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Spatial Analysis and WebGIS Visualization of Building Massing in the Prapatan Coastal Area: A Case Study for Waterfront City Development in Balikpapan

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Abstract: The Prapatan coastal area, located along Jalan Jenderal Sudirman in Kelurahan Prapatan, Balikpapan City, is an area of significant urban and environmental potential, particularly in the context of waterfront city development. This area is strategically positioned as an environmental service centre within the city's broader spatial structure plan, which identifies it as a key region for coastal development. Given the growing pressures on Prapatan Beach, particularly in light of the anticipated urban congestion due to the city's role as a buffer for Indonesia's new capital (IKN), there is a need for comprehensive planning to manage urban expansion and preserve the coastal ecosystem. This study employs a combined approach, integrating the Analytic Hierarchy Process (AHP) and Geographic Information System (GIS) analysis, to assess land suitability for waterfront development. The results of this analysis are then visualized through a WebGIS platform, enabling dynamic mapping of the area's environmental and spatial characteristics. The spatial analysis provides a framework for informed decision-making, highlighting areas with the greatest potential for sustainable development while addressing the challenges posed by urbanisation, environmental preservation, and infrastructure development. Ultimately, the research aims to contribute to the strategic planning of the coastal area, ensuring alignment with regional spatial policies and fostering the sustainable development of Balikpapan as a model waterfront city. The proposed spatial development concepts offer insights for future planning processes, assisting in the identification of potential risks and opportunities.

Keywords: Analytic Hierarchy Process (AHP); Geographic Information System (GIS); Land suitability; Waterfront city; Spatial planning; Urbanisation; Environmental sustainability; WebGIS visualization

1 Introduction

Regional development is based on a process that involves various strategic efforts in advancing an area with the aim of improving the quality of life index of the local community. It includes various aspects, such as infrastructure development, economic development, accessibility improvement, environmental preservation, community empowerment, and public service provision. Regional development has an important role because it can provide great benefits to local communities, including improving quality of life, increasing income, creating jobs, helping to increase investment and the local economy, and increasing accessibility or connectivity between regions [1].

Strategies in regional development planning will determine the spatial structure of the region. Based on Indonesian Law No. 26 of 2007 concerning spatial planning, it is explained that the region is a space that becomes a geographical unit and all elements related to the boundaries and systems that have been determined based on administrative and / or functional aspects. The region itself is divided into five types, and one of them is the coastal area. Coastal areas have specific characteristics compared to other areas because they are transitional places for land and marine ecosystems and are mutually influenced by changes in land and sea [2]. Development by utilizing coastal resources without paying attention to ecological aspects will only damage the function of the coastal ecosystem. Not to mention that it is influenced by the population growth that crowds the coastal area, which will save complex problems if no development direction is carried out because the community will be in direct contact with the coastal and marine ecosystems, which will affect the quality of the coastal area. Therefore, a water-oriented development concept is needed, namely the concept of developing coastal areas with waterfront cities.

One of the cities that has a plan on waterfront city development is Balikpapan City. Based on Balikpapan City's RTRW and RTBL documents, the city has a plan to realize the concept of a waterfront city through the development of coastal roads and coastal reclamation projects. The city has various potential coastal areas, such as beautiful beaches, beachfront resorts, shopping centers, entertainment venues, and cultural and historical diversity. Some of the potential that can be developed along this coastal area, such as developing an artificial island with a water theme park and a large river delta as a clubhouse, orientation of residential buildings and views of the area on the edge towards the sea, provision of spaces and activities that can be utilized for the potential and attractiveness of the ocean, such as seafood culinary tours or tourist boat docks, and can be developed as a downtown where this area can be equipped with new functions that can support activities such as shopping malls, hotels, modern retail, apartments, and civic centers [3]. One area of the city that has an attraction is the waterfront area along Jalan Jenderal Sudirman, which is located in Kelurahan Prapatan. Based on the city's spatial structure plan, Kelurahan Prapatan is included as a city service center area supported by the location of the area in the urban center so that it physically supports this city to develop the concept of a waterfront city. In addition, Kelurahan Prapatan (Sub BWP IV.D) is one of the areas planned for the coastal road development program and coastal reclamation. The development is carried out due to the fear of the city's coastal conditions, especially on the edge of Prapatan Beach, which will be increasingly congested so that alternative solutions should be realized, especially since Balikpapan City will become a buffer city for the Ibu Kota Nusantara (IKN).

Therefore, this research will map as well as visualize the condition of environment-based land capability for the development of the waterfront city area in Balikpapan City's Prapatan Beachfront area along with the building mass layout through the area typology approach. The result of this research is the mapping of potential development zones of the area in terms of land capability parameters such as land elevation, land slope, surface geology, rock geology, land cover, rainfall, water service coverage, erosion rate, and land resistance to natural disasters. Familiar with the land use conditions, including building massing and community activities in the study area, is also needed to determine the waterfront city concept that is suitable to be applied based on existing conditions. The existing conditions are obtained from analyzing population density, building density, road network density, centrality index, connectivity index, and entropy index. Based on the study results of all these aspects, the results of waterfront city zoning mapping in Balikpapan City's waterfront area are expected to help optimize spatial planning and identify potential areas for future development, whether commercial, residential, or recreational, in accordance with the RTRW policy direction as a form of support in solving urban problems.

This research also developed information on the concept of regional development in the form of digital mapping visualization. It is expected that the development of digital map-based information can increase user understanding because it is easier to monitor the area or spatial management so that it is expected to help in making better decisions and recognizing potential problems. Digital map presentation is the most important thing where people can explore the contents of a database system in order to identify an exclusive requirement [4].

2 Methodology

The methods used in the processing in this research consist of GIS and AHP methods. GIS technique is a technology that utilizes geographic or spatial data to collect, organize, analyze, manage, and present information visually and graphically. GIS allows users to understand the relationship between various geographic phenomena through interactive digital representations and plays an important role in making better decisions in various fields, such as spatial planning, surface mapping, or monitoring predictions or natural disaster events. In concept, GIS has three main elements consisting of a system, information, and geography [5]. The AHP technique is a method that can help find problem solutions by conducting pairwise comparisons between factors. AHP is often chosen in problem solving because of its various advantages. First, AHP has a hierarchical structure that allows decomposing the problem to the most detailed sub-criteria, making the problem more structured and systematic. Second, AHP considers validity up to the tolerance limit of inconsistency in the decision-making process. Third, AHP takes into account the robustness of results through sensitivity analysis, allowing evaluation of how small changes in inputs can affect the final outcome [6].

Based on Figure 1, this research is divided into three data processing flows, namely making basic maps, analyzing development classifications based on land capabilities, analyzing regional typologies, and mapping the direction of waterfront city-based area development. Pleiades satellite data was used to create a base map with an RDTR mapping approach in the Prapatan coastal area, Balikpapan City. The method used is on-screen digitization. Land capability parameter data consists of topography, morphology, elevation, soil type, watershed hydrology, rainfall intensity, land use, and natural disaster maps. Based on the parameter data, the land ability unit will be identified to obtain the results of the analysis of the land capability map. The method used in this processing is the AHP method to determine the weight value of each land ability unit. The typological analysis of Prapatan Subdistrict was carried out to identify the characteristics of the area, which was reviewed through several indicators such as population nests. The results of the overall study are used as a consideration in determining the direction of waterfront city-based area development.

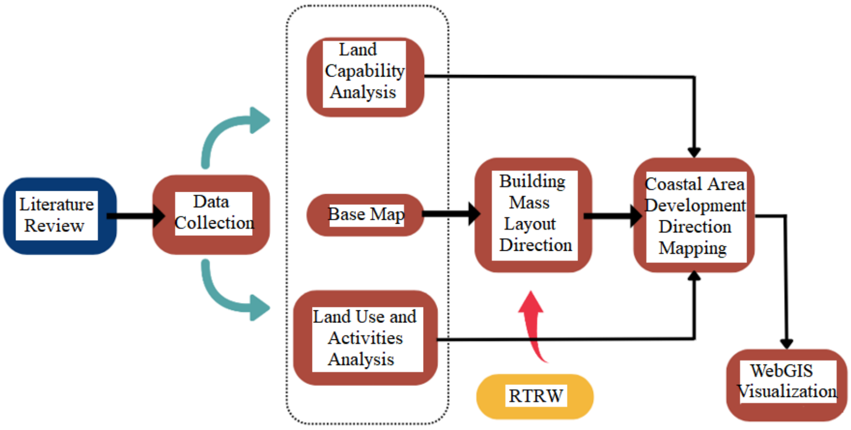


Figure 1. Flow chart of the research

2.1 Study Area

The scope of the research area is the coastal area of Prapatan Subdistrict, Balikpapan City, East Kalimantan Province, and more precisely in part of the corridor of Jenderal Sudirman Street. Prapatan Subdistrict is one of five subdistricts in the Balikpapan Kota District. This sub-district has geographical conditions that are directly adjacent to the beach [7].

Based on Figure 2, the astronomical location of Prapatan Subdistrict is at 116.8185 East Longitude (BT) and -1.2724 South Latitude (LS) with an area of 442.47 ha. This sub-district consists of 38 RTs. The number of residents in Prapatan Subdistrict in 2020 amounted to 11,677 people and consisted of 4,118 families. The male population is 5,899 people, and the female population is 5,778 people [8]. There are several classifications of land in coastal areas that are included in the case study area, such as industrial areas, marine and historical tourism, sports, open spaces, and housing. Around the coastal waters there is a small island called Bawui Malawai Island (Pig Island), which is in the form of a rock mound.

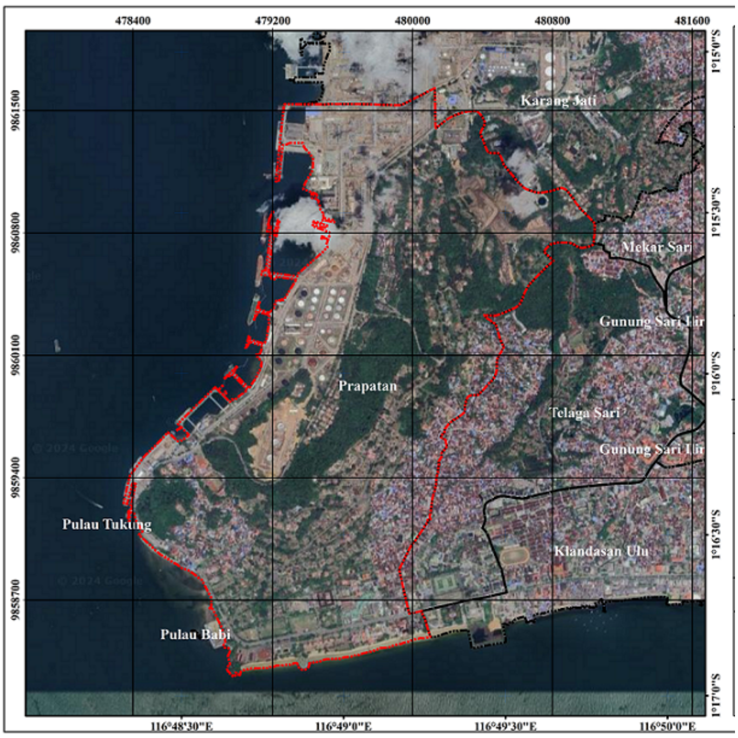


Figure 2. Map of study area

Table 1. Research data

Analysis	Variable	Sub Variables	Format	Source
Basemap Mapping	Base map	Land use	Vector map	Satellite imagery of the Pleiades
		Building	Vector map	Bappeda of Balikpapan City
		Road network	Vector map	Satellite imagery of the Pleiades
Development Zone	Land capability weighting	-	Questionnaire interview	Interview with DPU Balikpapan City
	Morphology	Slope (%)	DEM data	BIG
		Height (m)	DEM data	BIG
	Ease of work	Height (m)	DEM data	BIG
		Slope (%)	DEM data	BIG
		Surface geology (Soil type)	Vector map	Bappeda of Balikpapan City
		Land use	Ultra-high-resolution satellite imagery	BRIN
		Rock geology (Permeability)	Vector map	Kementerian ESDM dan Hidrogeologi Global Univ. Victoria
	Slope stability	Height (m)	DEM data	BIG
		Slope (%)	DEM data	BIG
		Surface geology (Soil type)	Vector map	Bappeda of Balikpapan City
		Land use	Ultra-high-resolution satellite imagery	BRIN
		Rock geology (Permeability)	Vector map	Kementerian ESDM dan Hidrogeologi Global Univ. Victoria
		Rainfall (mm)	Rainfall intensity data	BMKG
	Foundation stability	Rock geology (Permeability)	Vector map	Kementerian ESDM dan Hidrogeologi, Global Univ. Victoria
		Surface geology (Soil type)	Vector map	Bappeda of Balikpapan City
		Land use	Ultra-high-resolution satellite imagery	BRIN
	Water availability	Water service area	Vector map	PDAM of Balikpapan City
		Rainfall (mm)	Rainfall intensity data	BMIKG
		Slope (%)	DEM data	BIG
		Land use	Ultra-high-resolution satellite imagery	BRIN
		Slope (%)	DEM data	BIG
		Height (m)	DEM data	BIG
		Rock geology (Permeability)	Vector map	Kementerian ESDM dan Hidrogeologi, Global Univ. Victoria
		Surface geology (Soil type)	Vector map	Bappeda of Balikpapan City
		Land use	Ultra-high-resolution satellite imagery	BRIN

Continued

	Land resistance to erosion	Erosion rate map	Vector map	DLH
		Land use	Ultra-high-resolution satellite imagery	BRIN
	Land resilience to natural disasters	Landslide	Vector map	BPBD of Balikpapan City
		Flood	Vector map	BPBD of Balikpapan City
	Land capacity unit for drainage	Slope (%)	DEM data	BIG
		Height (m)	DEM data	BIG
		Rock geology (Permeability)	Vector map	Kementerian ESDM dan Hidrggeolegi, Global Univ. Victoria
		Surface geology (Soil type)	Vector map	Bappeda of Balikpapan City
		Land use	Ultra-high-resolution satellite imagery	BRIN
		Rainfall (mm)	Rainfall intensity data	BMKG
Waterfront City Concept	Classification of development zones	Results of Land Capacity Analysis	Vector map	Results of the author's analysis
	Land use	Base map	Vector map	Results of the author's analysis
	Regional Spatial Plan (RTRW)	Classification of regional spatial plans	Vector map	Bappeda of Balikpapan City
Development Concept Direction Reviewed from Building Mass Planning	Waterfront city concept	Results of Land Capacity Analysis	Vector map	Results of the author's analysis
	Building mass planning regulations	Building Base Coefficient	Balikpapan City RTRW Regulation Document	Bappeda of Balikpapan City
		Building Floor Coefficient		
		Height Building		
Land Use and Activities	Population density	Population data	Subdistrict Profile Document	Prapatan Subdistrict Office
		Area	Vector map	Bappeda of Balikpapan City
	Building density	Total of buildings	Vector map	Bappeda of Balikpapan City
		Area	Vector map	Bappeda of Balikpapan City
	Road network density	Road network	Vector map	Results of the author's analysis
		Area	Vector map	Bappeda of Balikpapan City
	Centrality index	Public facilities	Vector map	Google Earth, Survei Lapangan dan Verifikasi Instansi
		Strategic objects	Vector map	Google EaOpen Green Space, Survei Lapangan dan Verifikasi Instansi
	Connectivity index (Beta)	Road network	Vector map	Results of the author's analysis
	Entropy index	Land use	Vector map	Results of the author's analysis
	Building mass planning	Building Base Coefficient	Vector map	Bappeda of Balikpapan City
		Building Floor Coefficient	Vector map	Bappeda of Balikpapan City

2.2 Data Preparation and Collection

At this stage, observations were made on the existing environmental conditions of the coastal area of Prapatan, Balikpapan City. Discussions with several related parties are needed to find out the picture of environmental phenomena that occur in the area. The following data used in this study are as follows:

1. Balikpapan City RTRW data for 2012-2032. The data is based on aerial photo data from the Balikpapan City Bapeda Agency.

2. Tetrarectified Pleiades High-Resolution Satellite Images (CSRT) according to the study area from the LAPAN Agency.

3. Balikpapan City Basic Building Coefficient policy data.

4. Parameter data to analyze the direction of regional development based on land capabilities and land allocation criteria for tourism support facilities are available in Table 1.

2.3 Basic Map Processing

The basic data used as a basemap is a very high-resolution satellite imagery of Pleiades in the study area of Prapatan Subdistrict, Balikpapan City. The method used in this processing is the digitization on-screen method, which refers to the technical guidelines of Perka BIG No. 16 of 2014 concerning the creation of a basic map of spatial details using the ArcGIS spatial application. Figure 3 displays the basic mapping process in the Prapatan Subdistrict.

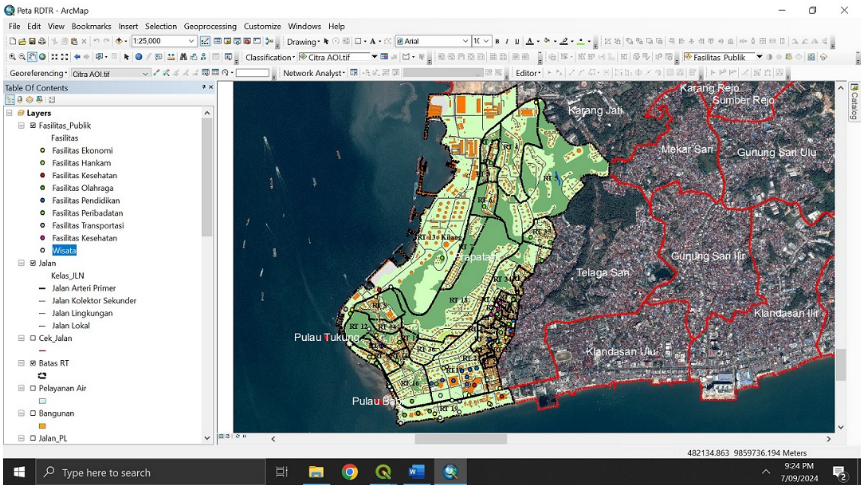


Figure 3. The process of mapping the base map in Prapatan Subdistrict

2.4 Weighting with the AHP Method in Regional Development Zones

The method used in determining the weighting value of the regional development zone is the AHP method. This method uses the opinions of 4 expert respondents from the Bappeda Agency and the Balikpapan City Public Works Office. Meanwhile, the scores obtained use references from several previous relevant studies.

The basic procedures carried out using the AHP method are [9]:

1. Hierarchical Arrangement

The preparation of the hierarchy is carried out to find the structure of a system and its relationships between components and their influence on a system. This aims to describe the influencing elements of the system and obtain identified decision alternatives [9].

2. Determining Priorities

Each criterion or alternative that has been obtained needs to be analyzed in a pairwise comparison matrix. This matrix compares criteria with each other in pairs so that element-level values will be obtained through expert opinions converted into quantitative data [10].

3. Consistency Testing

The consistency test was carried out to get the weight value obtained from the calculation results to see whether it was consistent or not. The consistency test is a weight value test by calculating deviations from the consistency of the value, and the deviation is called the consistency index (CI) [9].

$$CI = \frac{\lambda_{\max - n}}{n - 1} \tag{1}$$

where,

$\lambda_{\max}$: Maximum eigen value;

n: Matrix size.

In the concept of consistency test, the value of CI is compared with the random index (RI) for each n objects [11]. In the concept of consistency test, the CI value is compared with the random index (RI) for every n objects. n objects are the number of parameters used in the research. Number of parameters (n) 1 has an RI value of 0.00. Number of parameters (n) 2 has an RI value of 0.00. Number of parameters (n) 3 has an RI value of 0.58. Number of parameters (n) 4 has an RI value of 0.90. Number of parameters (n) 5 has an RI value of 1.12. Number of parameters (n) 6 has an RI value of 1.24. Number of parameters (n) 7 has an RI value of 1.32.

The comparison matrix will be acceptable if the consistency ratio (CR) value ≤ 0.1. This value illustrates that the expert's answer is consistent so that the solution obtained can be optimal. CR is the result of a comparison between CI and RI [12]. The following is the calculation to obtain the CR ratio.

$$CR = \frac{CI}{RI} \tag{2}$$

where,

CI: Consistency index;

RI: Random index.

After weighting and processing AHP, the weight value and score of each land capability parameter can be obtained in Table 2.

Table 2. Results of weighting of land capacity parameters

Weight of Criteria	Criteria	Priority Criteria
0.235	Morphologicalland capability unit	1
0.078	Unit of land capability ease of working	6
0.152	Land capability unit slope stability	3
0.046	Unit of land capability foundation stability	7
0.228	Unit of land capability water availability	2
0.116	Unit of land capability for drainage	4
0.038	Unit of land capability to erosion	8
0.109	Unit of land capability to natural disasters	5
1.000	**Total Weight**	

The weighting results in Table 2 show that the highest priority land capability unit is morphology with a weight value of 0.235, and the lowest priority is erosion with a weight value of 0.038. The result of the geometric weighting mean has a ratio consistency value of < 0.01, which is 0.040, which means that the CR value meets the criteria. This weight value will be used as a weighting reference in the process of determining the classification of regional development.

2.5 Land Capacity Unit Analysis

Land capability is the assessment of land according to its components systematically and its grouping into several classifications based on characteristics that are potential and obstacles in its sustainable use. The classification of land capacity is influenced by land characteristics in determining land quality so that it can be used in determining appropriate land allocations for both agriculture and non-agriculture [13].

Based on the Regulation of the Minister of Public Works No.20/PRT/M/2007 concerning technical guidelines for the analysis of physical and environmental, economic, and socio-cultural aspects in the preparation of spatial plans, to assessing regional capabilities can be done by analyzing land capacity units. The analysis of the land capability unit is divided into 8 aspects: morphological land capability unit, unit of land capability ease of working, land capability unit slope stability, unit of land capability foundation stability, unit of land capability water availability, unit of land capability for drainage, unit of land capability to erosion and unit of land capability to natural disasters [14].

In general, in the analysis of each unit of land capacity, scoring and weighting are carried out in accordance with the previous research score and the results of the weight from AHP for each parameter and multiplication between the score value and weight. The multiplication results are summed against all parameters of each aspect of the land capability unit. This operation uses an overlay technique on vector data. Table 3 shows the parameter data used for the analysis of land capacity along with score and weight values.

Table 3. Land capability unit score and weight

Input Data	Class	Score	Weight
	Morphological Land Capability Unit		
Slope (%)	0-8	5	0.235
	8-15	4	
	15-25	3	
	25-45	2	
	> 45	1	
Height	Less (0-17 m)	5	
	Low (17-36 m)	4	
	Keep (36-55 m)	3	
	High (55-75 m)	2	
	Very high (75-103 m)	1	
	Unit of Land Capability Ease of Working		
Height (m)	Less (0-17 m)	5	0.078
	Low (17-36 m)	4	
	Keep (36-55 m)	3	
	High (55-75 m)	2	
	Very high (75-103 m)	1	
Slope (%)	0-8	5	
	8-15	4	
	15-25	3	
	25-45	2	
	> 45	1	
Surface geology (soil type)	Aluvial glei soil, planossol, grey hydremorph, groundwater literite	5	
	Latosol	4	
	Brown forest soil, non-calcic	3	
	Andosol, laterictic gromusol. podsolik	2	
	Regosel, litosol grganosel renzine	1	
Land use	Built land	1	
	Non-built land	2	
Rock geology	Highly permeable	5	
	Quite permeable	4	
	Less permeable	3	
	Very less permeable	2	
	Impermeable	1	
	Land Capability Unit Slope Stability		
Height (m)	Less (0-17 m)	5	0.152
	Low (17-36 m)	4	
	Keep (36-55 m)	3	
	High (55-75 m)	2	
	Very high (75-103 m)	1	
Slope (%)	0-8	5	
	8-15	4	
	15-25	3	
	25-45	2	
	> 45	1	
Surface geology (soil type)	Aluvial, glei soil, planossol, grey hydromorph, groundwater literite	5	
	Latosol	4	
	Brown forest soil, non-calcic	3	
	Andosol, laterictic gromusel, podsolik	2	
	Regosol, litosol organosol renzine	1	

Continued

Input Data	Class	Score	Weight
	Built land	1	
Land use	Non-built land	2	
	Highly permeable	5	
	Quite permeable	4	
Rock geology	Less permeable	3	
	Very less permeable	2	
	Impermeable	1	
	0-1000	5	
	1000-2000	4	
Rainfall (mm)	2000-3000	3	
	3000-4000	2	
	> 4000	1	
	Unit of Land Capability Foundation Stability		
	High	5	
Slope stability land ability unit	Enough	4	
	Keep	3	
	Less	2	
	Low	1	
	Highly permeable	1	
	Quite permeable	2	
Rock geology	Less permeable	3	
	Very less permeable	4	0.042
	Impermeable	5	
	Aluvial, glei soil, planossol, grey hydromorph, groundwater literite	5	
Surface geology (soil type)	Latosol	4	
	Brown forest soil, non-calcic	3	
	Andosol, laterictic gromusol, podsolik	2	
	Regosol, litosol organosol, renzine	1	
	Built land	1	
Land use	Non-built land	2	
	Unit of Land Capability Water Availability		
Water availability	Areas served by clean water	2	
	Areas not served by clean water	1	
	0-1000	1	
	1000-2000	2	
Rainfall (mm)	2000-3000	3	
	3000-4000	4	
	> 4000	5	
	0-8	5	0.228
	8-15	4	
Slope (%)	15-25	3	
	25-45	2	
	> 45	1	
	Built land	2	
Land use	Non-built land	1	
	Unit of Land Capability for Drainage		
	0-8	5	
	8-15	4	
Slope (%)	15-25	3	
	25-45	2	
	> 45	1	

Continued

Input Data	Class	Score	Weight
Height (m)	Less (0-17 m)	5	0.116
	Low (17-36 m)	4	
	Keep (36-55 m)	3	
	High (55-75 m)	2	
	Very high (75-103 m)	1	
Rock geology	Highly permeable	5	
	Quite permeable	4	
	Less permeable	3	
	Very less permeable	2	
	Impermeable	1	
Surface geology (soil type)	Aluvial, glei soil, planosssol, grey hydromorph, groundwater literite	1	
	Latosol	2	
	Brown forest soil, non-calcic	3	
	Andosol, laterictic gromusol, podsolik	4	
	Regosol, litosol organosol renzine	5	
Land use	Built land	1	
	Non-built land	2	
Rainfall (mm)	0-1000	5	
	1000-2000	4	
	2000-3000	3	
	3000-4000	2	
	> 4000	1	
	Unit of Land Capability to Erosion		
Erosion rate map	Very light (< 15 tons/ha/year)	5	0.038
	Light (15-60 tons/ha/year)	4	
	Medium (60-180 tons/ha/year)	3	
	Heavy (180-480 tons/ha/year)	2	
	Very heavy (> 480 tons/ha/year)	1	
Land use	Built land	1	
	Non-built land	2	
	Unit of Land Capability to Natural Disasters		
Landslide	Very high	1	0.109
	High	2	
	Enough	3	
	Less	4	
	Very less	5	
Flood	Very high	1	
	High	2	
	Enough	3	
	Less	4	
	Very less	5	

Table 4. Classification of development zones

Land Classification	Description	Referral
Zone A	Very low development capabilities	Directions to become protected areas due to low land capability levels.
Zone B	Low development capabilities	
Zone C	Medium development capabilities	Instructions to be a buffer area.
Zone D	High development capabilities	The directive becomes a development area zone because it has a high level of land capability.
Zone E	Highly developed capabilities	

The classification of regional development zones is carried out to obtain final recommendations on land suitability for regional development. In the analysis of the development zone, the ability of the land that has been cultivated previously is used. The method used to determine the classification of this land is the overlay technique with intersect. All total values of each land capability unit will be summed up and classified into regional development zones from those that have the potential to be developed to those that are less likely to be developed. The zoning in the analysis of land capacity is divided into five classes to find out the areas that have the highest to lowest development potential presented in the following Table 4 [15].

2.6 Analysis of Land Use and Activities

The analysis of land use and activities in the Prapatan Subdistrict uses spatial patterns from several data sources, namely population density, building density, road network density, centrality index, connectivity index, and entropy index.

1. Population density

Population density is a measure of the ratio of the number of people to the area [16].

2. Building density

Building density analysis is one of the indications of a compact city. The higher the building density, the more characteristic the service center [17].

3. Road network density

The analysis of road network density is the ratio between road length and area [18].

4. Centrality index

The centrality index is an analysis of service functions spread across the study area in relation to various population activities to take advantage of these facilities [19]. This analysis uses data input in the form of the number of each type of facility which is then weighted into a function index.

5. Connectivity index

Beta index analysis serves to measure the level of road network connectivity in an area. The higher the Beta value, the greater the connectivity value in an area [20]. The environmental carrying capacity in encouraging the success of pedestrian mobility in an area is measured through the walkability index. One of the factors is by using the land use entropy index analysis. The higher the entropy value, the easier it is for pedestrians to access destinations without having to move far from the area [21].

6. Entropy index

The entropy index is a tool used to measure the level of land use diversity by considering the relative percentages of two or more types of land use in an area. The value of the entropy index shows how balanced land use is in an area compared to other land uses in the same area. Areas that have a uniform proportion of land use will reach the maximum value on the entropy index. This index only measures the presence or absence of land use variation, not the type or intensity of the mixture. The value ranges from 0 until 1 [22].

2.7 Building Mass Analysis

The direction of building mass planning in the Prapatan Subdistrict refers to the building mass policy of the Regional Spatial Plan (RTRW) of Balikpapan City. The mass system used is the Basic Building Coefficient , the Building Floor Coefficient, and the maximum height of the building.

2.8 Web-Based Digital Mapping

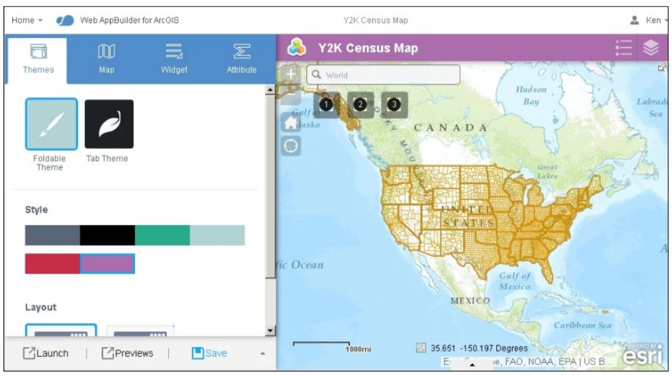


Figure 4. ArcGIS Web App Builder

Digital maps are the presentation of geographical phenomena that are stored and analyzed by digital computers. Every element present on a digital map will be stored as a component of geometry, such as coordinates. Objects in the form of locations with point symbolization will be stored as a coordinate, while objects in the form of areas or lines will be stored as a set of coordinate points. Digital maps have an advantage when compared to analog maps, namely they have not much map storage space. Digital maps can also be presented in a more interactive format with web-based [23]. Figure 4 is the ArcGIS Web App Builder platform used to design the WebGIS [24].

Web-based digital mapping was created using ESRI's ArcGIS Online platform. This digital map was created with the intention to help provide visualization of research results in the form of a digital map so that it is more informative to present a large number of mapping forms along with attributive data at the same time.

2.9 3D Model

A 3D model is a visual representation of an object from a three-dimensional point of view. There are 3 axes of coordinates in a three-dimensional model, namely the x, y, and z axes. This makes three-dimensional models have space and volume, in contrast to 2D models that only have length and width [25].

Nowadays, 3D urban modeling focuses more on the geometric representation of buildings, although non-building objects also play an important role in the process of urban development. Thematic non-building objects, such as tunnels, bridges, vegetation, urban furnishings, and water bodies, contribute to the modeling. In particular, 3D vegetation models are needed as visualization and analysis tools in various fields, as well as a basis for urban design simulations, such as urban greening, air quality conservation, and flood mitigation [26].

The 3D model was created using CityEngine software. The area that will be modeled is the Prapatan Subdistrict. The object of three-dimensional modeling consists of buildings and roads.

3 Results and Discussion

3.1 Base Map Results

This base map contains all elements visible on the surface of satellite imagery data, which generally includes administrative boundaries of urban subdistricts obtained from Bappeda of Balikpapan City and RT boundaries from the government of Prapatan Urban Subdistrict of Balikpapan City. In addition, other objects are identified, such as road networks, water, and land cover.

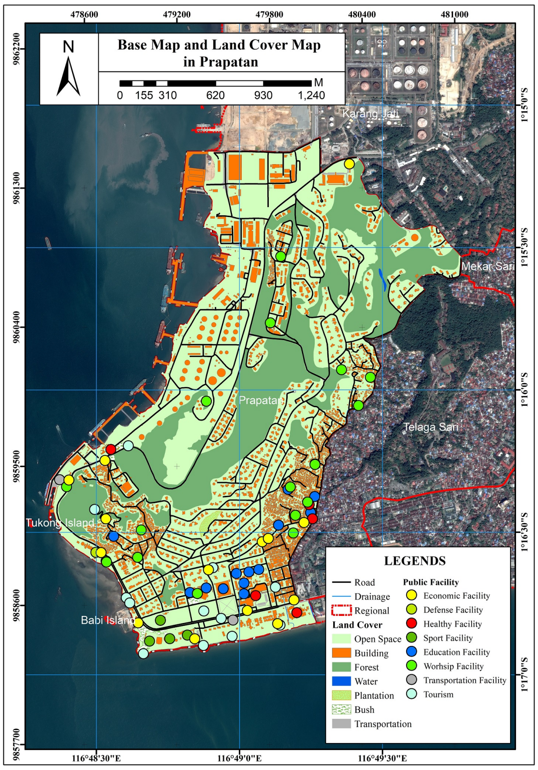


Figure 5. Base map

Based on Figure 5, the Kelurahan has 38 RTs, with 1 RT being the Pertamina RU V Oil Refinery area of Balikpapan City. The RT with the largest area is RT 13, or the Oil Refinery area, with an area composition of 25.337% or 110.984 hectares of the total area of the Kelurahan, and the smallest RT area is in RT 29 with an area composition of 0.153% or 0.669 hectares. Meanwhile, the land cover element is seen to have a variety of land types ranging from open areas, green open spaces, residential buildings, public facility buildings, transportation, waters, and vegetation. The dominating land type in Prapatan Subdistrict is yard area, with a land composition of 44.869% or 196.543 ha, and the smallest land area is found in pond land, with a land composition of 0.011% or 0.050 ha.

The road network consists of 4 road classifications, namely primary arterial, secondary collector, neighborhood, and local roads. These classifications have been adjusted to the Balikpapan City RTRW document. The longest accumulated road type is in the neighborhood road type, and the shortest road is in the secondary collector road.

Public facilities in Kelurahan Prapatan consist of education, health, worship, economy, sports, defense and security, transportation, and tourism facilities. The most facilities are found in economic facilities with 14, and the least number of facilities is defense and security with only 1 object. Overall, the total number of public facilities is 61, with 12 tourist objects. When viewed visually, public facilities and tourist objects are spread out.

3.2 Mapping of Land Capability Units

Land capability unit analysis is carried out to identify the characteristics of physical and environmental aspects so that the development of the area/region can be carried out optimally and still pay attention to the balance of the ecosystem. There are several aspects that are analyzed in the land capability unit, namely as follows.

3.2.1 Morphological land capability unit

The morphological land capability unit analysis was carried out to determine the shape of the landscape or the level of morphology in the Prapatan Subdistrict area that has the potential for development. This land capability unit considers two parameters, namely slope and land elevation. Figure 6 is the result of the analysis of land capacity units from the morphological aspect in Prapatan Subdistrict.

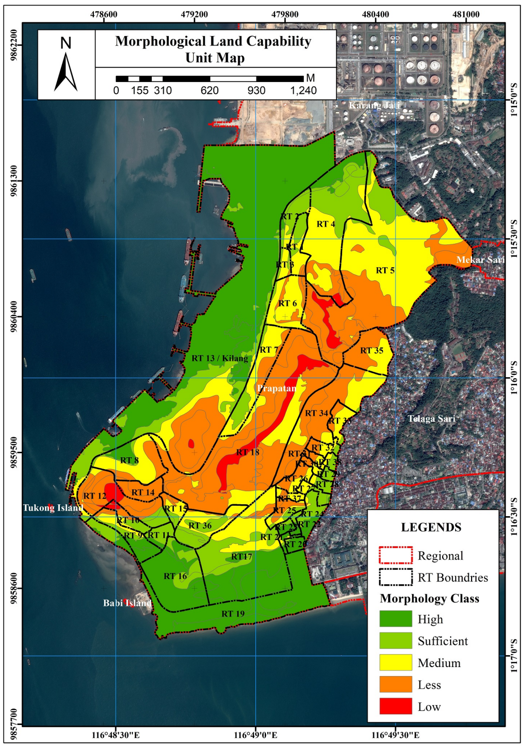


Figure 6. Morphological land capability unit

Table 5. Morphology percentage

Morphology Class	Area (ha)	Percentage
Low capability morphology sufficient	11.105	2.535
Land capability morphology less	120.580	27.527
Medium morphology land capability	102.306	23.356
Land capability morphology sufficient	65.126	14.868
High morphological land capability	138.918	31.714
Total	**438.034**	**100.000**

Based on Table 5, the Prapatan Subdistrict has a high morphological land capability that dominates with a percentage of 31.714% or 138.918 ha. While the area with low morphological land capability is the smallest percentage of 2.535% or 11.105 ha of the total area.

3.2.2 Unit of land capability ease of working

The analysis of the ease of working land capability unit was carried out to obtain the level of ease of land in Kelurahan Prapatan to be explored or finalized during the development process. This land capability unit considers several parameters, including altitude, slope, surface geology, rock geology, and land use. Figure 7 below is the result of the analysis of land capacity units from the ease of working aspect in the Prapatan Subdistrict.

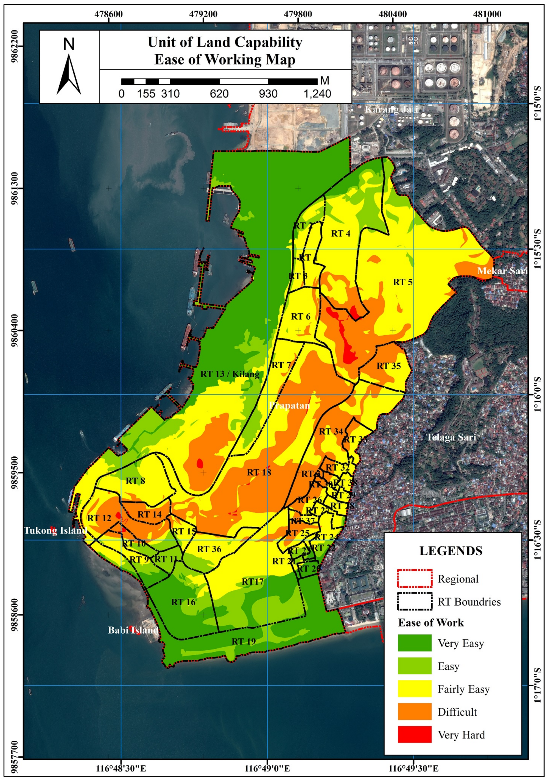


Figure 7. Unit of land capability ease of working

Table 6. Ease of working percentage

Ease of Working Class	Area (ha)	Percentage
Very hard to do	14.787	3.376
Difficult to work	81.289	18.558
Fairly easy to work with	180.380	41.179
Easy to do	55.254	12.614
Very easy to do	106.324	24.273
Total	**438.034**	**100.000**

Based on Table 6, the Prapatan Subdistrict has a level that is quite easy to work on, which dominates with a percentage of 41.179% or 180.380 ha, while the level that is very difficult to work on has the smallest percentage with a value of 3.376% or 14.787 ha. This shows that Kelurahan Prapatan has the potential to be developed because it is dominated by land that is quite easy to work on.

3.2.3 Land capability unit slope stability

The slope stability land capability unit analysis was carried out to obtain the level of safety in Prapatan Subdistrict in accepting above-ground loads in the event of development. It considers several parameters, such as elevation, slope, surface geology, rock geology, land use, and rainfall. In the following, Figure 8 is the result of the analysis of land capacity units from the slope stability aspect in Prapatan Subdistrict.

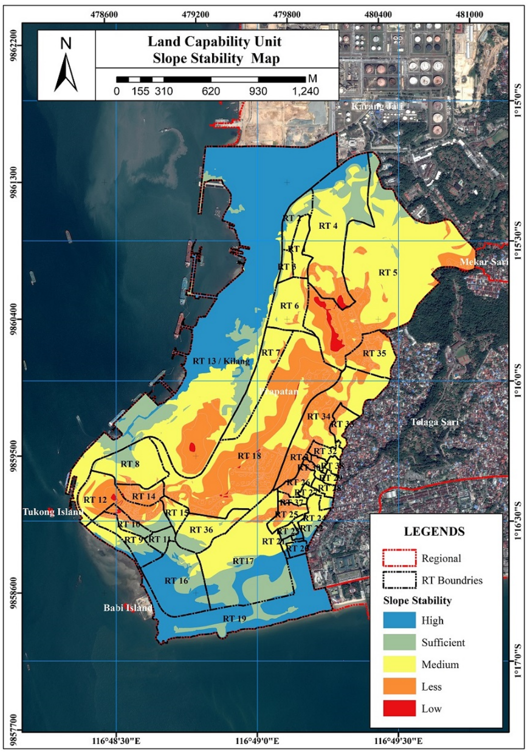


Figure 8. Land capability unit slope stability

Table 7. Slope stability percentage slope stability percentage

Slope Stability Class	Area (ha)	Percentage
Low slope stability	2.636	0.602
Less slope stability	93.188	21.274
Medium slope stability	178.492	40.748
Sufficient slope stability	55.496	12.669
High slope stability	108.221	24.706
Total	**438.034**	**100.000**

Based on Table 7, the Prapatan Subdistrict is classified as medium slope stability with a percentage of 40.748% or 178.492 ha. Low slope stability has the smallest percentage of 0.602% or 2.636 ha.

3.2.4 Unit of land capability foundation stability

The foundation stability land capability unit analysis was conducted to determine the level of land capability in Prapatan Subdistrict in maintaining the foundation structure when receiving heavy building loads above it. This land capability unit considers several parameters, such as slope stability, rock geology, surface geology, and land use. Figure 9 is the result of the analysis of land capacity units from the foundation stability aspect in the Prapatan Subdistrict.

Based on Table 8, Prapatan Subdistrict has the largest percentage of foundation stability in the less foundation stability class at 32.430% or 142.054 ha. The smallest percentage of foundation stability is in the high foundation stability class at 2.075% or 9.089 ha. It can be seen that the ability of land in the Prapatan Subdistrict is still relatively unstable to withstand foundation structures.

3.2.5 Unit of land capability water availability

The water availability land capability unit analysis was conducted to obtain the level of water availability to support regional development and water supply capability. The land capability unit considers several parameters, such as water service area, rainfall, slope, and land use. Figure 10 is the result of the analysis of land capacity units from the water availability aspect in the Prapatan Subdistrict.

Based on Table 9, water availability in Kelurahan Prapatan is dominated by the medium class with a percentage of 25.358% or 111.077 ha and the smallest percentage of water availability is in the sufficient class of 13.430% or 58.827 ha.

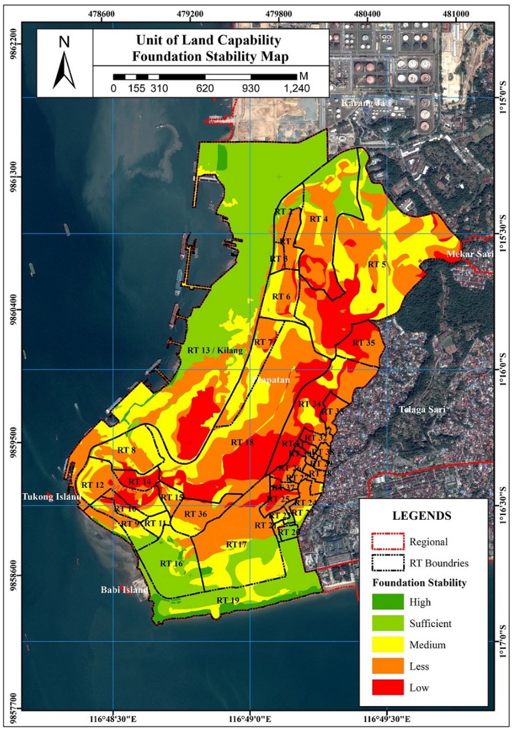


Figure 9. Unit of land capability foundation stability

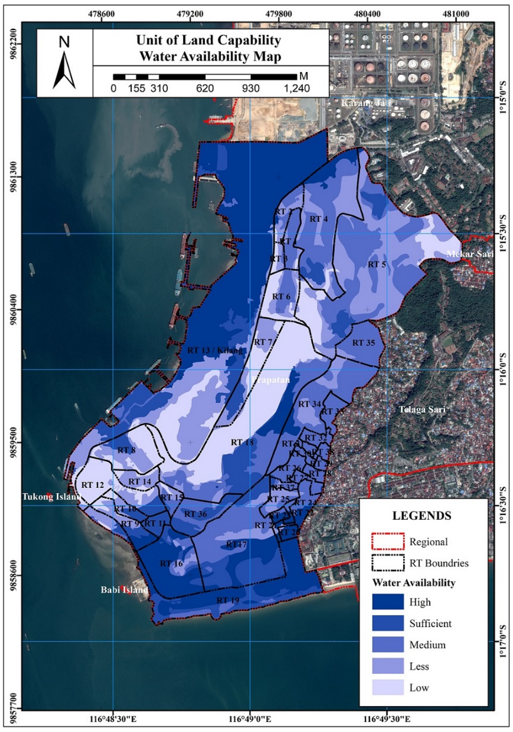


Figure 10. Unit of land capability water availability

3.2.6 Unit of land capability for drainage

The drainage land capability unit analysis was conducted to determine the level of land's ability to naturally infiltrate water so that localized inundation can be avoided. It considers several parameters, namely slope, elevation, rock geology, surface geology, rainfall, and land use. Figure 11 is the result of the analysis of land capacity units from the natural drainage aspect in the Prapatan Subdistrict.

Table 8. Foundation stability percentage

Foundation Stability Class	Area (ha)	Percentage
Low foundation stability	65.577	14.971
Less foundation stability	142.054	32.430
Medium foundation stability	111.537	25.463
Sufficient foundation stability	109.776	25.061
High foundation stability	9.089	2.075
Total	**438.034**	**100.000**

Table 9. Water availability percentage

Water Availability Class	Area (ha)	Percentage
Low water availability	66.152	15.102
Water availability less	94.040	21.469
Medium water availability	111.077	25.358
Sufficient water availability	58.827	13.430
High water availability	107.938	24.641
Total	**438.034**	**100.000**

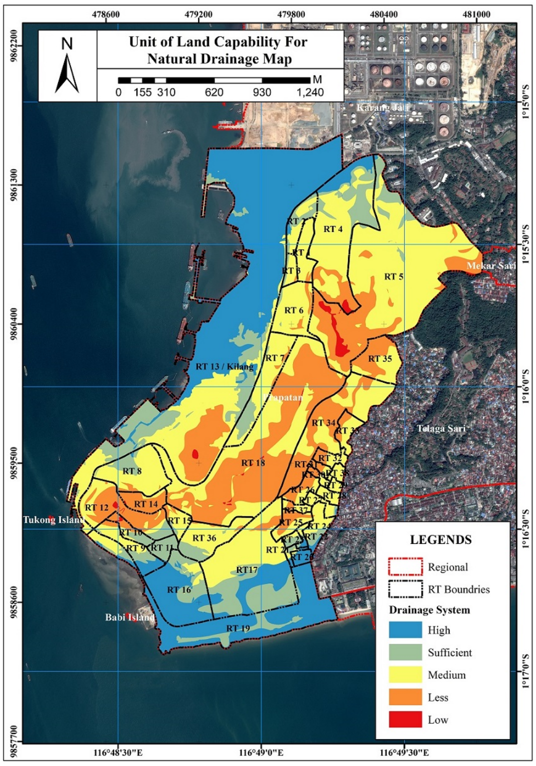


Figure 11. Unit of land capability for drainage

Table 10. Drainage percentage

Drainage Class	Area (ha)	Percentage
Low drainage capability	2.636	0.602
Less drainage capability	93.114	21.257
Medium drainage capability	149.857	34.211
Sufficient drainage capability	62.668	14.307
High drainage capability	129.758	29.623
Total	**438.034**	**100.000**

Based on Table 10, land capability in natural drainage in Kelurahan Prapatan is dominated by the medium class with a percentage of 34.211% or 149.857 ha and the lowest drainage capability is at a percentage of 0.602% or 2.636 ha.

3.2.7 Unit of land capability to erosion

The land capability unit analysis of erosion was conducted to determine the level of land resistance to erosion and the level of soil erosion in Prapatan Subdistrict. This land capability unit considers several parameters, namely the level of erosion and land use. Figure 12 below is the result of the analysis of land capacity units from the erosion aspect in the Prapatan Subdistrict.

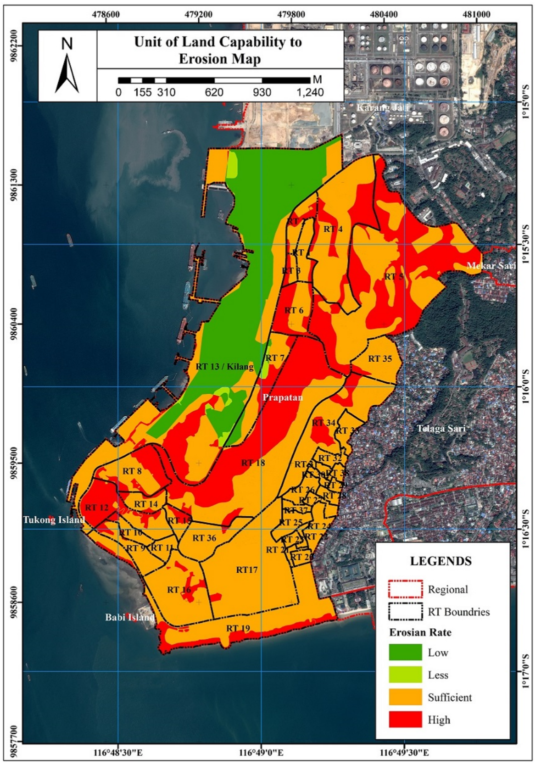


Figure 12. Unit of land capability to erosion

Table 11. Erosion percentage

Erosion Resistance Class	Area (ha)	Percentage
Low erosion resistance	65.011	14.842
Less erosion resistance	3.145	0.718
Medium erosion resistance	256.358	58.525
High erosion resistance	113.520	25.916
Total	**438.034**	**100.000**

Based on Table 11, the ability of land to erode in the Prapatan Subdistrict is still classified as sufficient with a percentage of 58.525% or 256.358 ha, while the ability of land to erode with the lowest percentage is in the less class with a composition of 0.718% or 3.145 ha.

3.2.8 Unit of land capability to natural disasters

The analysis of land capability unit on natural disasters is carried out to determine areas that have a level of resilience to the vulnerability of natural disasters that can be dangerous. This land capability unit is analyzed using natural disasters that have the potential to occur in the Prapatan Subdistrict, namely landslides and floods. Figure 13 is the result of the analysis of land capacity units from the natural disasters aspect in the Prapatan Subdistrict.

Based on Table 12, land capability against natural disasters in the Prapatan Subdistrict is still dominated by the low class with a percentage of 35.948% or 157.462 ha, while the land capability against natural disasters with the lowest percentage is in the sufficient class with a composition of 14.314% or 62.699 ha. When viewed from the percentage of land, the ability of land to natural disasters in the Prapatan Subdistrict district is still low, so it is very potential for natural disasters, especially landslides.

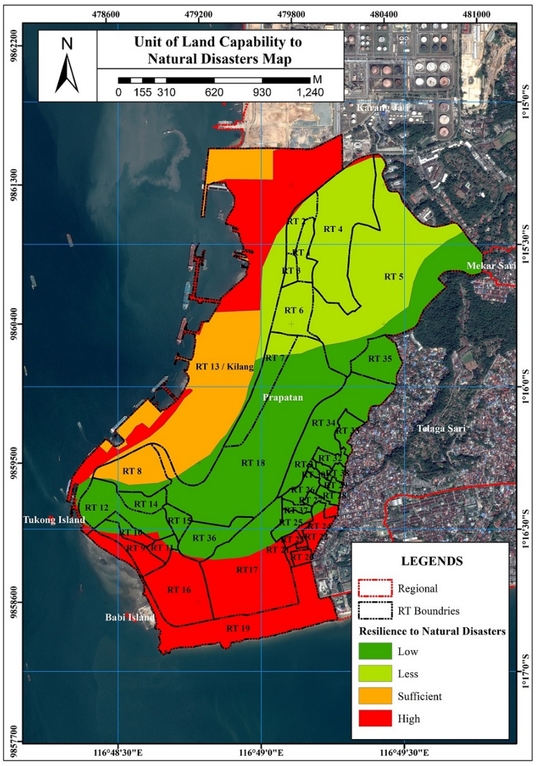


Figure 13. Unit of land capability to natural disasters

Table 12. Natural disaster percentage

Natural Disaster Resilience Class	Area (ha)	Percentage
Low natural disaster resilience	157.462	35.948
Natural disaster resilience less	98.535	22.495
Natural disaster resilience sufficient	62.699	14.314
High natural disaster resilience	119.338	27.244
Total	**438.034**	**100.000**

3.3 Regional Development Classification

The results of the classification of area development were obtained from the analysis of all land ability units, namely morphology, ease of work, slope stability, foundation stability, water availability, drainage, erosion, and natural disasters. This classification provides an overview of the suitability of areas that are suitable for development as cultivation areas and protected areas. Figure 14 is the result of the classification of development in the Prapatan Subdistrict.

Based on the results of the development classification shown in Figure 14, Prapatan Subdistrict has 5 classes of areas that are reviewed from their land capabilities, namely class A is a very low development ability class, class B is a low development ability class, class C is a medium development ability class, class D is a high development ability class, and class E is a very high development ability class. Classes A and B are recommended for protected areas because they are areas that have low development capabilities and are designated as non-building areas; class C is a buffer, and classes D and E are areas with great potential to be developed. In Table 13, the following are the results of the development classification percentage.

The development classification with the highest land composition is class C, with a percentage of 31.846% or 139.496 ha, and the second highest is class A, with a percentage of 31.520% or 138.070 ha. Meanwhile, the development class with the lowest composition is class E, with a percentage of 2.569% or 11.255 ha. This shows that the land in the Prapatan Subdistrict has the potential to be developed as a buffer area.

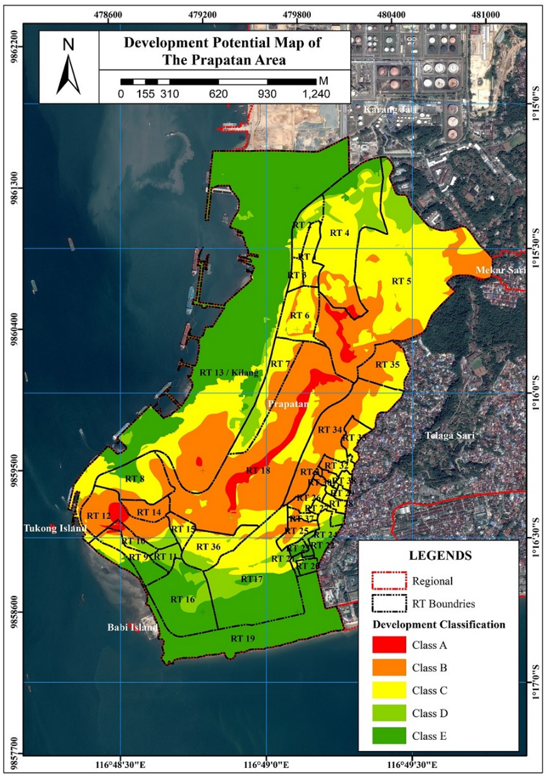


Figure 14. Development classification map

Table 13. Development classification percentage

Development Classification	Area (ha)	Percentage
Class E	11.255	2.569
Class D	115.140	26.286
Class C	139.496	31.846
Class B	34.073	7.779
Class A	138.070	31.520
Total	**438.034**	**100.000**

3.4 Analysis of Land Use and Activities

The use of land in the Prapatan Subdistrict is quite varied in both the built and non-built areas. This land use was obtained from the results of land cover classification analysis that had been carried out using Pleiades satellite images. Figure 15 is the result of a land use map in the Prapatan Subdistrict.

Based on the results of visualization on the land use map, several land classifications were obtained, namely forest areas, industrial areas, commercial areas, coastal areas, fruiting areas, residential areas, industrial housing areas, and green open space areas. The largest land composition is in an industrial residential area with a percentage of 28.945% or 126.787 ha. The industrial housing is housing used as a residence for employees of PT Pertamina RU V Balikpapan. The land with the smallest composition is in the coastal area with a percentage of 0.890% or 3.899 ha. The beach area is an area of beach sand and beach boundary. In Table 14, it shows the percentage value of each land in the Papatan Subdistrict.

The analysis of land use and activities in the Prapatan Subdistrict presented in Figure 16 also considers several aspects, namely population density, building density, road network density, centrality index, connectivity index, and spatial plan policy direction.

The RT areas that have the highest level of population density, road network density, centrality index, and connectivity are 11 RTs located in RTs 11, 21, 22, 23, 26, 27, 29, 30, 32, 37, and 38. RT areas that have density levels and indigo indices in the medium class are 17 RTs located in RTs 1, 2, 3, 6, 7, 8, 9, 10, 14, 15, 20, 24, 25, 28, 31, 33, and 35. Meanwhile, RT areas that have a low level of density and index value are 10 RTs located in RTs 4, 5, 12, 13, 16, 17, 18, 19, 34, and 36. Figure 17 is the result of the analysis of activities in the Prapatan Subdistrict.

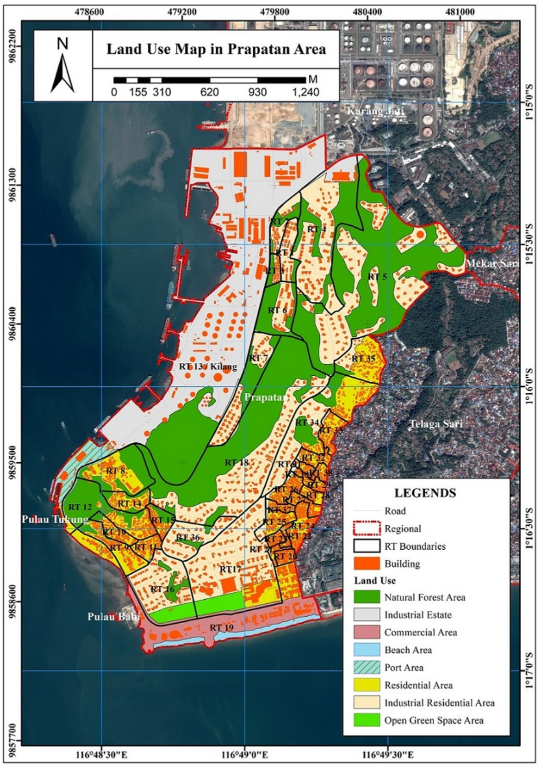
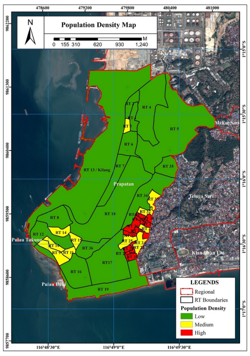
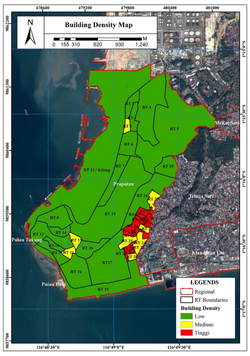


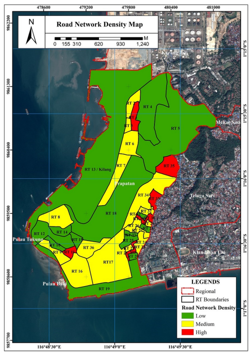
Figure 15. Land use map



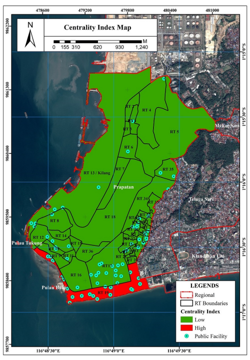
(a)



(b)



(c)



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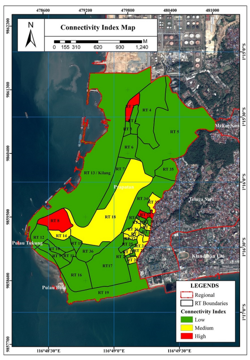


(e)

Figure 16. Activity parameters (a) Population density map; (b) Building density map; (c) Road network density map; (d) Centrality index map; (e) Connectivity index map

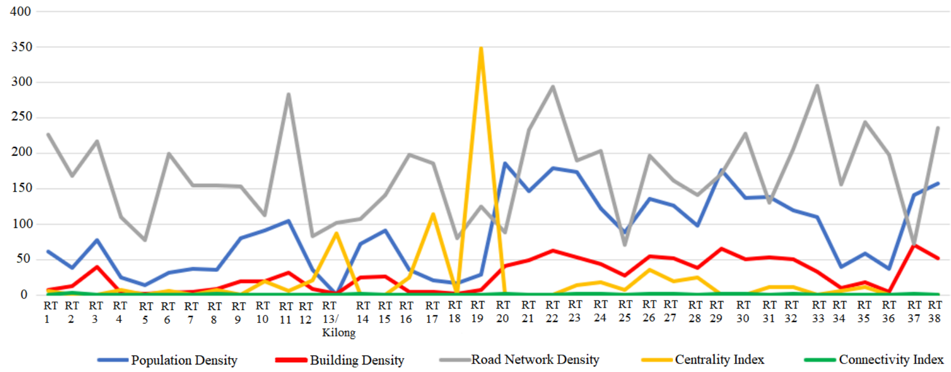


Figure 17. Regional characteristics graph

Table 14. Land use percentage

Land Classification	Area (ha)	Percentage
Residential areas	62.467	14.261
Open green space area	5.837	1.333
Natural forest areas	122.581	27.984
Industrial estate	92.448	21.105
Industrial residential area	126.787	28.945
Port area	6.015	1.373
Beach area	3.899	0.890
Commercial area	18.001	4.109
Total area	**438.034**	**100.000**

Based on the results of the analysis of land use and activities in Prapatan Subdistrict, it was obtained that this area has a diverse land use pattern, which can be seen from the high value of the diversity index (entropy). The results of the calculation of the entropy index value in Prapatan Subdistrict have a value of 0.775, which is visualized in Figure 15. The most dominant land use is forest areas and industrial employee housing. Existing activities consist of social activities in residential areas, production and trade activities and services in commercial areas, and tourism activities in several objects such as beach tourism, history, and sports. The level of mobility activity is supported by a well-conditioned road network, having public transportation for the Trans Balikpapan Bus and sea transportation in the form of piers and city ports.

3.5 Building Mass Mapping

The direction of building mass planning in Prapatan Subdistrict refers to the building mass policy of the Regional Spatial Plan (RTRW) of Balikpapan City. The mass system used is the Basic Building Coefficient , the Building Floor Coefficient, and the maximum height of the building. In Figure 18, it shows a map of the direction of the Basic Building Coefficient in Prapatan Subdistrict.

Based on the visualization of the Basic Building Coefficient map, the ratio of the total land area to the land allowed to be built is at least 20% for urban forest areas and open green space, and Basic Building Coefficient 80% are in high-density residential areas and trade and services. There is 1 area reviewed from existing buildings that have a total building area that exceeds the Basic Building Coefficient standard, namely buildings located in urban forest areas with a difference of 2.314%. Table 15 shows the values of the area and percentage of Basic Building Coefficient.

Figure 19 shows a map of the direction of the Building Floor Coefficient in the Prapatan Subdistrict.

Based on the visualization of the Building Floor Coefficient map, the ratio of the total floor area of the building that can be built with a minimum of 0.2 and a maximum of 4.0 is the land area controlled. The area of the Building Floor Coefficient with the highest percentage is 81.203% or 355.695 ha with the direction of Building Floor Coefficient 4.0, while the land area of the Building Floor Coefficient with the lowest percentage is 0.072% or 0.314 ha with the direction of Building Floor Coefficient 2.1. In Table 16, it shows the values of the area and percentage of the Building Floor Coefficient.

Figure 20 shows a map of the maximum building height in the Prapatan Subdistrict.

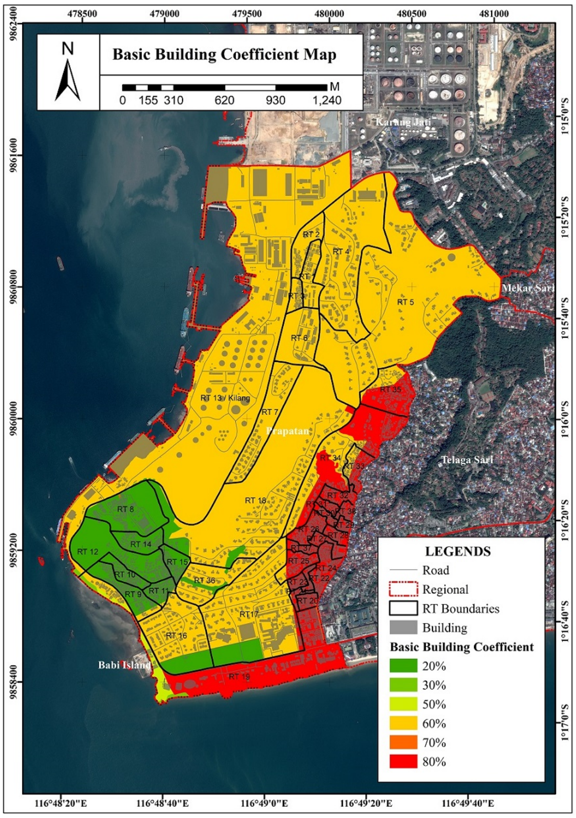


Figure 18. Basic Building Coefficient map

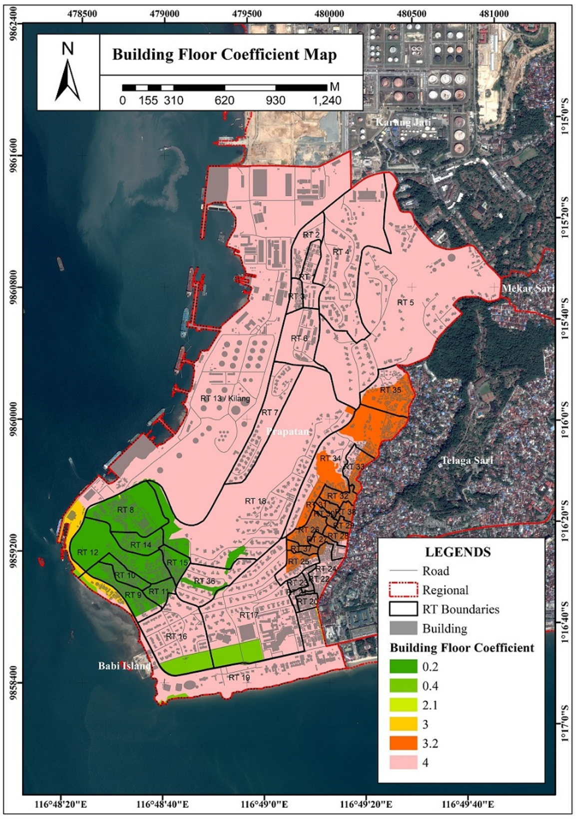


Figure 19. Building Floor Coefficient

Table 15. Conformity of building basic coefficients

Region	Basic Building Coefficient	Area (ha)	Existing Buildings	Building Area (ha)	Ratio (%)	Ratio Total (%)	Notes
Urban forest area	20%	39.279	Hankam building	0.711	1.810	22.314	Not suitable
			Education building	0.088	0.225		
			Buildings of worship	0.177	0.452		
			Office buildings	0.302	0.769		
			Residential buildings	7.339	18.683		
			Social buildings	0.117	0.299		
			Utility building	0.030	0.076		
City green open space area	20%	7.378	Residential buildings	0.033	0.447	0.447	Suitable
Coastal border area	30%	0.930	No existing buildings	0.930	-	-	-
Tourism area	50%	2.681	Sports buildings	0.167	6.232	16.248	Suitable
			Tourism and entertainment building	0.096	3.577		
			Buildings of worship	0.008	0.310		
			Residential buildings	0.089	3.313		
			Transportation building	0.076	2.817		
Large industrial estate	60%	324.836	Hankam building	0.010	0.003	14.414	Suitable
			Industrial buildings	13.172	4.055		
			Health building	1.041	0.321		
			Education building	2.282	0.702		
			Service trading building	0.028	0.009		
			Buildings of worship	0.488	0.150		
			Office buildings	1.292	0.398		
			Residential buildings	20.632	6.351		
			Social buildings	0.015	0.005		
			Transportation building	7.666	2.360		
			Utility building	0.194	0.060		
Port area	60%	4.666	Hankam building	0.046	0.978	20.574	Suitable
			Industrial buildings	0.156	3.341		
			Tourism and entertainment building	0.025	0.537		
			Buildings of worship	0.035	0.743		
			Office buildings	0.023	0.484		
			Residential buildings	0.310	6.633		
			Social buildings	0.041	0.872		
			Transportation building	0.326	6.985		
Defense and security zone	70%	0.314	Tourism and entertainment building	0.000	0.089	31.119	Suitable
			Office buitdings	0.026	8.339		
			Residential buildings	0.071	22.691		
High-density residential areas	80%	29.771	Hankam building	0.001	0.003	33.911	Suitable
			Health building	0.034	0.115		
			Education building	0.082	0.277		
			Buildings of worship	0.081	0.272		
			Residential buildings	9.887	33.211		
			Utility building	0.010	0.034		

Continued

Trade and service zone	80%	28.177	Hankam building	0.005	0.018	32.292	Suitable
			Health building	0.752	2.670		
			Sports buildings	0.188	0.669		
			Tourism and entertainment building	0.553	1.964		
			Government buildings	0.366	1.299		
			Education building	0.257	0.911		
			Service trading building	0.077	0.273		
			Buildings of worship	0.430	1.526		
			Office buildings	0.156	0.555		
			Residential buildings	5.849	20.757		
			Social buildings	0.447	1.587		
			Utility building	0.018	0.065		

Table 16. Building Floor Coefficient percentage

Region	Building Floor Coefficient	Area (ha)	Percentage
Urban forest area	0.2	39.279	8.967
City open green space area and coastal boundary	0.4	8.308	1.897
Defense and security zone	2.1	0.314	0.072
Port area	3.0	4.666	1.065
High-density residential areas	3.2	29.771	6.797
Large industrial estate, tourism, trade and services	4.0	355.695	81.203
Total		**438.034**	**100.000**

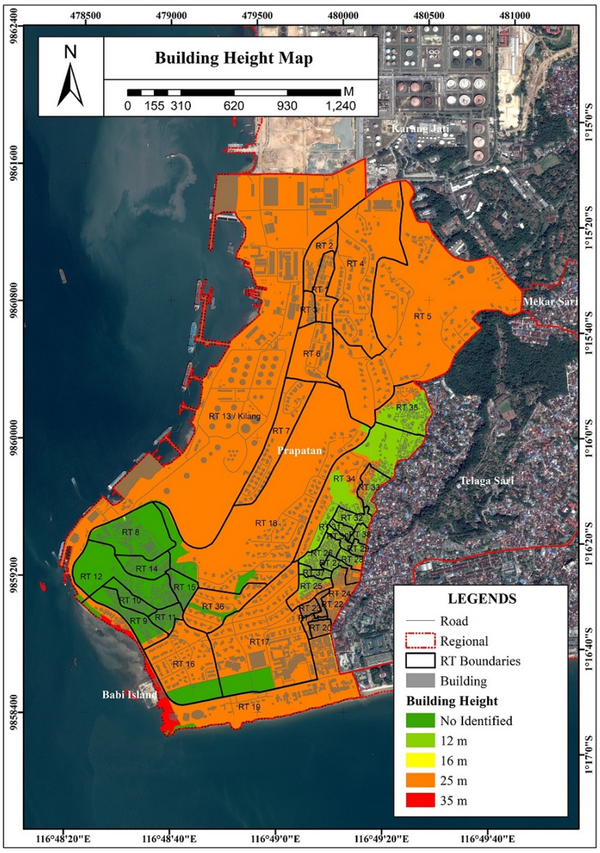


Figure 20. Building height map

Based on the visualization of the direction map, the maximum building height allowed is 16 meters, and the maximum height is 35 meters. The composition of the highest land area is 81.656% or 357.680 ha with a building height of 25 meters, and the lowest land area composition is 0.072% or 0.314 ha with a building height of 16 meters. The height of the building is unknown, with a land composition of 10.864% or 47.588 hectares, namely on urban forest land and open green space. Table 17 shows the value of the area and percentage of the maximum building height rule in the Prapatan Subdistrict.

Table 17. Building height percentage

Region	Building Height (Max)	Area (ha)	Percentage
Urban forest area, coastal boundary and open green space	-	47.588	10.864
High-density residential areas	12 m	29.7710046	6.797
Defense and security zone	16 m	0.314	0.072
Large industrial estates, ports, trade and services	25 m	357.680	81.656
Tourism area	35 m	2.681	0.612
Total		**438.034**	**100.000**

Based on the results of the visualization of the building mass plan, the direction of the lowest building mass is the building class, which has a Basic Building Coefficient of 20%, a Building Floor Coefficient of 0.2, and the maximum building height is unknown where the land is an urban forest area. The direction of the highest building mass is Basic Building Coefficient 80%, Building Floor Coefficient 4.0, with a maximum building height of 35 meters, which is in the tourism area.

3.6 Waterfront City Development Mapping

Prapatan Subdistrict is a subdistrict located in a coastal area, so it can have the potential to be developed as a waterfront city area. There are several conditions if an area can be developed with the concept of a waterfoil city, namely the location that is planned to be developed is on the edge of a large water area, there are residential areas, trades, ports, and tourist attractions or attractions, it has the main function as a port area, residential, industrial, and tourism/recreation, and development plans are based on water [27]. Construction is carried out in a vertical direction. In Table 18, the followings are the results of identifying the suitability of the implementation of the waterfront city concept in Prapatan Subdistrict, Balikpapan City.

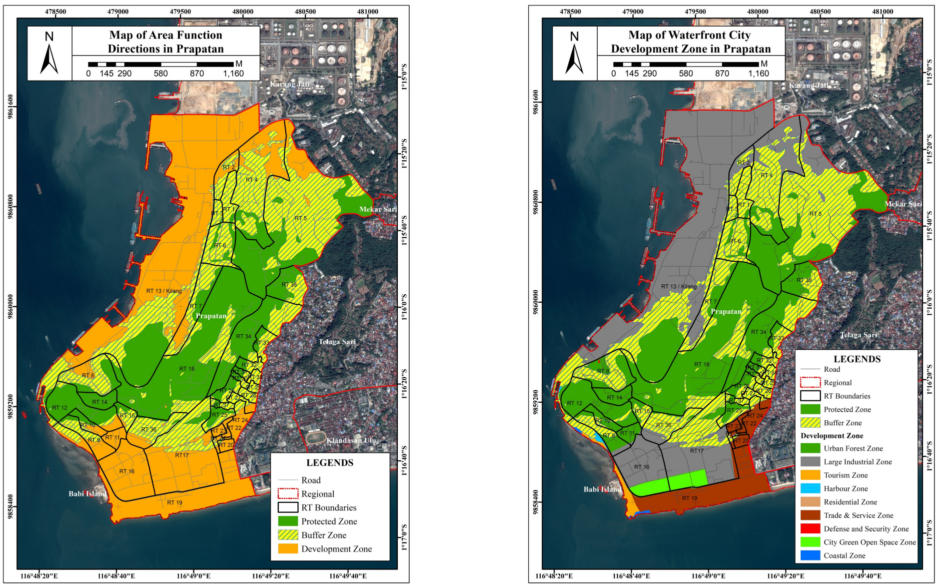
Table 18. Waterfront city development requirements

Criteria	Yes	No	Description
The location that is planned to be developed is on the edge of a large water area.	✓		The geographical condition of Prapatan Subdistrict is directly adjacent to the waters on the shore of Balikpapan Bay.
There are residential, commercial, port, and tourist attractions or attractions.	✓		Prapatan Subdistrict has a residential area designation from dense to low-lying residential areas. Low-density residential areas are residential areas for employees of PT. Pertamina RU V Balikpapan. High density of settlements is the residence of local residents. The trade and service area consists of shops and culinary places. This subdistrict also has the city's main port, namely Semayang Port or industrial pier. In addition, it has the potential for marine tourism, history, and artificial tourism. Based on the results of data collection, this subdistrict has 12 tourist locations and various activities in it.
It has the main function as a port, residential, industrial, and tourism/recreation area.	✓		Based on the Regional Spatial Plan (RTRW), Prapatan Subdistrict is intended for several regional functions, namely urban forest areas, large industries, tourism, transportation, trade and services, defense & security, green open spaces, and coastal borders.

Continued

Water-based development plan	✓	Based on the RTRW document, Prapatan Subdistrict is included as an area that is allowed for the development of coastal reclamation. Reviewed from the typology of Prapatan Subdistrict, the typology of this area is the longitudinal (linear) type following the beachfront pattern, and the building pattern follows the road network pattern so that some areas have an orientation towards the waters. In addition, based on a literature study, Prapatan Subdistrict is included as part of the area where coastal reclamation will be carried out and the coastal road development plan will be based on the waterfront area.
Construction is carried out in a vertical direction.	✓	Based on the RTRW document, the high percentage of Basic Building Coefficient (80%) in residential areas is directed vertically with a maximum building height of 25 meters, especially in high-density residential areas such as RTs 21, 22, 23, 26, 27, 29, 30, 31, 32, 37, and 38. The direction of the highest building height is in the tourism zone. Some other areas that are directed to be developed vertically are trade and service areas and industrial areas.

Based on the results of the identification of the criteria for the potential development of Prapatan Subdistrict towards waterfront city, these criteria have been met both in terms of geographical conditions, regional characteristics, and based on government policies reviewed from the Regional Spatial Plan (RTRW) so that Prapatan Subdistrict has great potential to implement regional development with the waterfront city concept. Waterfront city is an urban environment located on the edge of or adjacent to waters, such as in large port areas in metropolitan cities [28]. The results of the mapping of recommendations for the direction of waterfront city-based development areas are presented in Figure 21 below.



(a) (b)

Figure 21. Mapping of waterfront city-based area development (a) Regional development function direction; (b) Waterfront city development zone in Prapatan

In subgraph (a) of Figure 21, the results of the analysis of the direction of the function of the area are divided into three classifications of designated zones, namely protection zones, buffer zones, and cultivation. The dominating zone in this region is a cultivation area with a land composition of 39.299% or 172.143 ha. Development in cultivation areas can be directed to several regional activities reviewing existing land use, such as residential areas, green open spaces, industry, transportation, commercial, and tourism.

The results of the mapping of the direction of regional development in subgraph (b) of Figure 21 are based on the analysis of the level of land capability and the direction of the designation of the area in Prapatan Subdistrict whose development zone designation refers to the Regional Spatial Plan (RTRW). Zone D and zone E are zones that have high potential to be developed, and according to the designation of the area based on the RTRW, they are directed as urban forest areas, large industries, tourism, ports, trade and services, defense and security, housing, green open space, and coastal areas. Meanwhile, zone C is included as a buffer area that can be directed as a barrier between protected areas and cultivation areas where it is reviewed from the theory that the permitted land use is the development of people's plantation forests, plantations, and agroforestry with very minimal land cultivation. Zones A and B have low land capacity, so they are directed as protected areas. Previously, based on the spatial plan, in zones A and B there were several regional designations such as urban forest areas, most large industries, ports, trade and services, and housing, but after an analysis of the ability of land for the development of this area was included in zoning that had a low ability to be developed, this area was recommended to be included as a protected area. In Table 19, the following zoning recommendations and area designations according to the RTRW in the Prapatan Subdistrict are detailed.

Table 19. Recommended development zones

Zone Recommended	**Zone (RTRW)**	**Building Mass Layout Direction**			**Area (ha)**	**%**
		Building Base Coefficient	**Building Floor Coefficient**	**Max Building Height**		
Development Zone (172.143 ha)	Urban forest zone	20%	0.2	-	7.396	4.296
	Large industrial zone	60%	4.0	25 m	126.787	73.652
	Tourism zone	50%	4.0	35 m	2.632	1.529
	Harbour zone	60%	3.0	25 m	0.709	0.412
	Residential zone	80%	3.2	12 m	0.018	0.011
	Trade & service zone	80%	4.0	25 m	26.343	15.303
	Defense and security zone	70%	2.1	16 m	0.314	0.182
	City green open space zone	20%	0.4	-	7.378	4.286
	Coastal zone	30%	0.4	-	0.566	0.329
		Total			**172.143**	**100**
Buffer Zone (139.496 ha)	Buffer zone	Adjusting land use			139.496	100
		Total			**139.496**	**100**
Protected Zone (126.395 ha)	Protected zone	Protected zone			126.3949	100
		Total			**126.395**	**100**

Based on the results of the study, the area according to the RTRW that has the largest land allocation to be developed is a large industrial area with a percentage of 73.652% and a trade and service area with a percentage of 15.303%.

The results of the study on land use, activities, and directions for area allocation can be obtained so that Prapatan Subdistrict can be planned and developed with the category of mixed-use waterfront city. This can be specified in the following considerations.

1. Prapatan Subdistrict has a very high level of land capability for development in the coastal area with a total land composition of 39.299% or 172.143 ha.

2. This area is included as a City Service Center (PPK) area so that it has various strategic functions that can be developed in supporting social, economic, transportation, tourism, residential, or social and cultural activities.

3. The centrality index in the development zone (cultivation) is high. This can be seen from the large distribution of public facilities and strategic objects such as economic facilities, health, sports, education, worship, transportation, natural tourism, historical tourism, and defense and security. Reviewing this, the centrality index is able to provide an overview of the level of a region in supporting the development of various regional functions.

4. Prapatan Subdistrict has the majority of land use in forest areas and industrial housing, while according to the RTRW map, the most dominant areas are large industrial areas and urban forest areas. Based on the level of land composition, Prapatan Subdistrict can be directed to develop to focus on a residential waterfront or working waterfront. However, if Prapatan Subdistrict is only directed into one category of area, it will have an impact on the lack of social life and community activities as well as dependence on one economic source. Based on the Balikpapan

City RTRW document, Prapatan Subdistrict is directed into several regional functions such as commercial, health, and education so that, seeing this aspect, Prapatan Subdistrict can be directed to develop a mixed-use waterfront.

5. Prapatan Village is worthy of being directed to develop a mix-used waterfront as seen from the value of the land use diversity index (entropy) which is classified as having a high entropy index value. This indicates that land use in this area has land heterogeneity that will support the compactness of development and the balance of regional proportions. This type is a mixed use of waterfront areas such as docks, ports, trade and services, and so on [29].

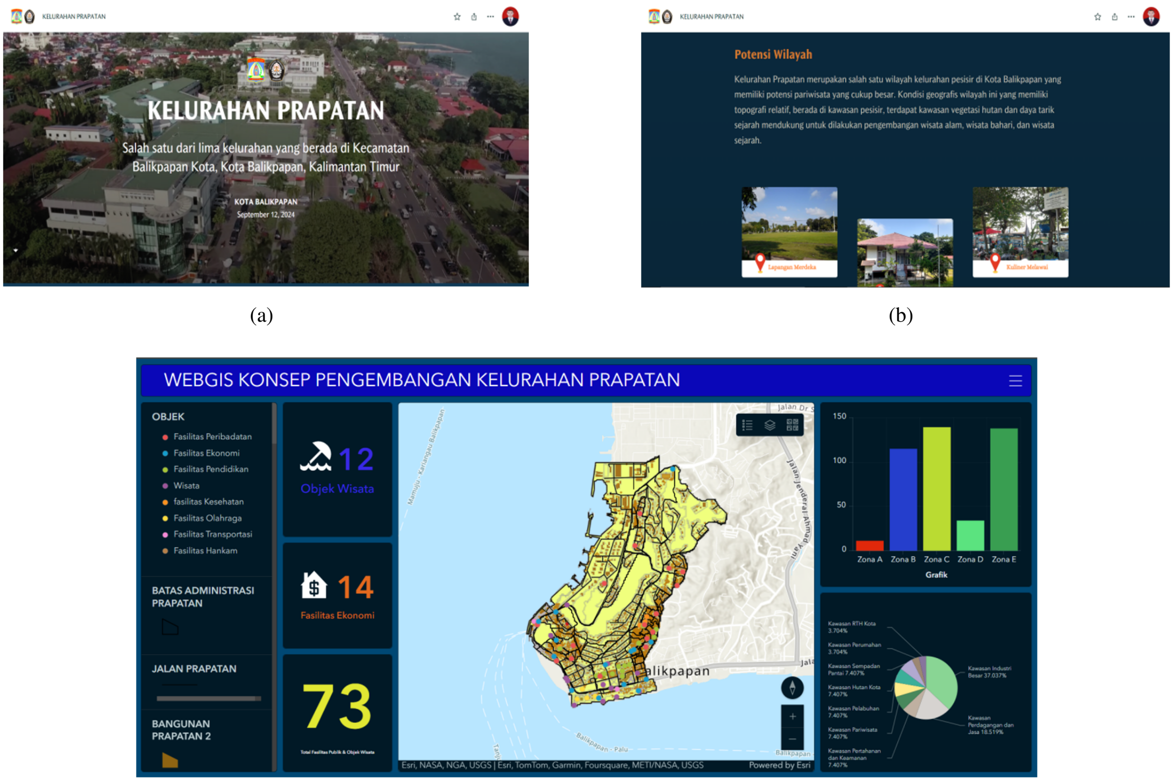
3.7 Web-Based Digital Maps (WebGIS)

Web-based digital map visualization is used to help present the results of research maps that are loaded into online maps so that they can be accessed by the public. The function of web GIS for urban planning has an important role, such as analyzing spatial distribution and supporting collaboration by various interested parties (government, community, private sector) because of the real-time and flexible nature of web GIS. In addition, web GIS can also be used as a monitoring medium in regional development planning and evaluation.

This WebGIS technology has been widely used in major cities in Indonesia such as Jakarta, Surabaya, Semarang, and other big cities. Many benefits can be obtained in urban planning monitoring and make it easier to identify regional problems without having to go directly to the field. This WebGIS can also make it easier for Prapatan Subdistrict to succeed in developing the concept of a smart city in Balikpapan City. So, it is hoped that the implementation of technology like this in Prapatan Subdistrict can also help efficiency for spatial planning of the area that is planned to be developed as a waterfront city. This can help a region pay attention to the aspect of sustainable development.

This visualization uses the ESRI platform, which combines the Dashboard WebMap feature with ArcGIS StoryMaps. The following is a display of the results of the online digital map that has been published.

Figure 22 below is the result of creating an online digital map consisting of profile information of Prapatan Subdistrict presented in ArcGIS story maps with the integration of online map presentation (dashboard). Story maps contain a profile of Prapatan Subdistrict, which contains a brief description of the subdistrict, physical and geographical conditions, regional potential, and a profile video. The dashboard displays the results of the layers of the research map that can be activated or deactivated on the layer menu. There is a basemap menu to change the basemap of the map you want to display, such as imagery, topography, or satellite. On the right side of the map, there is statistical data on the area of the development zone and the composition of the zone of the area.



(a)

(b)

(c)

Figure 22. WebGIS display (a) Cover display; (b) Institution profile information display; (c) Map dashboard display

3.8 3D Visualization of Building Mass Models

The 3D visualization of the model was obtained from the results of the automatic approach in the City Engine application and was only to help visualize the mass of buildings in the Prapatan subdistrict. This modeling is used to help visually represent urban planning from a more real existing condition. The disadvantage of this study is that it has not provided altitude values with good accuracy because it only relies on automatic extraction of altitude from available data. So, it is hoped that for FuOpen Green Spaceer research, it can use a method that has high accuracy in extracting building height data according to the actual value. The followings are the results of the visualization of 3D modeling presented in Figure 23.

Figure 23. 3D visualization of building mass planning model from multiple perspectives

The object of three-dimensional modeling consists of buildings and roads. The level of detail of the 3D model created is only up to the Level of Detail (LoD) 1 level, which only displays the shape of the building. Level of Detail (LoD) is very important in creating a 3D City Model because it serves as a work boundary and modeling goal. There are five levels of 3D detail in the Level of Detail (LoD) rule, where each level has a different level of detail. The higher the LoD level, the more detailed and accurate the 3D model will be, but the data acquisition cost will increase [30].

4 Conclusions

The conclusions of the results of this study are as follows.

1. Prapatan Subdistrict has 5 zones of development areas that are reviewed from their land capabilities, namely classes A, B, C, D, and E. Low development potential is in class A, and very high development is in class E. The development classification with the highest land composition is class C, with a percentage of 31.846% or 139.496 ha, and the second highest is class E, with a percentage of 31.520% or 138.070 ha. Meanwhile, the development class with the lowest composition is class A, with a percentage of 2.569% or 11.255 ha.

2. Based on the results of the analysis of land use and activities in Prapatan Subdistrict, it was found that this area has a diverse land use pattern, which can be seen from the value of the diversity index (entropy), which is in the high class. The most dominant land use is forest areas and industrial employee housing. Existing activities consist of social activities in residential areas, production and trade activities and services in commercial areas, and tourism activities in several objects such as beach tourism, history, and sports. The level of mobility activity is supported by a well-conditioned road network, having public transportation for the Trans Balikpapan Bus and sea transportation in the form of piers and city ports.

3. Based on the results of the visualization of the building mass plan, the direction of the lowest building mass is the building class that has a Basic Building Coefficient of 20%, a Building Floor Coefficient of 0.2, and the maximum building height is unknown where the land is an urban forest area. The direction of the highest building mass is Basic Building Coefficient 80%, Building Floor Coefficient 4.0, with a maximum building height of 35 meters, which is in the tourism area.

4. The results of the identification of development potential criteria show that Kelurahan Prapatan has the potential to be developed towards a waterfront city where the requirements have been met both in terms of geographical conditions and regional characteristics and based on government policies reviewed from the Regional Spatial Plan (RTRW). Zone D and zone E are zones that have high potential to be developed, and in accordance with the designation of the area based on the analysis of the RTRW and land use, it is directed as a residential area (industry and general public), industry, tourism, ports, trade and services, defense and security, green open space, and coastal boundaries. While zone C is included as a buffer area that is used as a barrier between protected areas and cultivation areas, it is reviewed from the theory that the allowed land use is the development of community plantation forests, plantations, and agroforests with very minimal land processing that can. Zones A and B have low land capability, so they are directed as protected areas. The results of the study of land use, activities, and direction of area designation can be obtained that Prapatan Subdistrict can be planned and developed with the category of mixed-use waterfront city.

5. This web-based digital map visualization uses an ESRI platform that combines the WebMap Dashboard feature with ArcGIS StoryMaps. In the dashboard view, the layers of the study area map and statistical data taken from the object area value are presented.

5 Research Advice

The suggestions in this study are as follows:

1. Using supporting data for the zoning of the RDTR spatial plan area so that the level of land allocation can be detailed.
2. It is hoped that this research can be continued by reviewing its carrying capacity.
3. The study of building massing directions is recommended to use a land plot map in order to obtain a value of conformity between existing conditions and the direction of government spatial policies.
4. In future research, it can be recommended to design a WebGIS that can provide a more interactive display.
5. In future research it is recommended to visualize in the form of a 3D Model, with detailed height values in order to have a specific picture of the building mass layout in terms of geometry.

Data Availability

The data used to support the research findings are available from relevant authors upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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