Sriwijaya Journal of Environment
Article
ojs.pps.unsri.ac.id

Coastal Development Implications to Changes of Coastal Typology in Denpasar City Environment

Dewa Made Atmaja[123*], I Made Gunamantha[1], Ida Bagus Arya Yoga Bharata[4]

[1] *Lecturer in Master of Environment Management Study Program, Postgraduate Program, Universitas Pendidikan Ganesha, Jl. Udayana No.11, Banjar Tegal, Singaraja, Bali 81116*
[2] *Remote Sensing Engineering Technology Study Program, Geography Department, Faculty of Law and Social Science, Universitas Pendidikan Ganesha, Jl. Udayana No.11, Banjar Tegal, Singaraja, Bali 81116*
[3] *Geography Study Program, Geography Department, Faculty of Law and Social Science, Universitas Pendidikan Ganesha, Jl. Udayana No.11, Banjar Tegal, Singaraja, Bali 81116*
[4] *Postgraduate Student in Master of Environment Management Study Program, Postgraduate Program, Universitas Pendidikan Ganesha, Jl. Udayana No.11, Banjar Tegal, Singaraja, Bali 81116*
**Corresponding Author: atmajadewamade@yahoo.com*

Article history

Received	Received in revised form	Accepted	Available online
06 September 2024	05 February 2025	12 February 2025	08 February 2025

Abstract: The physical development can change natural landscape units, and none other than that is the coastal typology in the coastal area of Denpasar City, which has a high development intensity. This research aims to describe the implications of coastal development on changes in coastal typology in Denpasar City. The method in this research design is quantitative descriptive using QGIS tools for analysis and Landsat satellite image data available on Google Earth Pro for the period December 1990, 2005, and 2020 that delineate. The results of the research show that development implications for changes in coastal typology that occur in the coastal area of Denpasar City include the addition or widening of the coastline for the anthropogenic coast coastal typology for the 1990-2005 period, which was ±21.12 km long and in the 2005-2020 period it was increased to ±2 km long. The widening of the coastline in the marine deposition coast typology experienced an increase of ±1.7 km in the 1990-2005 period. Changes due to development implications during the 1990-2005 period also included the loss of the marine deposition coast typology along ± 10.61 km. In the same period, ± 1.66 km along the coastal typology of build-by organisms disappeared. Residential settlements on Serangan Island, including the anthropogenic coast typology, also disappeared for ± 1.18 km during this period.
Keywords: development, implication, changes, coastal typology

1. Introduction

Bali Province is one of the regions that generates the most significant state income for the tourism sector [1]. It has coastal areas that are popular among domestic and foreign tourists [2]. Bali Province has been the centre of attention in tourism development, and tourism has even become a mainstay sector in Indonesia [3]. Even though the 10 New Balis have been established and are being developed by the Indonesian Ministry of Tourism and Creative Economy, the development of tourism accommodation and infrastructure in Bali continues to experience physical development, such as increasing the number of hotels and tourism accommodation and large infrastructure projects in coastal areas. The projects were the Bali Cultural Center (PKB) in Klungkung Regency [4], the Bali Maritime Tourism Hub (BMTH) [5], and Sanur Harbor [6]. On the other hand, Bali also has a track record of stalled projects, such as several hotels close to the beach in South Kuta District, the Reclamation of Serangan Island, which has never been completed, as well as contradictory projects by the Balinese people such as the Reclamation of Benoa Bay by PT Tirta Wahana Bali Internasional (TWBI) [7].

The construction of tourist accommodations and arrangements in coastal areas will undoubtedly impact changes in the natural landscape. This change in the natural landscape is also a serious concern in the regulations contained and mandated in Law No. 32 of 2009 concerning Environmental Protection and Management. New areas, such as the western part of Badung Regency, also show decreased environmental carrying capacity and ecosystem services [8]. The publication of the criticism made by Walhi Bali as one of the Bali Province Environment Impact Assessment (EIA) commission teams in various EIA public consultations stated that in the 2023-2024 period, there were at least six tourism support projects in Bali which were deemed not to comply with the rules and worsen Bali's already deficit environmental conditions. The issues are food deficit [9], unsustainable water reserves [10], seawater intrusion and high groundwater exploitation in some of the coastal areas and parts of Bali [11]. Some of the developments revealed in the

Bali Province EIA Commission include Sangsit Integrated Port Development [12], Vasa Ubud Hotel [13], Holiday Inn Resort Canggu Bali Hotel [14], Magnum Hotel Residence Sanur [15], Hotel N2S Lot 5 [16] and two projects in the Bali Beach Conservation Project Phase-II program to maintain tourist beaches affected by abrasion through the Sand Stockpile project in protected forest areas facing the sea [17] and Sand Sources for Nourishment which threaten water conservation areas and wildlife pathways, namely sea turtles, among the main goals for conservation [18]. Problems range from non-compliance with the applicable spatial plan, violations due to construction being carried out to marketing before an environmental permit, being in a disaster-prone area, to the potential impact on the carrying capacity and capacity of the environment. One of the areas with massive tourism development in coastal areas in Bali Province is Denpasar City [19].

Based on initial observations, the existence of many tourist accommodations and coastal protection structures such as Sanur Beach, such as embankments and breakwaters, former reclamation and dredging piles on Mertasari Beach, and the reclamation of Serangan Island, proves that the coast of Denpasar City has experienced massive changes due to coastal development that has occurred for a long time. Several studies have also discussed the problem of erosion on beaches and coastal areas in Denpasar City, which confirms that intensive development, such as the reclamation of Serangan Island, has had this impact [20-21]. One way to identify the implications of coastal development that can be reviewed by identifying changes in coastal landscapes is by identifying coastal typologies.

From the research that has been carried out, coastal typology is a landscape ecological unit or a geomorphological unit of land [22-24], which is caused by the identification of coastal typology, primarily based on Shepard (1972) [22-31], refers to geomorphological approaches. Aspects such as morphology and morphogenesis are the main guidelines in identifying coastal typology for a land unit or analysis unit on the earth's surface [23,25]. Previous research revealed that anthropogenic factors can significantly change coastal typology even within land units [24]. In general, many studies conducted in the coastal areas of Denpasar City are related to disasters [32-34] and tourism [35-37]. Several studies have also revealed lead (Pb) contamination in sediments around the coast of Denpasar City, Sanur [38]. Based on that problem, this research aims to describe the implications of coastal development for changes in coastal typology in Denpasar City.

2. Material and Methods

2.1. Materials

The research was conducted in the coastal area of Denpasar City, Bali Province. It is due to indications of massive coastal development along the coastal area of Denpasar City. Materials for the research include a Laptop device, which in this research uses ASUS TUF Gaming F15 intel core i5 for running geographic information system (GIS) software such as Google Earth Pro and QGIS Desktop version 3.34.5 prizren, microsoft excel to sum the total of the data that has been collected, and Alpine Quest Pro for ground check of location sample of data collection.

2.2. Methods

The research carried out is descriptive research, with an effort to explain or describe the implications of coastal development for changes in coastal typology. This research itself is a case study based on massive tourism development in coastal areas of Denpasar City, which has the impact of changes in the coastline and potential changes in coastal typology on the coastline of Denpasar City.

2.3. Data collections

The data was mainly collected utilizing visual interpretation and digitization of Landsat satellite image data in the Google Earth Pro application at three different times, namely 1990, 2005, and 2020, all of which are in the 12th month (December), and secondary data through literature studies taken from reference articles in scientific journals, proceedings, as well as government agency and NGO report documents. Landsat image data available on Google Earth Pro is fast in the data acquisition process and sufficient to identify changes in coastlines and coastal typology at a medium data scale amid massive tourism development in Bali. As for the characteristics of the data, the Landsat imagery available on Google Earth Pro itself is a mosaic of various Landsat ETM images with a resolution of 15 meters, but in the acquisition process, it can indeed provide changes in the spatial resolution and scale of the resulting pixels, especially when zooming in and zooming out via Google Earth Pro [39].

The Landsat image obtained from Google Earth [40] is then processed through georeferencing via the image overlay tool feature and saved as KMZ because the data is raster data or images that will be entered into QGIS for interpretation and delineation.

Coastal typology classification refers to Shepard 1972 [22-31], in which coastal typology data collection was carried out with the help of Landsat remote sensing imagery available on Google Earth Pro. Coastal typology delineation refers to the delineation of coastlines as in research [23] because research focuses on coastline changes. Because human factors will

dominate it, the anthropogenic coast typology classification referred to [22] also guides research.

2.4. Data Analysis

The data was analyzed with the help of a geographic information system (GIS) tool, namely QGIS, and three approaches were used. The approaches used in dissecting and analyzing research results are a spatial approach visualized with maps by delineation of the satellite imagery of Landsat and map layouts, a geomorphological approach to determine the process of changing coastal typology and an environmental approach to determine the implications of coastal development as human interaction with changes in coastal typology as an environment in Denpasar City. The flowchart of the research can be seen in Figure 1.

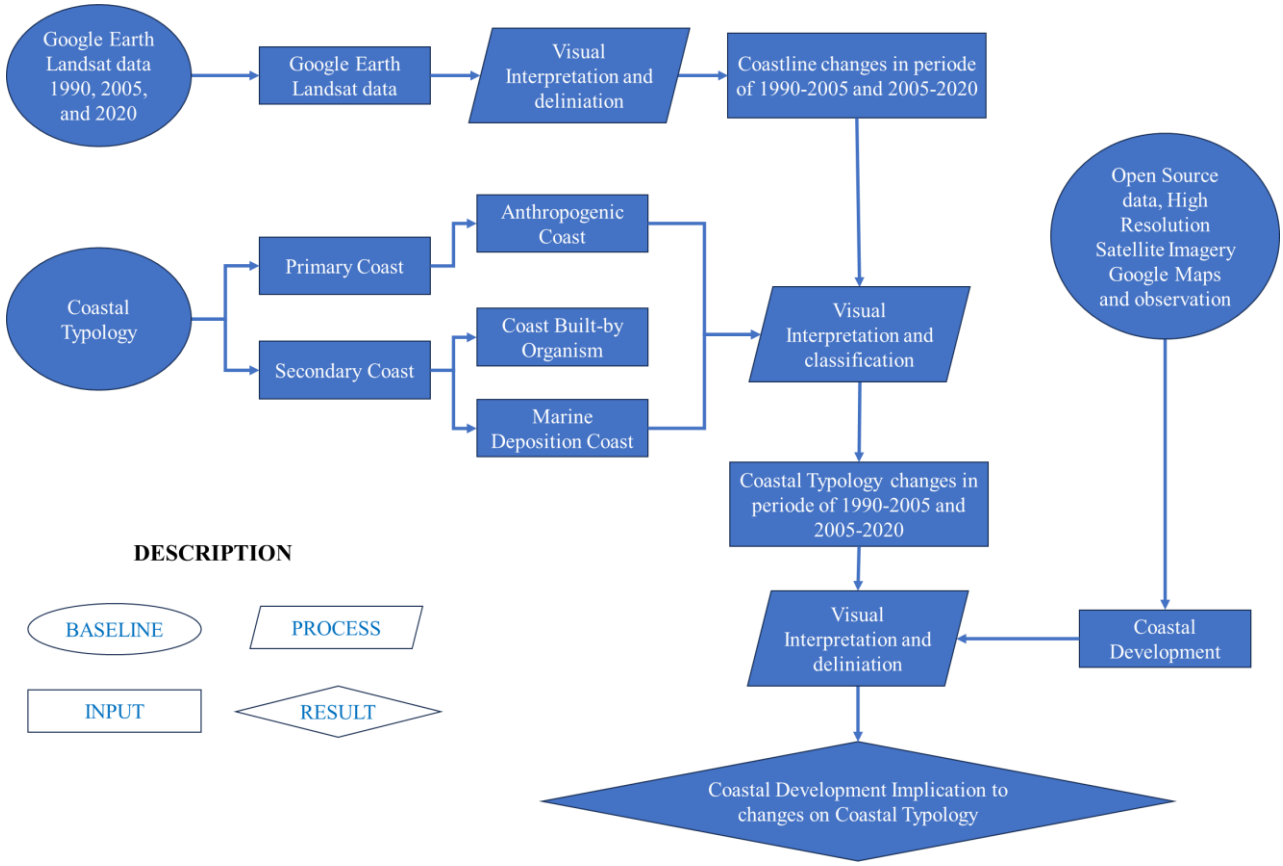

Figure 1. Research flowchart

3. Results and Discussion

3.1 Changes in Coastal Typology on the Coast of Denpasar City

The delineation from the research results shows that the delineated coastline experienced changes in the 1990-2005 and 2005-2020 periods. Based on research results, there are at least three coastal typologies in Denpasar City's coastal area: anthropogenic coast, coast build-by organism, and marine deposition coast. Human factors cause an anthropogenic coast in engineering the coast, especially coastlines [41]. Anthropogenic coasts also have immediate consequences and influence the coast as a coastal dynamic factor [23]. In the research results, the anthropogenic coast commonly found in research on the coastline of the coastal area of Denpasar City is reclamation, and some are residential. Generally, the coasts built by organisms found in Denpasar City are mangrove forests located south of the city and between the mainland and Serangan Island. Marine deposition coast as a coastal typology caused by the activity of hydrodynamic factors that cause sediment to settle due to coastal currents [23] dominates the eastern part of Denpasar City because it faces the open sea and the main body of water, namely the Badung Strait, which is also to the south of the Indian Ocean. However, due to existing coral reefs, the waves approaching some marine deposition coast typology locations are not very large even though erosion still occurs [20,21,42]. The research result of 3.1 Changes in Coastal Typology on the Coast of Denpasar City can be shown in detail in Table 1, and development changes in the coastal typology can be shown in Figure 2.

Table 1. Total of Coastlines length Changes of Coastal Typology in Denpasar City Coastal Area in the periods of 1990, 2005, and 2020.

No	Coastal Typology	1990	2005	2020
1	*anthropogenic coast*	±9.01 Km	±26.42 Km	±26.40 Km
2	*coast build-by organism*	±10.61 Km	±6.79 Km	±10.37 Km
3	*marine deposition coast*	±10.33 Km	±10.88 Km	±9.24 Km

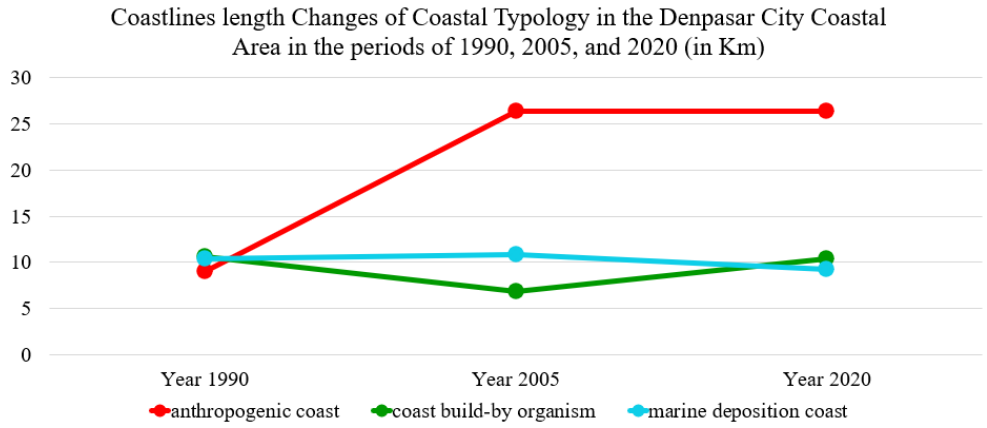

Figure 2. Diagram visualization on the Development of Coastlines length Changes of Coastal Typology in the Denpasar City Coastal Area in the periods of 1990, 2005, and 2020

The research results show that in 1990 the total length of the anthropogenic coast typology in Denpasar City was ±9.01 km. In 2005, it increased to ±26.42 km, of which there was a widening of ±17.41 km. In 2020 itself, the total length of the anthropogenic coast typology reached ±26.40, which means there was a shrinkage of around ±2 km throughout the development period 2005-2020. In the coastal typology of coast build-by organisms in 1990, the total length of the Denpasar City coastline reached ±10.61 km. In 2005 this coastal typology shrank to ±6.79 km. In 2020 itself, there will be widening again to ±10.37 km. The marine deposition coast typology in 1990 had a total length of the Denpasar City coastline reaching 10.33 km. In 2005 there was a slight widening to ±10.88 km. In 2020, the marine deposition coast typology shrank to ±9.24 km. The map (Figure 3) shows the spatial distribution of changes.

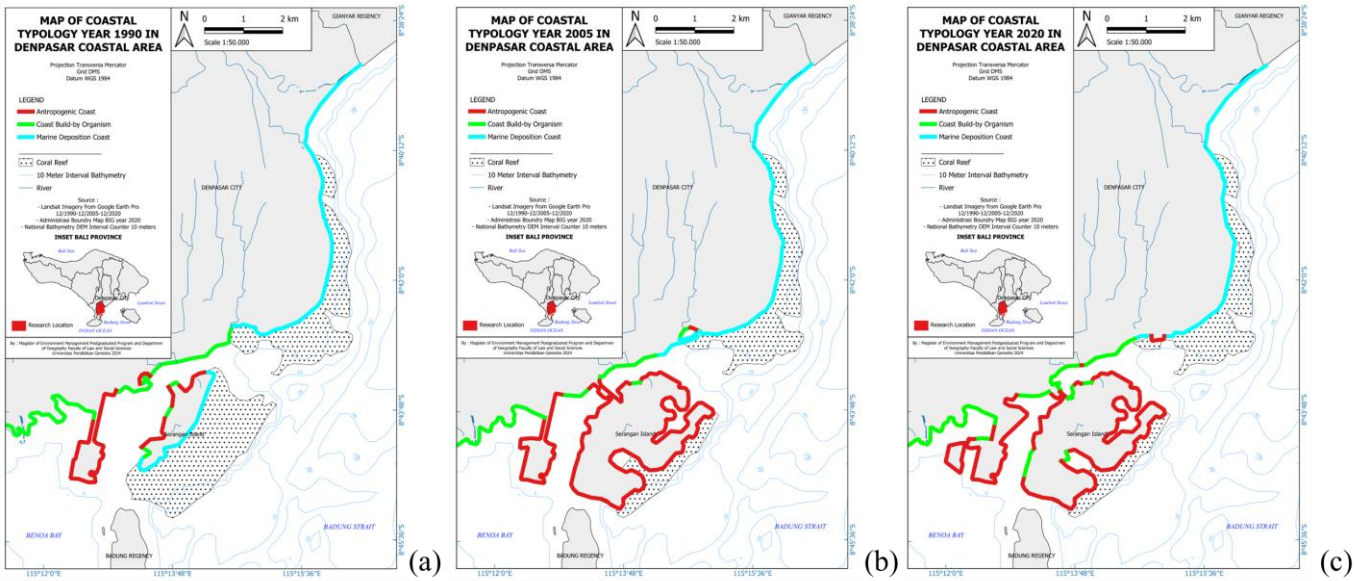

Figure 3. (a) 1990 coastal typology map on the coast of Denpasar City, (b) 2005 coastal typology map on the coast of Denpasar City, (c) 2020 coastal typology map on the coast of Denpasar City

3.2 Coastal Development Implication of the Changes in Coastal Typology on the Coast of Denpasar City

Data from the Central Statistics Agency [43-44] shows that there has been an increase in the number of star hotels in Denpasar City, from initially only 22 in 2000 to 48 in 2023. Apart from that, the number of rooms in non-star hotels and other accommodations has also increased, initially amounting to 3,670 in 2000 to 6,259 in 2019. This track record can also be traced from satellite image data, which shows that the construction of hotels and tourism accommodations is still being carried out on the coast of Denpasar City. It is also important to realize that the accommodation and food and drink provision sector in 2023 will contribute the highest GDP to Denpasar City out of 17 sectors, namely around 19.6% of GDP [45].

Of the various changes that occurred, changes in Serangan Island's coastal typology significantly contributed to the widening of the anthropogenic coast typology in the 1990-2005 period. The island's coast, which has advanced more than ±1 km, has also impacted the shrinking of the coastal coral reefs of Denpasar City. The results of the research show changes in coastal typology at several locations on the coast of Denpasar City, namely Mertasari Beach, erosion that occurred on the east coast of Denpasar City, which includes Sanur Beach, the expansion of Benoa port, the Reclamation of Attack Island, and the presence of the development of Bali Wake Island. This description only focuses on coastal typologies that increase and disappear due to indications from anthropodynamic activities in kilometres (km) of the coastline.

Table 1. Implications of Coastal Development on Changes in Coastal Typology identify that has been identify from visual deliniation

No	Periode Impact	Coastal Typology	Description	Location Description	Implication to Total Length Change (km)
1	1990-2005	*anthropogenic coast*	Increase	Mertasari Beach	±0.25
2	1990-2005	*marine deposition coast*	Increase	Mertasari Beach	±1.7
3	1990-2005	*marine deposition coast*	Loss	Erosion in east coast of Denpasar City	±6.5
4	1990-2005	*coast build-by organism*	Loss	Expansion of Benoa Harbor	±0.1
5	1990-2005	*anthropogenic coast*	Increase	Expansion of Benoa Harbor	±2.41
6	1990-2005	*anthropogenic coast*	Increase	Reclamation of Serangan Island	±18.46
7	1990-2005	*coast build-by organism*	Loss	Reclamation of Serangan Island	±1.65
8	1990-2005	*marine deposition coast*	Loss	Reclamation of Serangan Island	±4.11
9	1990-2005	*anthropogenic coast*	Loss	Reclamation of Serangan Island	±1.18
10	2005-2020	*anthropogenic coast*	Increase	Expansion of Benoa Harbor	±4.27
11	2005-2020	*anthropogenic coast*	Increase	Bali Wake Island	±0.34
12	2005-2020	*anthropogenic coast*	Increase	Mertasari Beach	±0.53

Referring map of coastal typology changes in Figure 2 and Table 2 we can see that implications of coastal development on changes in Coastal Typology. During the 1990-2005 period, the anthropogenic coast increased by ±21.12 km, mainly due to the reclamation of Serangan Island. Before reclamation, the coastline was only ± 2.67 km long in 1990. The expansion of Benoa Harbor also contributes and implicates the development changes to ±2.31 Km (-0,1 Km). Before the expansion, the coastline was only ± 0.57 km long in 1990.

In the 2005-2020 period, it was an increase of ±5.14 km. The widening of the coastline in the marine deposition coast typology experienced an increase of ±1.7 km in the 1990-2005 period. The development implications that occurred during the 1990-2005 period were the loss of the marine deposition coast typology along ± 10.61 km. Apart from that, in the same period, along ± 1.66 km, the coastal typology of build-by organisms disappeared. The Residential settlements on Serangan Island, which included the anthropogenic coast typology, also disappeared during this period for ± 1.18 km. The data shown in Table 2 is visualized in Map of Figure 4.

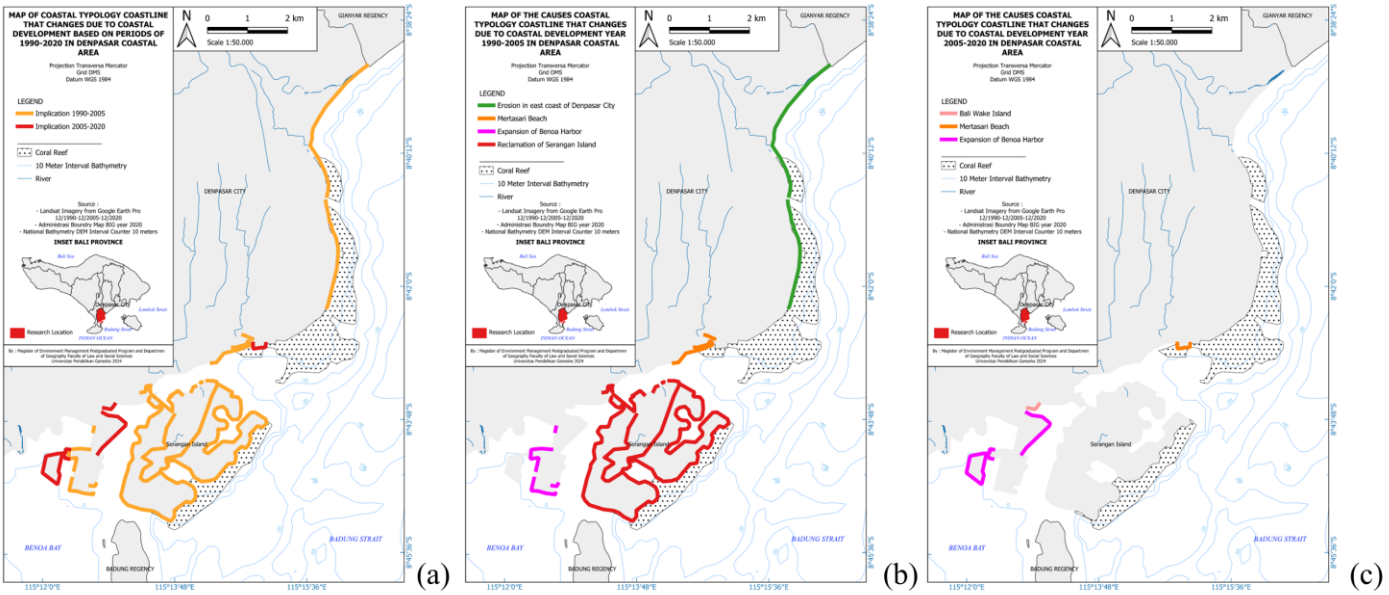

Figure 4. (a) Deliniation result of coastal typology coastline that changes due to coastal development implication based on periods of 1990-2020, (b) Deliniation identification of 1990-2005 the causes coastal typology coastline that changes due to coastal development on the coast of Denpasar City, (c) Deliniation identification of 2020 the causes coastal typology coastline that changes due to coastal development on the coast of Denpasar City.

The development carried out in Denpasar City also impacts the area of coral reefs. Based on the results of delineation on indicative coral reefs, it was found that the area of coral reef appearance in Denpasar City in 1990 was around ±978.46 Ha. However, in 2005, it decreased to ±534.67 Ha due to the reclamation of Serangan Island. From 1990-2005, coral reefs have shrunk by ±443.79 Ha or almost half the area in 1990. Meanwhile, in 2020, coral reefs have also experienced shrinkage of ±510.50 Ha or a reduction from the 2005-2020 period of ± 24.17 Ha. This research shows the determination of indicative coral reefs from various data such as the Allen Coral Atlas [46] and other related research [47-48]. Apart from coral reefs, this area also includes other coastal ecosystems, such as seagrass beds, with an area of 322 ha for the area around Sanur Beach [47].

In the midst of research results that trace changes in coastlines and changes in coastal typology that occur, strategic steps such as the Bali Beach Conservation Project (BBCP) were initiated by the Japan International Cooperation Agency (JICA) to protect the coast, one of which is in Denpasar City, such as Sanur Beach. Steps to build coastal protective infrastructure such as groins and breakwaters in BBCP change the coastal landscape. In terms of evaluation, this strategy is able to contribute to the protection of beaches in the coastal environment of Denpasar City.

Amid research results that trace changes in coastlines and changes in coastal typology that occur, strategic steps such as the Bali Beach Conservation Project (BBCP) were initiated by the Japan International Cooperation Agency (JICA) to protect the coast, one of which is in Denpasar City, such as Sanur Beach. Steps to build coastal protective infrastructure such as groins and breakwaters in BBCP change the coastal landscape. In terms of evaluation, this strategy can contribute to protecting beaches in the coastal environment of Denpasar City.

However, referring to the discussion of EIA developments monitored by Walhi Bali as NGO and civil society representation, this is not the case [17-18]. Many plans for coastal development projects still threaten the coastal environment, whether supporting tourism or other supporting infrastructure. BBCP-II itself was indicated to have violated the Regional Spatial Plan, both the location of the sand source in the sea and the location of the Sand Stockpile, which was a note amidst several previous BBCP achievements, especially on the east coast of Denpasar City, such as Sanur Beach.

The size and enthusiasm of the BBCP project cannot be separated from the existence of tourism infrastructure that is very close and even touches the beach border, which is stipulated in regulations at 100 meters from the highest tide coastline. This results in beach privatization [49-50], thereby contributing greatly to the economy of Denpasar City [45]. Some of the existing infrastructure along the coast also results in indications of various violations and environmental risks [15,17,18].

Various studies have also revealed a situation where the coast of Denpasar City is one of the coasts with the highest changes in coastline, which is shown by the many coastal protection buildings found along the coast [21,51]. The phenomenon of changes in coastlines and coastal landscapes, tourism accommodation infrastructure such as hotels, and coastal protection buildings such as groynes and

breakwaters shows that high levels of human activity have created vulnerability to the coast. Research conducted by [52] shows that based on the coastal vulnerability index (CVI), the coast of Denpasar City is classified as having high to very high levels of coastal vulnerability.

4. Conclusion

The research results show that in 1990, the total length of the anthropogenic coast typology in Denpasar City was ±9.01 km. In 2005, it increased to ±26.42 km, of which there was a widening of ±17.41 km from 1990 to 2005. In 2020 itself, the total length of the anthropogenic coast typology reached ±26.40, which means there was a shrinkage of around ±2 km throughout the development period 2005-2020. In the coastal typology of coast build-by organisms in 1990, the total length of the Denpasar City coastline reached ±10.61 km. In 2005, this coastal typology shrank to ±6.79 km. In 2020 itself, there will be widening again to ±10.37 km. The marine deposition coast typology in 1990 had a total length of the Denpasar City coastline reaching 10.33 km. In 2005, there was a slight widening to ±10.88 km. In 2020, the marine deposition coast typology shrank to ±9.24 km.

Changes in beach types due to coastal development have been identified. In the 1990-2005 period, the anthropogenic coast increased by ±21.12 km; in the 2005-2020 period, it increased again by ±5.14 km. The widening of the coastline in the marine deposition coast typology experienced an increase of ±1.7 km in the 1990-2005 period. Changes due to development implications during the 1990-2005 period also included the loss of the marine deposition coast typology along ± 10.61 km. In the same period, ± 1.66 km along the coastal typology of build-by organisms disappeared. Residential settlements on Serangan Island, including the anthropogenic coast typology, also disappeared for ± 1.18 km during this period.

Though this research still does not cover the damage of development to the detailed ecosystem and environment, the damage to the changing environment can be seen. The risk of intensifying development without proper environmental consideration will further degrade the coastal environment of Denpasar City. Further research is needed, such as the socioeconomic impact of the negative force of development in the coastal area of Denpasar City.

Acknowledgement

This research is conducted independently by the authors. Dewa Made Atmaja as main author conceptualize the research, writing the substance in the article, methodology, formal analysis, supervision, validation, review and editing. I Made Gunamantha as co-author contributes to formal analysis, supervision, review, and editing, Ida Bagus Arya Yoga Bharata as co-author contributes to methodology, data collection including digitation, layout, writing the research report, formal analysis, visualization, and editing.

This research is conducted independently by the authors. Dewa Made Atmaja, as the main author, conceptualizes the research, writing the substance of the article, methodology, formal analysis, supervision, validation, review and editing. I Made Gunamantha as co-author contributes to formal analysis, supervision, review, and editing, Ida Bagus Arya Yoga Bharata as co-author contributes to methodology, data collection including digitation, layout, writing the research report, formal analysis, visualization, and editing.

References

[1] J. W. Lee, and A. M. Syah, "Economic and environmental impacts of mass tourism on regional tourism destinations in Indonesia", *Journal of Asian Finance, Economics and Business*, vol. 5, no. 3, pp. 31-41, 2018. https://ssrn.com/abstract=3250133

[2] M. Antara, and M. S. Sumarniasih, "Role of tourism in economy of Bali and Indonesia", *Journal of Tourism and Hospitality Management*, vol. 5, no. 2, pp. 34-44, 2017. http://dx.doi.org/10.15640/jthm.v5n2a4

[3] M. Basorudin, N. Afifah, A. Rizqi, M. Yusuf, N. Humairo, and L. M. S. Nugraheni, "Analysis of the location quotient and shift share of the tourism sector as indicators of the leading sector in Indonesia", *Ecobisma (Jurnal Ekonomi, Bisnis Dan Manajemen)*, vol. 8, no. 1, pp. 89-101, 2021. http://dx.doi.org/10.36987/ecobi.v8i1.1855

[4] I. N. A. Nuriawan, "Project Life Cycle Analysis for Development of the Bali Cultural Center Tourist Area in Klungkung", *Pariwisata Budaya: Jurnal Ilmiah Agama Dan Budaya*, vol. 9, no. 1, pp. 55-65, 2024. https://doi.org/10.25078/pariwisata.v9i1.3526

[5] P. Nugroho, and R. D. Nasihien, "Implementation of Design and Build on Development Bali Maritime Tourism Hub (BMTH)", *World Journal Of Civil Engineering*, vol. 3, no. 1, pp. 9-16. 2022. https://www.world.journal.or.id/index.php/wjce/article/view/127

[6] I. B. G. P. Putra, I. B. U.Putra, and N. P. R. P. A. Putri, "Arrangement and Integration of Harbor Support Facilities at Matahari Terbit Beach, Sanur Kaja Traditional Village, Denpasar, Bali", *Jurnal Sutramas*, vol. 4, no. 1, pp. 211-218, 2024. https://doi.org/10.24843/JAL.2022.v08.i02.p05

[7] I. G. A. A. K. Galuh, "*Social Media as a Strategy for the Bali Movement to Reject Reclamation*", *Jurnal ILMU KOMUNIKASI*, vol. 13, no.1, 73–92, 2016 https://doi.org/10.24002/jik.v13i1.602

[8] U. V. Sumadyanti, Z. Zuharnen, and P. Widayani, "Monitoring Environmental Carrying Capacity

Based on Ecosystem Services (Recreation & Ecotourism) in 2000 and 2015 Using Landsat Imagery (Location in West Badung Regency, Bali Province)", *Jurnal Bumi Indonesia*, vol. 5, no. 4, 2016. https://www.semanticscholar.org/paper/MONITORING-DAYA-DUKUNG-LINGKUNGAN-BERBASIS-JASA-%26-Sumadyanti-Zuharnen/555ab3f89322078c94dd3c4ad226c786be48b2fd

[9] Bali and Nusa Tenggara Ecoregion Development Control Center (P3E Bali Nusra), "*Document on Food Carrying Capacity Status of Bali Island*", Ministry of Environment and Forestry, 2021a. http://ppebalinusra.menlhk.go.id/kajian/

[10] Bali and Nusa Tenggara Ecoregion Development Control Center (P3E Bali Nusra), "*Bali Island Water Carrying Capacity Status Document"* Ministry of Environment and Forestry, 2021b. http://ppebalinusra.menlhk.go.id/kajian/

[11] Bali Water Protection, "*Final Report BWP Project Research Year 2018*", IDEP Foundation & Politeknik Negeri Bali, 2018.

[12] Walhi Bali, "*Potentially exacerbating abrasion and destroying productive rice fields in Bali, three organizations are protesting the construction of Sangsit Harbor*", [Online]. Available: https://walhibali.org/berpotensi-perparah-abrasi-dan-menerabas-sawah-produktif-di-bali-tiga-organisasi-protes-pembangunan-pelabuhan-sangsit/, 2023a, September 1.

[13] Walhi Bali, "*Assessed Not In Accordance with Spatial Planning 3 Organizations Criticize Construction of Vasa Ubud Hotel*", [Online]. Available: https://walhibali.org/dinilai-tak-sesuai-tata-ruang-3-organisasi-kritisi-pembangunan-hotel-vasa-ubud/, 2023b, December 28

[14] Walhi Bali, "*FRONTIER, KEKAL, WALHI protests DKLH Bali, allowing the Holliday Inn Resort Hotel to operate without EIA*", [Online]. Available: https://walhibali.org/frontier-kekal-walhi-protes-dklh-bali-biarkan-hotel-holliday-inn-resort-beroperasi-tanpa-amdal/, 2024a, January 8.

[15] Walhi Bali, "*Not having an EIA, Walhi urges DLHK to stop construction of the Magnum Residence Sanur Hotel*", [Online]. Available: https://walhibali.org/tidak-memiliki-amdal-walhi-desak-dlhk-hentikanpembangunan-hotel-magnum-residence-sanur/, 2024b, January 17.

[16] Walhi Bali, "*3 Organizations Protest Plans to Build the N2S Lot 5 Hotel Project Because They Are Allegedly Capturing Beach Borders and Potentially Exacerbating the Water Crisis in South Bali*", [Online]. Available: https://walhibali.org/3-organisasi-protes-rencana-pembangunan-proyek-hotel-n2s-lot-5-karena-diduga-caplok-sempadan-pantai-dan-berpotensi-perparah-krisis-air-di-bali-selatan/ , 2024c, July 10.

[17] Walhi Bali, "*Allegedly Violating RTRW and Damaging Fishermen's Habitat, 3 NGOs Protest Stockpile Plan in Bukit Gumang Karangasem Protected Forest*", [Online]. Available: https://walhibali.org/diduga-langgar-rtrw-dan-rusak-habitat-nelayan-3-lsm-protes-rencana-stockpile-di-hutan-lindung-bukit-gumang-karangasem/ 2024d, May 21.

[18] Walhi Bali, "*Allegedly Threatening Conservation Aquatic Ecosystems, 3 Organizations Reject Plans for Sea Sand Mining in Bali Sea Waters and the Badung Strait*", [Online]. Available: https://walhibali.org/diduga-ancam-ekosistem-perairan-konservasi-3-organisasi-tolak-rencana-tambang-pasir-laut-di-perairan-laut-bali-dan-selat-badung/, 2024e, May 22.

[19] H. P. E. Sari, I. W. Diara, and R. Suyarto, "GIS Application for Land Use Changes in Kuta, North Kuta, and Denpasar City, Bali Province. *Nandur,* vol. 3, no. 3, pp. 96-104, 2023. https://ojs.unud.ac.id/index.php/nandur/article/view/104602

[20] S. Onaka, S. Endo, and T. Uda, "Bali beach conservation project and issues related to beach maintenance after completion of project", In *Proceedings of the Seventh International Conference on Asian and Pacific Coasts, Bali, Indonesia*, pp. 24-26, 2013. https://www.semanticscholar.org/paper/Bali-beach-conservation-project-and-issues-related-Onaka-Endo/1cc974388702f2ae8d603c7e41d9b88457049819

[21] I. G. B. S. Dharma, and S. S. Efendi, "Study of the Evolution of Sanur Beach Nourishment Project for Beach Enhancement", *Applied Mechanics and Materials*, 776, pp. 145-150, 2015. https://doi.org/10.4028/www.scientific.net/AMM.776.145

[22] M. T. F. Baru, D. Mardiatno, and M. A. Marfai, "Analysis of Geotourism Potential Based on Coastal Typology in the Ende City Coastal Area", *Geosfera: Jurnal Penelitian Geografi*, vol. 2, no. 2, pp. 62-70, 2023. http://dx.doi.org/10.37905/geojpg.v2i2.22991

[23] I. P. W. W. Pucangan, and T. A. Prajnawrdhi, "Typology and Dynamics of the Padangbai Coastal Area in Karangasem Regency", *SPACE*, vol. 10, no. 2, 2023. https://doi.org/10.24843/JRS.2023.v10.i02.p01

[24] I. B. A. Y. Bharata, I. G. P. E. Suryana, and D. M Atmaja, "The change of coastal typology in Bali Island Karst Region at southern formation", In *Eighth Geoinformation Science Symposium*

2023: Geoinformation Science for Sustainable Planet, vol. 12977, 2024 January, pp. 343-351. SPIE. https://doi.org/10.1117/12.3009635

[25] N. Khakhim, D. Soedharma, A. Mardiastuti, V. P. Siregar, and M. Boer, "Analysis of visual preferences for the coastal landscape of the Special Region of Yogyakarta for the development of coastal tourism towards sustainable coastal area management", *Forum Geografi*, vol. 22, no. 1, pp. 44-59, 2008. http://dx.doi.org/10.23917/forgeo.v22i1.4925

[26] M. A. Marfai, A. Cahyadi, and D. F. Anggraini, "Typology, dynamics and potential for disasters in the coastal karst area of Gunungkidul district" *Forum Geografi*, vol. 27, no. 2, pp. 151-162. 2013. https://doi.org/10.23917/forgeo.v27i2.2373

[27] B. A. Prabawa, A. Cahyadi, V. T. Adrian, and D. F. Anggraini, "Study of the genesis and dynamics of the coastal area of the Sempu Island karst area, Malang Regency, East Java Province", *Ekologi Lingkungan Kawasan Karst Indonesia: Menjaga Asa Kelestarian Kawasan Karst Indonesia*. pp. 59-65, 2013. http://dx.doi.org/10.31227/osf.io/wru5k

[28] H. Nugraha, A. Cahyadi, E. A. Ayuningtyas, and M. A. A. Ramdani, "Evolution of Coastal Typology of Karst Areas at Watukodok Beach, Gunungkidul Regency", *Ekologi Lingkungan Kawasan Karst Indonesia: Menjaga Asa Kelestarian Kawasan Karst Indonesia*, pp. 66-72, 2013. https://osf.io/ack3s/download/

[29] A. Nurkholis, G. D. Jayanto, and N. Y. Jurnawan, "Landform Analysis as a Foundation for Realizing Sustainable Coastal Areas in Indonesia", In *LKTI IGSS 2016 : Sustainable Coastal Area*. 2016. http://dx.doi.org/10.31227/osf.io/muq85

[30] Y. A. Safitri, N. Khakim, and S. R. Giyarsih, "Physical Typology Of Coastal Area In The Teluk Ambon Dalam", *Geographica: Science and Education Journal*, vol. 3, no. 1, pp. 23-33, 2021a. https://doi.org/10.31327/gsej.v3i1.1431

[31] Y. A. Wibowo, L. Ronggowulan, H. Fatchurohman, M. Nursaputra, D. A. Arief, L. Permonojati, Suriadi., D. Kurniawan, and R. Afrizal, "Identification of coastal typology: potential resources and hazards" In *IOP Conference Series: Earth and Environmental Science*, vol. 986, No. 1, p. 012024. IOP Publishing, 2022, February. http://doi.org/10.1088/1755-1315/986/1/012024

[32] P. U. Dewi, M. Wahdini, N. Prasiamratri, M. B. Alghifarry, and N. A. Utami, "GIS Application for Mapping Danger Level Zones and Residential Exposure to the Tsunami in Denpasar City", *Jurnal Geosains dan Remote Sensing*, vol. 1, no. 2, pp. 80-88, 2020a. http://dx.doi.org/10.23960/jgrs.2020.v1i2.28

[33] D. P. Agustianingsih, and M. S. Roychansyah, "Measuring the resilience of Denpasar city residents to disaster threats and the quality of urban life", *Jurnal Ekonomi, Sosial & Humaniora*, vol. 3, no. 5, pp. 1-13, 2022. https://www.jurnalintelektiva.com/index.php/jurnal/article/view/680

[34] K. W. Widantara, and B. W. Mutaqin, "Multi-hazard assessment in the coastal tourism city of Denpasar, Bali, Indonesia", *Natural Hazards*, vol. 120, pp. 7105–7138. 2024. https://doi.org/10.1007/s11069-024-06506-3

[35] D. W. W. Buana, and I. N. Sunartaa, "The role of the informal sector in maintaining environmental cleanliness at the Sanur Beach tourist attraction", *Jurnal Destinasi Pariwisata*, vol. 3, no. 1, pp. 35-44, 2015. https://doi.org/10.24843/JDEPAR.2015.v03.i01.p05

[36] L. T. Samosir, and I. G. A. O. Mahaganggaa, "Marketing Strategy for Dream Island Beach in Mertasari, Intaran Village, Sanur Kauh, Denpasar City", *Jurnal Destinasi Pariwisata*, vol. 8, no. 2, 2020. https://doi.org/10.24843/JDEPAR.2020.v08.i02.p04

[37] L. N. Safitri, S. M. Mukaromah, and M. A. F. Habib, "Analysis of the potential of beach tourism objects with the concept of halal beach tourism in Denpasar City", *Ar Rehla: Journal of Islamic Tourism, Halal Food, Islamic Traveling, and Creative Economy*, vol. 1, no. 2, pp. 143-156. 2021b. https://doi.org/10.21274/ar-rehla.v1i2.4814

[38] N. P. S. S. Dewi, I. Y. Perwira, and N. M. Ernawati, "Lead (Pb) Content in Sediments in the Waters of Karang Beach, Sanur, Bali", *Current Trends in Aquatic Science*, vol. 3, no. 1, pp. 76-80, 2020b. https://ojs.unud.ac.id/index.php/ctas/article/download/52480/36067

[39] R. Hartono, "Identify forms of soil erosion through interpretation of Google Earth images in the Sumber Brantas area, Batu City", *Pendidikan Geografi (Berkala)*, vol. 21, no. 1, 2016. http://dx.doi.org/10.17977/um017v21i12016p030

[40] E. Suwandana. "Utilization of high spatial resolution Google Earth data for mapping changes in coastal morphology" *Depik*, vol. 8, no. 3, pp. 193-206, 2019. https://doi.org/10.13170/depik.8.3.14309

[41] J. A. G. Cooper, and I. Alonso, "Natural and anthropic coasts: challenges for coastal management in Spain" *Journal of Coastal Research*, SI 48, pp. 1-7, 2006. https://www.jstor.org/stable/25737374

[42] F. Muhammad, "*Study of Wave Refraction Characteristics at Sanur Beach, Denpasar City,*

Bali", Undergraduate Thesis, Universitas Brawijaya, 2016.
[43] Central Statistics Agency (BPS), "*Number of Star Hotels by Class and Regency/City in Bali Province*", [Online]. Available: https://bali.bps.go.id/indicator/16/222/1/jumlah-hotel-bintang.html, 2024a.
[44] Central Statistics Agency (BPS), "*Number of Rooms in Non-Star Hotels and Other Accommodations*", [Online]. Available: https://bali.bps.go.id/indicator/16/224/1/jumlah-kamar-pada-hotel-non-bintang-dan-akomodasi-lainnya.html, 2024b.
[45] Central Statistics Agency (BPS), "*Denpasar City Gross Regional Domestic Product Based on Constant Prices by Business Area (Million Rupiah), 2021-2023*", [Online]. Available: https://denpasarkota.bps.go.id/indicator/52/85/1/produk-domestk-regional-bruto-kota-denpasar-atas-dasar-harga-konstan-menurut-lapagan-usaha.html, 2024c.
[46] Allen Coral Atlas, "*Imagery, maps and monitoring of the world's tropical coral reefs*", https://doi.org/10.5281/zenodo.3833242, 2022.
[47] Y. I. Graha, I. W. Arthana, and I. W. G. A. Karang, "Seagrass carbon storage in the Sanur coastal area, Denpasar city", *Ecotrophic*, vol. 10, no. 1, pp. 46-53, 2016. http://dx.doi.org/10.24843/EJES.2016.v10.i01.p08
[48] P. I. D. Putri, I. K. Sudiarta, R. Prasetijo, and I. N. D. Prasetia, "Indonesia Coral Reef Garden Sanur Bali: National Economic Recovery through Coral Reef Restoration", *International Journal of Community Service Learning*, vol. 7, no. 2, pp. 168-177, 2023. https://doi.org/10.23887/ijcsl.v7i2.56525
[49] N. W. L. P. E. Sari, N. N. Pujianiki, and I. B. N. Purbawijaya, "Community Perceptions of the Implementation of the Coastal Area Management Law (Case Study: Sanur Beach, Denpasar)", *Jurnal Ilmiah Teknik Sipil*, vol. 20, no. 1, pp. 15-21. 2016. https://doi.org/10.24843/JITS.2016.v20.i01.p03
[50] N. A. P. Syahrin, "Management of National Tourism Strategic Areas, Old or New Issues in Indonesia? (Case study: Privatization of coastal borders in the KSPN area). *Jurnal Dimensi Hukum*, vol. 8, no. 1, 2024. https://doi.org/10.24843/JDEPAR.2019.v07.i02.p01
[51] R. R. Rahmawati, A. H. S. Putro, and J. L. Lee, "Analysis of long-term shoreline observations in the vicinity of coastal structures: a case study of south Bali beaches", *Water*, vol. 13, no. 24, 3527, 2021. https://doi.org/10.3390/w13243527
[52] A. W. Hastuti, M. Nagai, and K. I. Suniada, "Coastal vulnerability assessment of Bali Province, Indonesia using remote sensing and GIS approaches", *Remote Sensing*, vol. 14, no. 17, 4409, 2022. https://doi.org/10.3390/rs14174409