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# Morphological Analysis of Coastal Settlements in Tanjung Piayu Old Village, Batam City

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**ABSTRACT**

This study investigates the morphological characteristics of the coastal settlement in Tanjung Piayu Old Village and how they have evolved over time in response to social, cultural, and environmental factors. The research is guided by the question: What are the morphological characteristics of the coastal settlement in Tanjung Piayu Old Village, and how have they evolved over time? Using a combination of diachronic and synchronic analysis, this study traces the spatial transformation of the village through historical mapping, on-site observations, and semi-structured interviews with local residents and stakeholders. The analysis reveals a predominantly linear settlement pattern following the coastal edge, shaped by traditional fishing-based livelihoods and later influenced by urban expansion and shifting economic activities. Over time, the village has experienced increasing densification, plot fragmentation, and informal extensions to accommodate commercial uses and population growth. These changes have presented challenges to infrastructure development, environmental sustainability, and the preservation of local cultural identity. The findings underscore the importance of integrating morphological understanding into coastal planning strategies, particularly in rapidly developing regions like Batam. By identifying the relationship between spatial form and local dynamics, this study offers insights for more inclusive, sustainable, and culturally sensitive urban development in similar coastal communities.

**Keywords:** morphology, old village, settlement

## 1. Introduction

Coastal areas are regions where land meets the sea, but they are still significantly influenced by activities occurring on land. Coastal areas have a role in providing natural resources for humans. However, with human activities, the area is increasingly vulnerable to degradation and damage. Climate change and ongoing development can also pose a threat to coastal areas [1].

Batam is one of the island's industrial areas that is developing rapidly. As an industrial hub, Batam attracts significant attention from investors outside the island. Not only is Batam an island with many coastal areas, but many of these coastal areas are still preserved. The abundance of such areas makes Batam appealing to outsiders, and as a result, many of Batam's coastal areas remain active, offering a wide range of activities [2].

Coastal settlements are dynamic environments shaped by a convergence of natural forces and human activities. In rapidly urbanizing regions like Batam, Indonesia, these settlements are in a constant state of transformation, reflecting the tensions and synergies between traditional lifestyles and the pressures of modern development. Understanding the morphological evolution of such areas is essential for sustainable urban planning and heritage preservation.

Tanjung Piayu Old Village is part of the regional cultural heritage which is unique as a residence located in a coastal area. The morphology of the settlement was formed through historical processes and environmental adaptation which reflects the characteristics of the buildings in Tanjung Piayu Old Village. Tanjung Piayu, previously known for its coastal area, has now developed into one of the industrial and logistics centers in Indonesia, with many industrial facilities being built there. Tanjung Piayu has great potential to be developed into a place of economic development by building industrial sites. As an industrial area, Tanjung Piayu has big challenges to maintain the environmental quality in Tanjung Piayu. However, with increasing population and space requirements, these settlements face serious challenges in terms of space management and infrastructure.

Morphology is the placement of land on the earth's surface. Morphology does not only look at the placement on land but has more specific paths such as coasts, mountains, plains and hills. There is also morphometric morphology which has a quantitative aspect of an area and is usually expressed in the form of percent or degrees. A settlement is an area inhabited by a group of people who build houses on empty land, causing the layout pattern in the area to tend to become irregular. Settlements have quite high levels of population density. Meanwhile, a coastal settlement is an area inhabited by a group of people but who build houses in an orderly manner following the coastline [3][4].

This study investigates the morphological changes of Tanjung Piayu Old Village, a coastal settlement in Batam, with the central research question: *What are the key morphological changes in the Tanjung Piayu Old Village and how do they relate to social, cultural, and environmental factors?* This question guides a detailed analysis of the settlement's spatial development over time, including changes in building forms, street patterns, land use, and public spaces.

The hypothesis underlying this research is that the morphological evolution of Tanjung Piayu Old Village is significantly influenced by a combination of socio-cultural traditions, environmental constraints, and increasing developmental pressures from surrounding urban expansion. By tracing these influences, the study aims to reveal patterns that are not only locally specific but also relevant to broader discussions on coastal urbanization.

This research is particularly important given Batam's status as a rapidly developing island city, where traditional settlements are increasingly under threat from modernization. Analyzing the morphological adaptation of Tanjung Piayu Old Village provides valuable insights into how coastal communities respond to change, offering lessons for planning resilient and culturally sensitive settlements in similar contexts.

## 2. Method

This study employed a diachronic morphological analysis to examine the physical transformation of Tanjung Piayu Old Village over time during important time periods. The spatial changes were invertigated through three main time periods for the past decade; 2012-2015 (representing the traditional settlement form before major development), 2016-2018 (a transitional period marked by increasing infrastructure and economic activity), and 2019-2023 (reflecting the current condition influenced by rapid urban growth). Each time frame was chosen based on observable shifts in the village's physical layout and broader development trends in Batam. Data from these periods were derived from archival maps, historical satellite imagery, and government planning documents, which were compared to trace changes in street networks, plot divisions, building arrangements, and land use. Thereafter, the changes that occur will be shown along with the results of the analysis of the factors that influenced these changes [5].

The spatial data were analyzed using urban morphological principles based on the Conzenian approach, focusing on the transformation of town plan components such as street patterns, building footprints, and land utilization. On-site field surveys were conducted between May and August 2023 to document the current state of the settlement. These surveys included photographic documentation, GPS mapping, and visual observations of building typologies, open spaces, and circulation systems. The findings from the fieldwork were used to validate and complement the historical data, enabling a comprehensive assessment of the village's physical evolution.

To understand the socio-cultural and environmental factors behind the morphological changes, semi-structured interviews were conducted with 15 key informants. Participants were selected using purposive sampling, with criteria focusing on long-term residents (those who had lived in the village for over 20 years), community leaders, and local government officials. These individuals were considered to have rich insights into the historical context, cultural practices, and development challenges faced by the community. The interviews were designed to explore personal experiences, perceptions of change, and responses to environmental and planning interventions.

The qualitative data collected from interviews were transcribed and analyzed using thematic coding. Themes such as cultural continuity, community adaptation, land ownership patterns, and perceptions of government policies emerged from the coding process. These themes were then compared with the spatial data to identify correlations between morphological change and the underlying social, cultural, and environmental factors. By integrating diachronic spatial analysis with qualitative research, the study offers a multidimensional understanding of the transformation of Tanjung Piayu Old Village within the context of Batam's rapid urbanization.

## 3. Result and Discussion

Morphology, in short, refers to the structure or shape of the land or surface in an area. There are two types of morphology: morphography, which is the visual representation of the landform, and morphometry, which focuses on the quantitative analysis or measurement of the morphology, such as area calculations. The research area is divided into several characteristics, including hilly areas, forests, lowlands, and varied terrains [1].

**Table 1** Extensive in the Research Area.

| Number | Zone | Area |
|---|---|---|
| 1 | Pemko Area | 93,82 ha |
| 2 | BP Area | 14,38 ha |

Table 1 illustrates the land distribution within the research area, categorizing it into two main zones: the Pemko Area and the BP Area. The Pemko Area, managed by the local government, constitutes the majority of the land with an extensive coverage of 93.82 hectares, indicating its dominant role in the spatial layout and potential for development or planning initiatives. In contrast, the BP Area, which likely falls under the jurisdiction of the Batam Authority (BP Batam), covers a smaller portion at 14.38 hectares. This distribution reflects the governance structure and land control dynamics in the region, which are key in addressing local issues, such as land use conflicts or the "Angaria Problem" referenced in the source [1].

**Figure 1** Research's location (Tanjung piayu old village)

Figure 1 provides a satellite view of the research location in Tanjung Piayu Old Village, showcasing the overall layout and spatial distribution of the settlement. The village is situated on a coastal peninsula, with buildings densely clustered along the shoreline and extending slightly inland. Many structures appear to be built over water on stilts, reflecting the traditional architectural adaptation to the maritime environment. Inland areas show more solid constructions surrounded by vegetation and open land, connected by a winding road network. This aerial perspective highlights the close integration between land and sea in the community's spatial and infrastructural organization [5].

The development of Batam began with rapid growth in its economy and industrial areas. As a result, coastal areas like Tanjung Piayu Old Village have become vulnerable to transformation into potential tourist attractions. This rapid development started around 2015, following a period from 2012 when the area was primarily used for residential purposes. Between 2012 and 2015, the area became more densely populated, with an increasing mix of residential and tourism functions. These changes are evident when observed year by year.

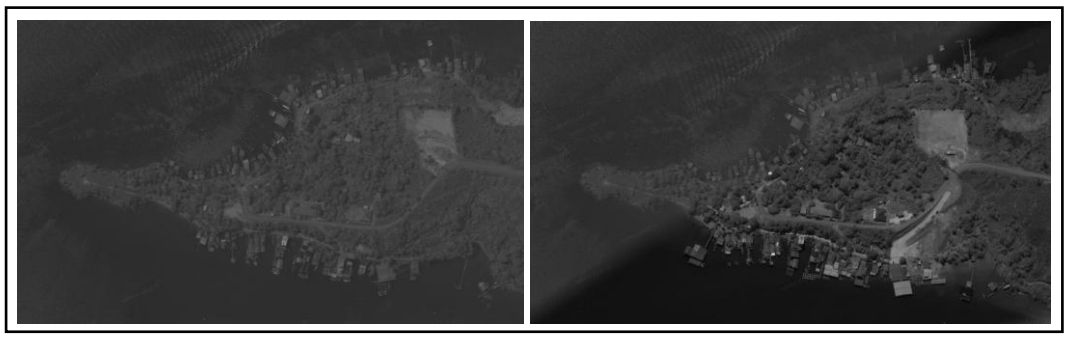

**Figure 2** Residential development from 2012 – 2015

The two satellite images show in the Figure 2 are the residential development in Tanjung Piayu Old Village between 2012 (left) and 2015 (right), highlighting changes in settlement density over time. In the 2012 image, the built-up area appears more limited, especially along the coastline and within inland spaces. By 2015, the village shows noticeable growth, with increased housing density and expanded structures along both the shoreline and landward areas. This suggests a gradual yet clear trend of urban expansion, likely driven by

population growth and evolving economic activities, leading to greater land use and transformation of the village landscape.

Based on visual analysis of map image research from 2012-2015, in the right image, you can see an expansion of the built-up coastal area compared to the left image. The tree vegetation in several areas in the right image appears to be decreasing due to the addition of facilities or buildings. The empty area or open land in the left image has in some parts been used for construction in the right image. It can be concluded from the comparison of the two maps that the green area is decreasing and the buildings are increasing [6].

**Figure 3** Residential development from 2016 – 2018

Figure 3 display the residential development in Tanjung Piayu Old Village between 2016 (left) and 2018 (right), revealing a continued trend of spatial growth and densification. By comparing the two, it's evident that more structures have been constructed along the coastal edge and within the inland areas, filling previously open or underutilized land [7]. The increased building density, especially near the shoreline, suggests an expansion of stilt houses or waterfront settlements, likely driven by growing population and housing needs. This development reflects ongoing urbanization and transformation of the village's landscape within just a two-year span.

In the results of visual analysis of map image research from 2016 - 2018, several changes can be observed, such as an increase in the number of buildings or structures in coastal areas. This shows that there is residential development in the area. Some visible green areas or vegetation have been turned into buildings. This shows that there is land clearing for residential or infrastructure development. On the right side of the image (eastern part of the island), you can see additional construction structures such as restaurants. There are changes to the coastline, which appears to be more filled with structures or buildings [8].

**Figure 4** Residential development from 2019 – 2023

Figure 4 show the residential development in Tanjung Piayu Old Village between 2019 and 2023, highlighting a significant increase in housing density and expansion of built-up areas, especially along the coastline. Compared to previous years, the settlement appears more compact and saturated, with fewer open spaces visible, indicating limited land availability and growing housing demands. The presence of additional stilt houses over the water and more structured road access also suggests ongoing infrastructure development [9]. Overall, this period reflects an advanced stage of urbanization with a clear transformation of the village into a denser, more structured residential area.

In the results of visual analysis of map image research from 2019 - 2023, there are changes that can be observed, such as an increase in the number of buildings or structures in several parts of the region, especially in coastal areas. The more infrastructure and buildings are added, the less vegetation there is. The residential area looks increasingly dense, this shows that there is rapid development of settlements in the area. Most of the developments that add to the coastal or beach area apart from being a residence can become a place of income with restaurants or fishing spots.

The physical changes seen in Tanjung Piayu Old Village—such as the shift from a linear layout to a denser and more irregular form—reflect how the community has adapted to social and economic pressures. These changes help answer the research question by showing how the settlement evolved in response to population growth, new sources of income, and limited space. Many houses were extended or divided to support small businesses or rentals, while some public and coastal areas were used for building due to lack of land. These patterns show that the changes are not random, but closely tied to how people live, work, and adjust to the rapid development around them. This highlights the importance of understanding not just the shape of the settlement, but the reasons behind it.


**Figure 5** Settlement patterns in Tanjung Piayu old village.

Figure 5 illustrates the settlement patterns in Tanjung Piayu Old Village, highlighting the spatial organization of different land uses. The pink-colored areas represent dense settlement zones, many of which are built on stilts along the coast, indicating the community's adaptation to its maritime environment. The white areas signify land-based settlements, suggesting more permanent residential or mixed-use structures. Green zones indicate undeveloped or preserved land, possibly used for agriculture or left as natural green space. The yellow lines represent the main road network, which loops through the village and connects various zones, reflecting a relatively centralized circulation pattern that integrates land and sea-based living.

The settlements in Tanjung Piayu Old Village show a linearly organized pattern. This pattern can be seen from the layout of the buildings which follow the coastline, where every year there will be the addition of new buildings which fill the space in rotation along the coastline. Linear patterns are generally chosen because of their position close to the sea, which is one of the main sources of livelihood for the population, such as fishing, sea transportation, or trade. Placing buildings that follow the coastline also provides easy access for residents to carry out their daily activities [10], both related to the economy and domestic needs.

Apart from the linear pattern, this settlement has also been equipped with several basic facilities designed to meet the needs of the people in Tanjung Piayu Old Village. These facilities include supporting facilities as well as simple infrastructure such as roads that connect buildings. The presence of these facilities is an

important factor in improving the quality of life of the residents of Tanjung Piayu Old Village. With the development of settlements from year to year, this development pattern shows a balance between the physical growth of settlements and efforts to meet the basic needs of the population.

The buildings in Tanjung Piayu Old Village generally reflect the richness of Malay culture that is still being implemented and maintained. This can be seen from the main material used in building construction, sucah as wood, which reflects simplicity and connection with nature. Wood was chosen not only because of its abundant availability in the region, but also because of its resistance to coastal weather which tends to be damp. Apart from that, wood is often used to strengthen the cultural identity of local communities.

Another uniqueness can be seen from the design of the building's roof which has its own characteristics. These roofs are designed with shapes and structures that are not only aesthetic, but also functional to deal with tropical climate conditions. Usually, these roofs are made of zinc with designs that reflect the cultural values and beauty of Malay traditions. The existence of these buildings is clear evidence of how the people in this village maintain their ancestral heritage, even during increasingly modern developments. This cultural identity makes the village not only a place to live, but also a symbol of rich, living traditions.


**Figure 6** Buildings in the Tanjung Piayu old village

Figure 6 depict traditional buildings in Tanjung Piayu Old Village, showcasing the unique vernacular architecture and lifestyle of coastal communities in Batam. The left image shows a stilt house built over water, constructed with basic materials like wood and elevated to adapt to tidal changes, reflecting the area's strong relationship with the sea. The right image features a local eatery or food stall, also built on stilts but situated closer to land, with signage and modest structures indicating its role as a social and economic hub in the village. Both images highlight the simplicity and functionality of local architecture adapted to the environmental conditions of the region.

Most of the residents in this village depend on marine-based economic activities for their livelihood, especially as fishermen or opening restaurants from collaboration with fishermen. Fishing has become a daily life activity for residents, carried out as an economic activity or as a hobby as a fisherman. Residents of Tanjung Piayu Old Village utilize marine resources to fulfill their family's livelihood, such as catching fish or other marine products that have sales value in local markets and restaurants. This profession is not only a source of income, but also the formation of social and cultural identity for the residents of Tanjung Piayu Old Village.

Apart from fishing, residents' activities often include other supporting activities related to the marine world. Some residents are involved in processing seafood, such as opening restaurants to invite tourists. Becoming an intermediary between islands is like opening a small port to make crossings to the opposite island. With the involvement of residents in various aspects of this sector, the Tanjung Piayu Old Village area shows strong marine-based economic potential, while reflecting a lifestyle that is highly dependent on coastal areas.

**Figure 7** Economic Activities in Tanjung Piayu old village

Figure 7 show the economic activities in the Tanjung Piayu Old Village, which are closely tied to the coastal and aquatic environment. The left image shows aquaculture ponds, likely used for fish or shrimp farming, indicating that aquaculture is a key source of livelihood for local residents. The right image captures traditional stilt houses built over the water, with boats nearby, suggesting that fishing and marine transportation also play vital roles in the community's economy. Together, these scenes highlight how the village's economic practices are deeply integrated with its natural surroundings and maritime culture.

Tanjung Piayu is an area surrounded by the coast or also called beaches and clear sea. The natural environment in the Tanjung Piayu Old Village area has stunning views, with sea water sparkling in the sun and relaxing beaches. This natural view can create a stunning atmosphere. Apart from that, clean sea conditions on the sea and beaches can show that the local people in Tanjung Piayu Old Village are aware of the importance of preserving the environment.

The beauty of Tanjung Piayu Old Village's beach is the main attraction for tourists as seen in Figure 8. Many visitors come to enjoy the beach atmosphere, taking photos with the stunning scenery as a backdrop. This pristine environment not only offers a pleasant tourist experience but also provides an opportunity for visitors to get closer to nature. With large tourism potential, Tanjung Piayu Old Village has the opportunity to become a leading destination that attracts the attention of tourists while supporting local economic growth through the tourism sector.

**Figure 8** Natural Environment in Tanjung Piayu old village

The image illustrates the natural environment surrounding the Tanjung Piayu Old Village, characterized by its coastal landscape and tranquil seaside atmosphere. The shoreline is lined with scattered vegetation and rugged terrain, while the clear blue waters and open sky reflect the area's untouched, serene beauty. A small, deteriorating pier structure extends into the sea, suggesting the past or occasional use of the area for fishing or docking small boats. This natural setting highlights the village's close connection to its coastal ecosystem and offers insight into the harmonious relationship between the community and its environment.

Infrastructure in the Tanjung Piayu Old Village area requires a lot of attention to achieve conditions that can be described as urban. Not all of the roads in the Tanjung Piayu Old Village area use asphalt and still use red soil as a route for the activities of the residents of Tanjung Piayu Old Village. A road surface using red soil will cause the road to become slippery and pose a threat of accidents if it rains on the road. This condition shows that the development of road infrastructure in Tanjung Piayu Old Village is still a problem that must be resolved immediately [11].

Tanjung Piayu Old Village has several public facilities, including places of worship, schools, and health centers. However, the limited availability of these facilities can hinder residents from fulfilling their basic needs. Given the area's potential for growth, improving the quality of infrastructure and expanding public facilities is essential to support a more comfortable and decent standard of living. Enhancing these services can also open up broader development opportunities across various sectors, including the economy, education, and tourism.

The physical transformation of Tanjung Piayu Old Village cannot be fully understood without examining the underlying socio-economic dynamics that have influenced its development. Over time, shifts in livelihood patterns—from a predominantly fishing-based economy to a mix of informal trade, tourism, and small-scale services—have directly impacted the spatial organization of the settlement. As residents sought to adapt to new economic opportunities, many extended or modified their homes to accommodate home-based businesses or boarding houses, contributing to a more compact and irregular built environment. Additionally, the rising land value due to Batam's regional development has led to the gradual subdivision of plots and informal construction, particularly in areas closer to main access roads. These changes reveal how economic adaptation and land commodification have played a critical role in reshaping the village morphology, resulting in a fragmented urban form that reflects both resilience and vulnerability within the community.

The morphological changes observed in Tanjung Piayu Old Village echo patterns found in other coastal settlements across Southeast Asia, where traditional spatial arrangements are increasingly pressured by rapid urbanization and shifting socio-economic demands. Similar studies in regions such as Kampung Baru in Malaysia and coastal kampungs in Makassar, Indonesia, have documented comparable transformations, including densification, the emergence of informal housing extensions, and the reconfiguration of public spaces in response to economic shifts and land pressure. These cases, like Tanjung Piayu, demonstrate how local communities adapt their built environment to new livelihoods and external development forces while attempting to maintain cultural identity and social cohesion.

The implications of such morphological evolution are significant. Environmentally, unplanned densification and infill development in vulnerable coastal zones can increase the risk of flooding, reduce green spaces, and strain waste and drainage systems. From an infrastructure perspective, the organic and unregulated growth of circulation networks may lead to accessibility issues and challenges in service delivery, particularly as the village integrates more closely with the expanding urban fabric of Batam. Culturally, the erosion of traditional spatial patterns and building typologies threatens the community's heritage and identity, especially as younger generations engage less with customary practices tied to the coastal landscape.

To address these challenges, urban planning in similar coastal contexts must adopt a more integrated and community-informed approach. Lessons from Tanjung Piayu suggest the value of preserving key morphological elements—such as waterfront communal spaces, traditional house forms, and historical circulation paths—while upgrading infrastructure and supporting economic transitions. Participatory planning, where residents actively contribute to spatial decisions, could help balance modernization with cultural continuity. Additionally, introducing flexible zoning regulations that recognize informal livelihoods and environmentally sensitive design guidelines could support more sustainable and inclusive development. These strategies are not only applicable to Batam but can also inform planning frameworks in other coastal settlements navigating the complex interface between tradition and transformation.

## 4. Conclusion

This study set out to explore the key morphological changes in Tanjung Piayu Old Village and how these changes relate to social, cultural, and environmental factors. Through a diachronic morphological analysis and qualitative insights from community members, the research has shown that the transformation of the settlement is shaped by a complex interplay of traditional coastal lifestyles, emerging economic pressures, and rapid urban expansion. The findings revealed that spatial modifications—such as building extensions, plot subdivision, and circulation changes—reflect community adaptation to shifting livelihoods and land value pressures, while also highlighting challenges to environmental sustainability and cultural continuity.

The research demonstrates that in rapidly developing regions like Batam, unregulated morphological evolution can result in fragmented infrastructure, environmental degradation, and the gradual loss of local identity. These insights have broader implications for sustainable development in coastal settlements. Planning strategies must go beyond physical upgrades and consider the socio-cultural dynamics that influence spatial organization. A more inclusive and context-sensitive approach is needed—one that protects heritage features, promotes environmentally resilient design, and supports community-based economic transitions.

To support sustainable and equitable development in similar settings, urban planners should incorporate participatory planning models, flexible land use regulations, and infrastructure improvements that respond to both current needs and long-term environmental challenges. Cultural heritage preservation must also be integrated into spatial planning through documentation, education, and adaptive reuse of traditional structures.

Future research could further enrich the understanding of coastal morphology by examining the effects of tourism-driven development on spatial and social dynamics, particularly in areas where traditional and commercial land uses increasingly overlap. Comparative studies with other coastal regions undergoing similar transformations could also reveal transferable planning principles and contribute to more robust, regionally grounded urban development policies.

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## 6. Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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