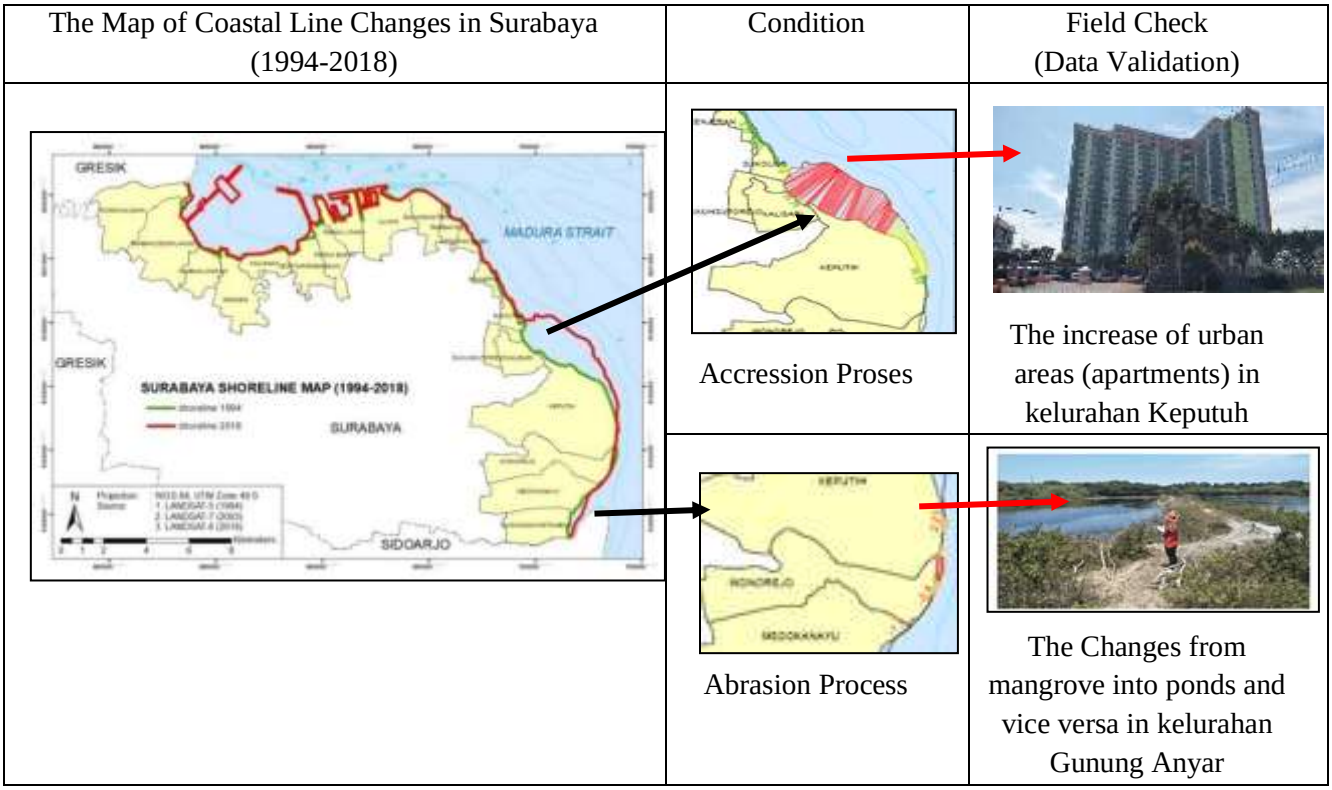

Figure 5. The condition of coastal line changes in Surabaya
(Sources: Processed by researchers and personal documentation)

In this research, mangrove forests grow side by side with ponds and housings along Surabaya's coastline. Surabaya's coastal lines show that the lines have experienced a certain degree of accretion, abrasion/erosion, and anthropogenic. This research noted that the highest erosion occurred in Kelurahan Wonorejo with a value of 141,637.1 m^2. This issue was caused by land conversion between pond areas, mangrove forests, and urban areas [26].

Ponds in Surabaya are still managed traditionally. Such a management system eventually causes several consequences. One of them is the non-optimal quality of the ponds (unproductive). During the dry season, the majority of ponds in Surabaya have

converted to salt ponds. Some of the fishermen believed that instead of making their ponds unproductive, they replaced their ponds with salt ponds or for recreational purposes. This is the best way for these fishermen to survive [27].

The Socioeconomic Condition of Coastal Coast Areas

Based on the statistics data, the total production of pond fish in the last 24 years, is by 1,125.6 tons. The quantity of fish above was similar to the land cover changes that decease to 8.6642 km^2. Another factor that plays a role in the decline of pond fish production is that the function of the fish ponds has changed to salt so the pond was left to dry out due to a lack of capital for pond fishermen for pond fish nurseries. Additionally, Pond fishermen need assistance from the government or other stakeholders to increase pond fish production.

Indonesia's marine wealth can contribute to global fisheries needs, reaching 10%. This fact at the same time shows Indonesia's opportunities as a producer of marine products not only to meet local needs but also internationally [23]. The production of marine and freshwater products is shown in the value of Surabaya's Gross Regional Domestic Product (GRDP) in category A. The category includes the agricultural, forestry, and fisheries sectors. Processed fishery products are not only in the form of raw materials but also other processed products such as frozen fish, smoking, and others.

In 2020, the economy of Surabaya City decreased by 4.85%. The impact of the COVID-19 pandemic dragged down global economic growth. The growth contraction for category A was 4.90% [10]. The GRDP value for 2019, which amounted to 580.49 trillion rupiah, decreased in 2020 due to the impact of the COVID-19 pandemic. However, in 2021 the economy of Surabaya will start to recover with a value of 590.228 trillion rupiahs.

The pond areas and fish production that were volatile during 1994 – 2018 make the value of GRDP in Category A up and down. Between 1994 – 2018, the value was billions of rupiah, while in 2019 – 2021 its worth was trillions of rupiahs. This is a positive increase in category A. This is then confirmed by the GRDP value of category A which decreased in 2020 but has increased again by 0.02 trillion rupiahs in 2021. This is a positive increase in category A. This is then confirmed by the GRDP value of category A which decreased in 2020 but has increased again by 0.02 trillion rupiahs in 2021.

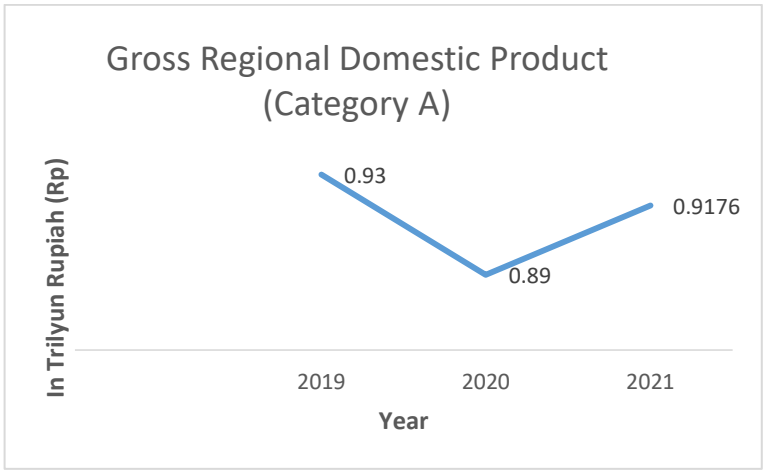

Figure 6. A linear trend Of Gross Regional Domestic Products (GRDP) Category A (Sources: Statistics Surabaya City, 2022)

4. CONCLUSION

Monitoring coastal areas using multitemporal satellite imagery is necessary to observe the changes in coastal lines and land cover in the coastal areas of Surabaya. The phenomena of erosion and accretion in coastal areas are due to changes in the function of land cover, for example from mangrove forests to ponds or permanent housing, and vice versa. One of the coastal areas that should be paid attention to by Surabaya's government is the mangrove forest and pond areas in Kelurahan Keputih and Gunung Anyar (East Surabaya). Landsat satellite imagery data from 2011 to 2017 shows the trend of changes in pond area in Surabaya which has fluctuated. From 2011-2017, there appeared to be a decreasing trend in the pond area, although in 2018 it increased again. Therefore, the change in pond area from 2011 to 2018 was 0.4635 km2. The reduction in the pond area and pond fish production has not had a significant impact on category A Gross Regional Domestic Product (GRDP) over the last 20 years. This is because fish production does not only come from ponds (freshwater) but also from marine fish production. In addition, category A is supported by other factors such as forestry and agricultural products.

For further research, it is necessary to monitor changes in land cover using high-resolution satellite imagery, for example, Sentinel imagery and interviews with coastal communities regarding the condition of mangrove forests and ponds on their socio-economic conditions. The government needs to monitor coastal areas to manage this area better. One of the reasons for the reduced production of pond fish (freshwater) apart from the reduced pond area is due to the lack of assistance from the government and related stakeholders. In fact, the fishermen really need guidance and assistance, such as education about managing traditional pond areas and managing fish production and marketing. In addition, there is a need for policies or regulations regarding changes in land cover in coastal areas (for example related to regional regulations). It is hoped that with the assistance and regulations for the management of coastal areas, the pond

area can optimally produce freshwater fish and provide additional GRDP value for Surabaya in the future.

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