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Protecting Palu Bay: Land Capability Mapping and Coastal Typologies with SPOT-6

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ABSTRAK

Kawasan pesisir Teluk Palu mengalami dinamika geomorfik cepat, tekanan pemanfaatan ruang, serta perubahan pasca tsunami 2018. Evaluasi kemampuan lahan penting untuk mengungkap potensi tersebut, namun metode lapangan konvensional memakan biaya, waktu, dan tenaga besar sehingga kurang efektif—terutama di wilayah pesisir yang dinamis dan rawan bencana seperti Teluk Palu (gempa, tsunami, likuifaksi, longsor bawah laut). Pembangunan tanpa mempertimbangkan tipologi pesisir berisiko memicu bencana berulang. Penelitian ini memanfaatkan citra satelit SPOT-6, Sistem Informasi Geografis untuk menyusun klasifikasi tipologi pesisir secara efisien. Data pendukung meliputi peta rupa bumi, peta tematik, dan data sekunder; klasifikasi berbasis objek dari citra satelit diikuti verifikasi lapangan berdasarkan Klasifikasi Tutupan Lahan BSN. Pengukuran parameter lahan dilakukan melalui pengukuran cepat dan pengambilan sampel tanah. Integrasi data spasial dan atribut dengan teknik overlay menghasilkan enam kelas kemampuan lahan. Analisis menunjukkan perubahan kapasitas lahan pasca-tsunami, dengan dua kelas yang memerlukan evaluasi lanjutan. Selain itu, studi mengidentifikasi sembilan tipologi pesisir yang mencerminkan kondisi biofisik pantai Teluk Palu, menegaskan bahwa kemampuan daratan memengaruhi kondisi fisik pesisir. Temuan ini menyediakan dasar ilmiah bagi penyusunan *setback zone*, prioritas rehabilitasi ekosistem, serta arahan pemanfaatan ruang pesisir yang selaras dengan risiko. Studi ini menegaskan peran penginderaan jauh resolusi tinggi sebagai alat penting dalam perencanaan pesisir yang tangguh dan berkelanjutan.

Kata kunci: Kemampuan lahan, Tipologi pesisir, Pemetaan, SPOT-6, SIG

ABSTRACT

The coastal area of Palu Bay experienced rapid geomorphic dynamics, pressure on space utilization, and changes after the 2018 tsunami. Evaluation of land capabilities is important to uncover this potential, but conventional field methods are cost-intensive, time-consuming, and labor-intensive, and less effective—especially in dynamic and disaster-prone coastal areas such as Palu Bay (earthquakes, tsunamis, liquefaction, underwater landslides). Development without considering coastal typology risks triggering repeated disasters. This study utilizes SPOT-6 satellite imagery and Geographic Information System to efficiently compile coastal typology classification. Supporting data includes terrain maps, thematic maps, and secondary data; object-based classification from satellite imagery followed by field verification based on BSN Land Cover Classification. Measurement of land parameters is carried out through rapid measurements and soil sampling. The integration of spatial data and attributes with overlay techniques results in six classes of land capabilities. The analysis showed changes in post-tsunami land capacity, with two classes requiring further evaluation. In addition, the study identified nine coastal typologies that reflect the biophysical conditions of the Palu Bay coast, confirming that land capabilities affect coastal physical conditions. These findings provides a scientific basis for the preparation of setback zones, ecosystem rehabilitation priorities, and directions for the use of coastal space that are aligned with risk. This study confirms the role of high-resolution remote sensing as an important tool in resilient and sustainable coastal planning.

Keywords: Land capability, Coastal typology, Mapping, SPOT-6, GIS

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1. INTRODUCTION

Tortsev (2020) mentioned that coastal ecosystems have biodiversity that plays a role in carbon storage, flood protection, and can be cultivated. This ecosystem plays a role in reducing the impact of coastal disasters, such as tsunamis. Palu Bay experienced a large-scale earthquake, tsunami, and liquefaction phenomenon on September 28, 2018, which triggered changes in coastal morphology and extensive damage to settlements and coastal ecosystems. This event causes subsidence, changes in the coastline, and mudflows that change the ability of land in the coastal zone (Jalil et al. 2021; Fuad, Hardiansyah, and Semedi 2022). Today, combining traditional methods with modern technologies such as remote sensing and GIS can improve the accuracy and relevance of land capability assessments. This technology is increasingly used to obtain spatial information and improve the accuracy of land capacity assessments (Dar, Dar, and Gul 2024). Modern coastal monitoring and mapping increasingly rely on high-resolution satellite imagery, such as SPOT6 (panchromatic resolution 1.5 m; multispectral 6 m) to efficiently capture typological details and shoreline changes (Astrium Services 2013). The Object-Based Image Analysis (OBIA) technique allows for more accurate extraction of coastal features than single-pixel analysis, making it suitable for typological classification and land capability mapping (Widyastuti, Hartono, and Kurniawan 2020; Sreekesh, Kaur, and Sreerama Naik 2020). In addition, the integration of land evaluation, GIS, and remote sensing is essential for technological advancement, and methodology is essential to keep land evaluation practices up-to-date and effective (Partoyo and Lukito 2022; Singh et al. 2023).

Tiando et al. declare that the ability of land and coastal typologies that do not follow their designation poses a risk of disaster. Climate change exacerbates existing problems, such as sea level rise and extreme weather, which are often not fully integrated into land capacity evaluations (Bell, Etheridge, and Hall 2022). Fuad et al. (2022) emphasize that conventional field methods for land capability evaluation are time-consuming and cost-effective, making them less practical for dynamic and disaster-prone coastal areas such as Palu Bay. Furthermore, the lack of land capability maps and coastal typologies integrated with post-disaster data hinders the determination of setback zones, rehabilitation priorities, and risk-based space utilization policies (*Undang-Undang RI Nomor 1 Tahun 2014 Tentang Pengelolaan Wilayah Pesisir Dan Pulau-Pulau Kecil* 2014). For this reason, a method that combines high-resolution remote sensing data, land characteristics, and field verification is needed to produce spatial products that can be directly used by planners and policymakers.

The complexity of coastal areas, with the existence of diverse ecosystems and landscape characteristics, becomes difficult to recognize from the characteristics of the land. Coastal areas often have complex socio-ecological systems that differ significantly from those in the interior. Although there are studies of shoreline change and post-2018 liquefaction analysis, the main gap is the lack of studies that integrate OBIA-based coastal typology classifications in SPOT6 imagery with field land ability measurements to produce a post-disaster calibrated map of land affordability. In addition, little research has translated the results of the mapping into setback zoning recommendations and operational rehabilitation priorities for the Indonesian legal and spatial planning context, specifically in Palu Bay (Fuad, Hardiansyah, and Semedi 2022; Haweika 2022).

This research is important because the coast of Palu Bay, especially after the 2018 tsunami earthquake, caused a lot of construction damage, physical environmental damage, and fatalities. Development without paying attention to coastal typology has the potential to repeat disasters (Jamelot et al., 2019; Mikami et al., 2019). Land subversion and coastal subsidence further exacerbated the impact of tsunamis, which led to inundation and severe damage. Purnama dkk. (2021) mentioned that the lack of a comprehensive tsunami mitigation system and proper management of coastal zones contributed to the high rate of casualties and damage. At the same time, Stolle et al. (2020) emphasized that the region's infrastructure is not sufficiently prepared to deal with such disasters. Wooden buildings along the coast suffered severe damage, while reinforced concrete structures fared better (Aránguiz et al., 2020). Rapid and unplanned urban development without considering coastal typology and geological risks has increased the vulnerability of the area. The expansion of settlements into high-risk zones, such as near river mouths and low-lying coastal areas, has increased the risk of disasters (Imran et al., 2020; Majewski et al., 2023).

High-resolution satellite imagery, such as Landsat, Quick Bird, and other sources, is essential for capturing detailed coastal features (Thi My et al., 2024). Techniques such as Object-Based Image Analysis (OBIA), spectral classification, and texture analysis are used to classify coastal features such as sandy beaches, shallow seas, and deep seas (Kefi et al., 2022). Likewise, Widyastuti et al. (2020) used OBIA for land cover extraction and land use on the Palu Bay coast. This integration shows promising results in identifying different types of land cover, including vegetation and water bodies, with an accuracy of more than 70%. Furthermore, this research develops an efficient method to map the land capabilities and coastal typology of Palu Bay using OBIA on SPOT6 imagery, which is verified, and Cepat surveys are integrated with post-tsunami soil samples and classify coastal typologies to support resilient and sustainable coastal planning. This research is expected to fill the shortcomings of post-disaster geomorphic mapping and evidence-based coastal space management policies, as well as strengthen the role of high-resolution remote sensing in adaptive planning of Indonesia's coastal areas.

2. METHODHOLOGY

This study uses a descriptive quantitative method with a spatial approach. Primary data were used to interpret satellite imagery processed using GIS and SPOT-6 satellite imagery in 2018, as well as terrain maps, other thematic maps, and fieldwork. The location of the study is in Palu Bay, as shown in Figure 1. Overall, the stages of the research can be seen through the achievements below.

2.1. Land Cover

The SPOT-6 image is a land cover data source, by performing a combination of pixel-based and object-based classification. The combination is meant to achieve better accuracy. Furthermore, images based on land cover class refer to SNI (Table 1). Field work was carried out to see the suitability of soil sampling. Data analysis is carried out in stages to produce new information in the form of maps, tabulations, and diagrams. Sampling is according to the number of land classes by considering accessibility and the ability of knowledge and understanding related to the location/area on the Palu Bay coast. Land cover and land use maps from the Indonesian National Standard or the Land Cover Guidelines from the Geospatial Information Agency. Land cover class extraction results (Table 1).

2.2. Land Capability

Land capability is an important aspect of land use. The evaluation of land capabilities began with the creation of a baseline map (RBI map overlay, thematic maps, and land cover maps from Citra SPOT-6). Land capability analysis was obtained from field surveys (2018-2019), laboratory tests, rapid observations, and spatial analysis with GIS, for the land capability variables in Table 2. Furthermore, tentative land capability maps are generated from land cover maps and land capability variables, resulting in mapping unit maps. With the similarity of field conditions and limited access in the field, field observations and laboratory samples were carried out as shown in Table 3.

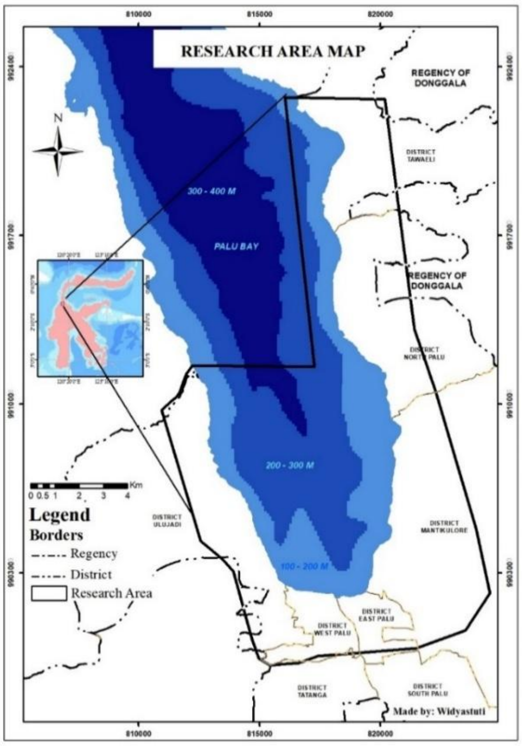

Figure 1. Research Location

Table 1. Land Cover Classes and Classification Levels

Level 1	Level 2	Level 3
Non-natural/semi-natural vegetation area	Natural/semi-natural water body	Natural/semi-natural water body
Non-vegetated areas are cultivated/cultivated.	Natural / semi-natural open land	Other open land
	Open land cultivated/ hardened surface	Asphalt surface Other artificial surfaces
	Buildings/buildings	Residential/ mixed buildings Non-residential buildings
Natural/semi-natural vegetated areas	Permanent natural vegetation	Lowland forests Shrubs Herbs and grasses
Vegetated areas are cultivated/cultivated.	Sedentary cultivated vegetation	Cultivated vegetation

Source: (BSN 2014).

One approach to determine land capability is to use various thematic maps according to the variables needed in the preparation of land capacity, including slope maps, soil type maps, rainfall maps, and land use maps. The map is overlaid using ArcGIS. The overlapping results were obtained from a combination of various parameters used to determine the sample and tested in the laboratory to strengthen the results of measurements and observations in the field.

Land capability maps contain information on land capability classes that are limited by inhibiting factors. The results of the land capability analysis are then assessed with a landscape map so that the relationship between the two is obtained to determine the suitability of its use.

2.3. Coastal Typology

Furthermore, the results of observations of land capacity, biophysical aspects, and landscapes were superimposed to obtain the coastal typology of Palu Bay. Suprajaka et al. (2005) stated that each typology consists of three components, namely abiotic, biotic, and culture. The formation of coastal typologies is greatly influenced by geological conditions, geomorphology, and the ability of vegetation to grow on certain beaches, as well as human activities. The list of coastal typology observations was compiled using integrated rapid survey guidelines (Gunawan et al. 2005) with the classification of Indonesian coastal typology (Suprajaka et al., 2005). Overall research stages, as shown in Figure 2.

Table 2. Data Required for Land Capability Analysis

Variable	Data source
slope	Quick observation, RBI, and SRTM Imagery
Soil texture	Rapid observation and laboratory tests (soil samples)
Rock	Quick observation
Drainage	Quick observation
Soil depth	Quick observation
Erosion	Quick observation
Flood threat	Quick observation and community information
Salinity	Quick observation
Organic matter	Laboratory tests (soil samples)
pH H2O dan KCL	Laboratory tests (soil samples)
Calcium	Laboratory tests (soil samples)
Temperature	Instrumental measurements and Laboratory tests (soil samples)

Table 3. Soil Samples

No.	Sample Code	Coordinate		pH	BO	Ca	Texture
		X	Y				
1	Tawaili	817847,82	9917772,42	6,58	0.60 - 3.15 light-coloured soil, Soil contains minerals and a few nutrients.	14,95	soft
2	Mamboro	821147,34	9914131,43	6,85		15,6	keep
3	Tondo-a	820699,65	9908529,66	6,86		29,95	keep
4	Talise-a	822114,65	9903528,5	6,94		18,75	rough
5	Talise-b	819711,97	9902767,56	6,9		11,21	a bit rough
6	Tondo-b	820644,76	9905882,24	6,75		17,71	soft
7	Balaroa	816166,41	9899669,81	6,89		17,84	a bit rough
8	Silae	814549,81	9903649,15	6,88		12,86	a bit rough
9	Tipo	814096,84	9906221,7	6,94		14,75	a bit rough
10	Watusampu	812179,66	9911038,98	6,88		19,81	keep

Source: Laboratory analysis, 2019

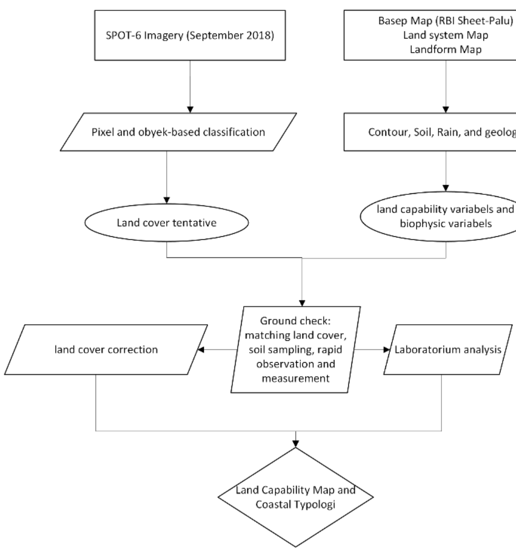

Figure 2. Research Flowchart

3. RESULTS AND DISCUSSION

3.1. Land Capability

Land capability classification helps in understanding the suitability of land for various uses, especially agriculture, and in sustainable land management planning. Overall, the results of the image interpretation produced a land cover map, which was used as field observation data. Some changes and information were recorded, and from the point of observation of soil parameters, 10 soil samples were taken (Table 3), which were evenly distributed in the study area. Observation and measurement of soil and rock parameters are carried out qualitatively with prepared materials. Land cover maps, field data, and soil sample analysis were processed using GIS attribute data. Maps of slopes, soil types, rainfall, and land cover are layered into a map of land capabilities. The research area around Palu Bay, based on the classification of land capabilities with eight assessed parameters, obtained six classes of land capabilities (Figure 3).

The land capacity at the research site is classified into six classes, namely:

1. Class III land is generally cultivated land. This class dominates, which is 8,743.24 ha. Class III soil has heavier barriers than class II soil. This land is intended for annual crops such as grasslands, production forests, protected forests, and wildlife sanctuaries. The coastal topography of Palu Bay is characterized by flat, sloping, and undulating terrain, especially in the eastern and western parts of the bay. The obstacles that can be directly observed are: (1) slightly sloping or undulating slopes, (2) sensitive to erosion or subjected to heavy erosion, (3) in the event of prolonged rainfall, triggering frequent erosion and flooding that damages crops, (4) slow permeability of the soil layer, (5) shallow soil depth that limits rooting and water storage, (6) low water resistance, (7) moderate salinity or sodium content, or (8) relatively significant climate barriers.
2. Class IV Soil Capability is still included in fertile land. However, the barriers and threat of damage are more significant than class III, and the choice of plants is also more limited. If used for annual crops, more careful management is required, as is soil conservation, such as creating terraces, canals, or control dams. Class IV land can be used for perennials, grasslands, production forests, grasslands, protected forests, or nature reserves. Class IV is generally located in the middle and upper slope areas in the research area of 7,544.95 ha. The ability of class IV is affected by (1) sloping slopes or hilly reliefs, (2) very large erosion sensitivity, (3) the influence of heavy erosion, (4) shallow soil, (5) low water holding capacity, (6) moderate to high salinity or sodium content, and (7) less favourable climatic conditions.

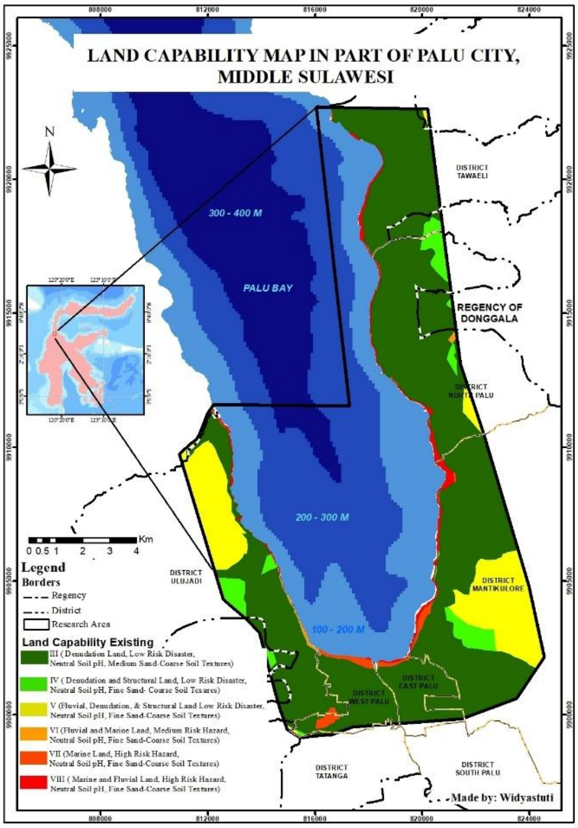

Figure 3. Land Capability Map

3. The class V land capability of 7,696.7 ha is located on a slope of > 15%. This land consists of grass crops, grazing fields, production forests, protected forests, and nature reserves. This land is of limited use, especially for seasonal crops. These soils are in a flat or nearly flat topography but are waterlogged, often waterlogged, rocky in unsuitable climates, or have a combination of these obstacles. Floods have hit class V land in the last 10 years, so it generally consists of shrubs, shrubs, and seasonal plants. In addition, some class V soils are rocky and are highly climate-dependent.
4. Class VI, on this soil, cannot be used for agriculture. Its use is limited to grass crops or grazing fields, production forests, protected forests, or nature reserves. Class VI soils have boundaries in the form of rocky areas, contain dissolved salt or sodium, have very shallow roots, and are unsuitable for the climate. Located along the coast, covering an area of 2,072.48 ha.
5. Class VII, land that is not suitable for agricultural cultivation, has greater obstacles. Class VII land has obstacles or threats of severe damage and cannot be removed, such as liquefaction areas, very shallow root areas (coastal), and sandy beaches (former tsunamis). The Class VII land area is 143.47 ha.
6. Class VIII land is not suitable for agricultural cultivation and is generally left in natural conditions. As a result of measurements and observations in the field, the most significant obstacles are very low water holding capacity, slopes, and sandy beaches. The area of Class VIII land capacity is 224.01 ha.

In general, land capacity (class I-VIII) is land capacity for agricultural use. This concept can be adapted to land use in general. The findings of the study show that after the disaster (map overlap analysis/attribute analysis, and sample analysis), six classes of land capabilities were obtained. This is because the measured parameters, both in situ and laboratory analysis, are no longer in accordance with the previous conditions or those that support agricultural use and other land use.

Palu City (Palu Bay Coast) is not fertile agricultural land, but it can still be planted. The change in land capacity in the study area was not as good as the initial conditions, and this appears to have been influenced by the 2018 earthquake. After earthquakes, tsunamis, and liquefaction, land conditions changed drastically so that the areas directly affected by the earthquake showed the original character of the land. Like class III ability, after liquefaction, it changes to class VII. Similarly, the class II land capability around the post-tsunami coast will be suitable as a class VII protected area. If the strong wave character of the Indian Ocean and the Mentawai Strait, especially when the west season winds accelerate the abrasion of coastal areas in Sumatra (Octavian et al. 2022), then the change of land in Palu Bay, in line with the Hu, Barberopoulou, and Koch (2025) dan Liu et al. (2020) in the Balaroa area due to liquefaction and land subsidence, the land class changed from built to degraded land or shallow waters. Meanwhile, in Aceh, after the tsunami, there was a loss of coastal vegetation with extensive sediment accumulation (Utami 2022). Even those caused by megatrusts in Japan, showing massive coastline changes and destroyed infrastructure (Hara et al. 2015). Differences in tsunami sources change the pattern of land change: local landslides in Palu generate high spatial heterogeneity so that coastal typologies must be more refined, while the megathrust (Tohoku) resulted in a more uniform change to the coastline. In other words, it is necessary to retest or revise land capability data (Figure 3) for Palu City as a whole.

Palu Bay land capability, using a combination of SPOT-6 imagery with 70% accuracy (Widyastuti, Hartono, and Kurniawan 2020). Evaluation of land capacity and GIS processing. This method adjusts the availability of data and access in research. With limited validation time, the area coverage conditions are quite difficult (destroyed). Widyastuti (2022) mentions clearance, relocation of settlements, construction of temporary embankments, and changes in land use for assistance/logistics to rapidly change land classes. In addition, the character of the coastal city of Palu is different from other regions in Indonesia, especially after disasters. This approach ensures that land use supports sustainable development goals.

3.2. Coastal Typology

The determination of the coastal typology of Palu City uses integrated rapid survey methods, observations, and biophysical observations in the field. The integrated rapid survey method of coastal areas uses land cover extraction data from the SPOT-6 image, mainly to determine the typology of hard-to-reach coastal areas and socio-economic conditions. Furthermore, data on land cover, biophysical, land capacity, and socioeconomic overlap were carried out, as shown in Table 4.

The coastal typology at the research site, in general, has the same characteristics as other regions in Indonesia. However, in terms of utilization and development, it is different from other locations. Nine coastal typologies were obtained from land capabilities and socio-economic data through an integrated rapid survey. Physically, the shape of the soil is determined by the geological conditions that make up this area. Geomorphologically, Palu Bay is made up of four prominent landscapes (structural, delusional, fluvial, and fluvio-marine). These natural conditions show the characteristics of Palu Bay but have become a typological variation due to socioeconomic aspects (Figure 3).

Table 4. Coastal Typology of Palu Bay

No.	Coastal Typology	Characteristic			Information	Utilize
		Physical	Biotic	Social-economic		
A	Coastal inland sediments	Muddy	mangrove	1. Tourist and trade areas 2. Accessibility	The Palu River Delta is a mangrove conservation area (destroyed/lost after the earthquake).	Breakwater around the beach. Reclamation for docking ships.
B	Coastal inland sediments	Muddy	river crocodiles, seagulls, and grasses	Accessibility	The mouth of the Palu River is a brackish swamp.	River embankment with a new gate.
C	Coastal marine sediments	Rocky Sandy		1. Tourism 2. Hospitality 3. Accessibility	It is located along Palu Bay (the widest in West Palu and Mantikulore districts).	The land use is the same, with some improvements according to the extent of damage.
D	Coastal sediment organisms	Sandy	Coral reefs	Accessibility	In 4 dive points 4 along Palu Bay, only a small part is still in good condition.	-
E	Coastal erosion waves	Rocky, Sandy	Coral reefs	1. Mining 2. Accessibility 3. Settlements	Loli and Watusampu Villages are dominated by sandstone mines.	The land use is the same, with some improvements according to the extent of damage.
F	Coastal erosion waves	Rocky, Sandy	Mixed garden	1. Settlements 2. Accessibility	Spread evenly in 6 coastal sub-districts	The same condition
G	Coastal erosion waves	Rocky, Sandy	Dryland forests	Accessibility	Vital objects, gas, electricity, water, and other construction (3 sub-districts).	The land use is the same, with some improvements according to the extent of damage.
H	Coastal erosion waves	Rocky, Sandy	Mixed garden	1. Settlements 2. Accessibility 3. Industry and warehousing	It is found in Tawaili, North Palu, and West Palu.	The same condition
I	Coastal erosion waves	Rocky, Sandy	Mixed garden	1. Settlements 2. Accessibility 3. Services and offices	Found in West Palu District, East Palu, and Mantikulore District,	The land use is the same, with some improvements according to the extent of damage.

Source: Widyastuti (2022) and ground check (2025)

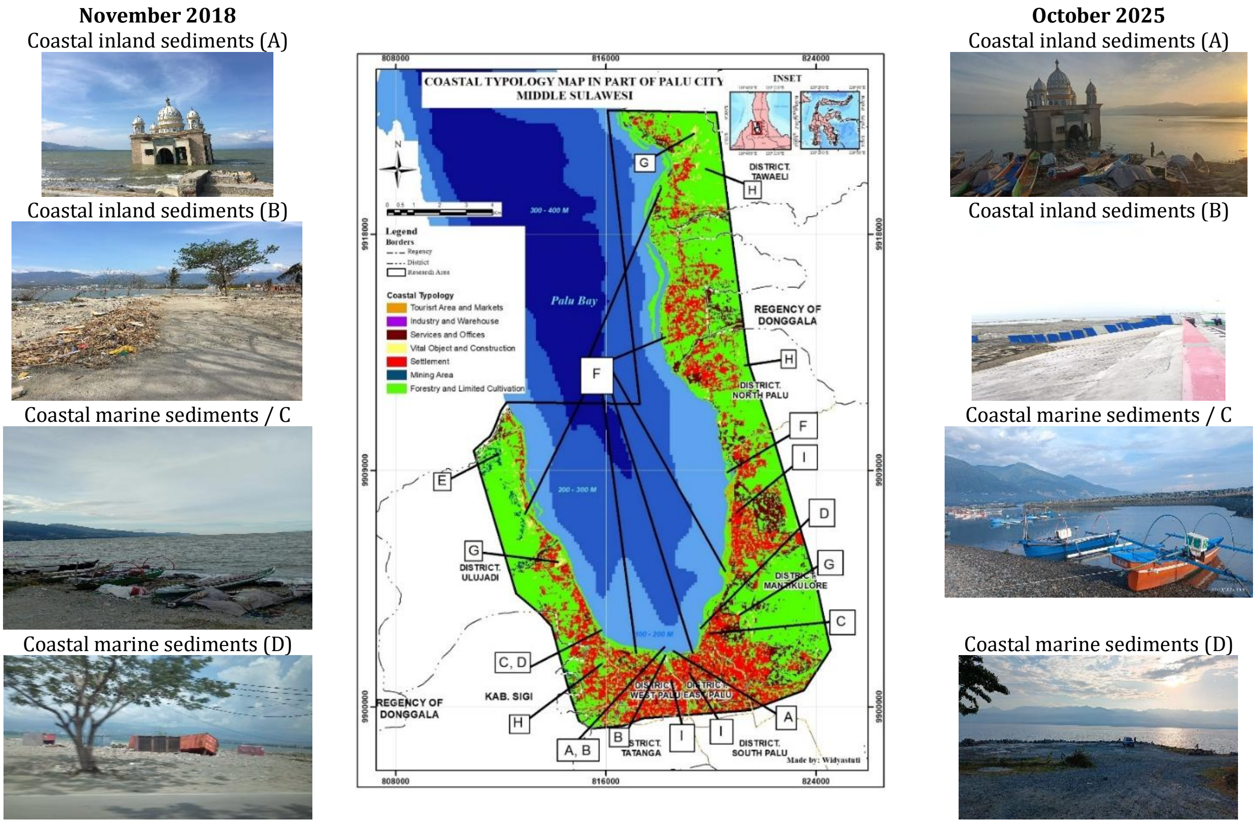

Figure 4. Coastal Typology Map and Some Rehabilitation/Reconstruction Sites

Coastal areas will be difficult to develop because the interaction between land and sea is very dynamic. The coast of Palu Bay has changed in the last 35 years. Human activities, including tourism, fisheries, and urban expansion, increase the dynamics of nature, which ultimately leads to increased pollution and habitat degradation (Chairmain, 2023; Innocenti & Musco, 2023). The existence of an earthquake-tsunami-liquefaction in 2018 showed high vulnerability in Palu Bay. The coast of Palu Bay is vulnerable to extreme natural events such as tsunamis and underwater landslides that can damage the local economy and ecosystem. Tsunami waves and currents move sediment, damage coastal vegetation, and alter the morphology of the coastline (erosion/accretion). Coastal avalanches and bathymetric changes in Palu Bay were recorded as secondary tsunami sources (Liu et al. 2020). Constant change is caused by natural forces such as tides, waves, and erosion, which can also significantly alter landscapes and ecosystems (Woodroffe et al., 2023).

Geological and geomorphological characteristics, such as lithology and structure, play an important role in determining coastal landscapes. Palu Bay Beach geomorphologically consists of 4 landscapes, namely structural, denudational, fluvial, and fluvio-marine. These landscapes also influence each other, especially in the Palu River delta. This result develops the classification of land forms by Sultanisah (2007). The formations that can be seen are rocky beaches, sandy beaches, small parts of coral reefs, river deltas, swamps, and mangroves. The physical properties of the beach also determine erosion and accretion patterns. Coastal areas with high sediment transport rates can experience significant morphological changes, such as sediment accumulation on the upper side and erosion on the lower side. Human interventions, such as the construction of coastal structures (e.g., breakwaters, piers) and land-use changes, can modify natural coastal processes, which in turn affect coastal land characteristics (Solihuddin et al., 2021).

Land capacity assessments help identify the most appropriate land use based on the intrinsic qualities of the land, such as soil type, slope, and drainage. The results show that land use allocation should look at the feasibility of land marked by nine types of beaches, to at least ensure that land is used in a way that maintains long-term productivity and prevents degradation (Dar et al., 2024).

Land capacity mapping and classification are fundamental tools for land use planning and policy development. They assist in making informed decisions about land allocation, zoning, and conservation efforts. Land capability assessment not only considers the physical attributes of the land but also socio-economic factors, so that it can adapt to changing conditions and needs. Many studies ignore the socio-economic dynamics that determine whether land is rehabilitated or converted, without this integration, land affordability maps risk becoming static and irrelevant to policy (Widyastuti 2022), and this holistic approach ensures that land use remains sustainable even as economic and social conditions evolve (B. Han et al., 2023).

The use of SPOT-6 satellite technology and GIS processing helps in the mapping of coastal typologies. SPOT-6 provides high-resolution images (1.5 panchromatic 1.5 meters), which are important for detailed mapping and analysis of coastal features. This high resolution allows for precise depictions of various coastal habitats and land cover types. By integrating the SPOT 6 imagery with the GIS, the researchers were able to create detailed maps that highlight changes in coastal typology over time. This integration is critical for monitoring dynamic coastal processes such as erosion, accretion, and habitat change (Gomes da Silva et al. 2024; Widyastuti, Hartono, and Kurniawan 2020).

Coastal typology is the basic data for designing the spatial arrangement of Palu Bay. The physical condition of the landscape and the vulnerability to disasters need to be a major concern. The typology provides an analysis unit for multihazard risk models, validation of tsunami source models (e.g., avalanche contributions), and prioritization of bathymetric/geomorphological surveys. Allows typology-based restoration scenarios. In terms of policy, the typology supports reconstruction zoning (building bans, vegetation buffer zones), risk-based relocation plans, and restoration strategies for coastal ecosystems (mangroves, seagrasses) that differ per typology. Policy recommendations should incorporate land capability maps as the basis for permitting and reconstruction funding.

Field validation in 2019 experienced limited access after the disaster, which often limited the number of field samples. Without adequate field validation, classification and interpretation of typologies are at risk of containing thematic errors. Meanwhile, the 2025 ground check shows physical rehabilitation and reconstruction, where the ability of the land is only based on physical parameters, as emphasised by Liu et al (2020) that zoning is typology-based; focus on landslides and local rehabilitation. Moreover, if you ignore stakeholder decision factors (relocation needs, economic pressures), policy recommendations can be less realistic. Nine typologies simplify coastal complexity; Some heterogeneous areas are forced to be mapped to a single typology, thus losing local nuances, resulting in typological ambiguity.

The results of this study are recommendations for the government and the community regarding future land use. The long-term impact of climate change on coastal typology and disaster risk is difficult to predict and not fully understood by all parties. Although some studies recommend incorporating climate change impact assessments into national development strategies, the practical implementation and effectiveness of these recommendations remain uncertain. The adaptive capacity of coastal communities and the effectiveness of governance structures in managing and mitigating risks are not well documented. There is a need for a collaborative approach involving scientists, managers, government entities, and the public to increase adaptive capacity and ensure effective risk management (Barros et al., 2023).

4. CONCLUSION

Mapping land capabilities with SPOT-6 imagery, field observation, and soil sample measurement resulted in six classes. Land capability analysis shows a change in land capacity from previous conditions. And there are two ability classes, which changed after the tsunami earthquake. This means that this land class needs to be reviewed for its allocation, by re-evaluating the land to be handled and managed according to development directions.

Coastal typology is an important part of coastal area management, observation/fieldwork in 2025, showing that the nine (9) coastal typologies reflect the biophysical conditions on the coast of Palu Bay, a combination of physical, environmental, and socioeconomic aspects, it is necessary to be careful in making spatial planning and land use policies in the coastal area of Palu Bay.

The shortcomings of this research need to be improved, such as combining SPOT6 with LiDAR, Sentinel1/2, as well as multitemporal imagery and multibeam bathimetry to capture elevation, subsurface structures, and shoreline changes with higher resolution. Conduct household surveys and local policy analysis to understand relocation preferences, adaptation capacity, and barriers to typology-based zoning implementation. As well as designing periodic monitoring programs and testing land allocations in each typology to measure ecological and protective effectiveness.

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