Transformations of Vernacular Geographies: Changes in the Morphology of Residential Areas of Sentani in Indonesia

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Abstract

Sentani is a city in Indonesia. Here, the problems are closely related to development and population, both in the city as well as the nearby vernacular settlements. One of these impacts is in the functions and utilization of land. As to be expected, changes in land use for one activity lead to reductions in the availability of land for the other uses. In fact, the higher the people's need for housing, the higher the need for land. In this context, this research examines the changes and use of residential land in the city of Sentani and how that transforms the vernacular geography.

The research focuses on the residential area within the Sentani City and employs purposive sampling to identify areas. It is qualitative descriptive research and uses geographic information system analysis. Variables such as land use, road patterns, buildings and open spaces are examined to determine the morphology changes in the city. Spatial analysis begins with a field survey utilizing the Global Positioning System (GPS) during field surveys, importing survey coordinate data. It then identifies satellite images in the form of aerial photos and adjust them to the results of data collection via GPS. Data is then processed using a computer equipped with Arc GIS software.

Findings show that there are significant changes in land use starting in 1994, at the beginning of the development of Sentani City, which includes land use for residential areas. It continues to increase yearly and absorbs the nearby vernacular spaces. The residential area, which was 305.95 Ha in 1994, became 660.66 Ha in 2003 expanding outwards. City development and land requirements have continued to increase for thirteen years. Land area for the settlement has changed from 1,040.84 Ha in 2013 to 1,562.91 Ha in 2023. The residential pattern is linear and follows a road. Subsequent developments show concentric patterns concentrated in several locations. Other morphological elements, with buildings has a dominant permanent form and has only a small non-permanent portion. Open spaces have experienced a reduction in area from 1994 to 2023 due to these land conversions.

Keywords: Morphology, Area, Settlement, Sentani City.

Introduction

Settlement is an activity of settling in a place resulting in a distinct relationship between people and their environment. Living needs not just a place of shelter and activities but also the establishment of self-identity. In these processes of settlement activities, there is a connection between the past and the present, and this continues to transform a settlement. During its development, there are always changes of settlers, either naturally or due to the mobility of people. People always come and go. This causes an area to experience development.

Development of a city is influenced by the growth and development of its population. A city is a physical container for all kinds of community activities and their various problems. Thus, almost always, a city experiences development as its residents change.

Sentani City has a heterogeneous population. There are not only local Papuans but also others from areas such as Java, Bugis and Madura. Thus, the problem of the development of the city of Sentani is closely related to changes in population. These invariably change the land functions. A reduction of land use in one aspect follows changes in in other types of land use. Thus, the higher the people's need for housing, the higher the need for land.

According to Jabareen (2006), cities are not only attractive to research, but urban sustainability needs to be researched continuously so that urban growth patterns become good and cities become livable. (Pramesti, 2017) also said that not all towns can grow sustainably; this is because the fundamental economic growth is no longer attractive or is declining.

Land use change is a transition from one use to another. One of the causes is the increase in population, which also impacts the need for housing, because the largest proportion of land use is for settlements. Needless to say, housing is a very important basic need in human life. Population development and growth, lead to changes in settlement patterns. Furthermore, a city will also experience natural physical changes from time to time. These changes in physical forms are known as morphology.

Changes in the morphology or physical appearances occur in almost all Sentani urban areas. Initially, it may only have been a vernacular rural area or a small town, but has experienced development over time. This has happened at the Sentani City, which initially only had the status of sub-district capital but is now experiencing quite rapid development. Therefore, an analysis of the morphological elements that influence these changes is needed to anticipate density and shifts in land function or physical conditions and settlement patterns there.

Most visible in the city of Sentani however is an irregular and high density of land use, resulting in an atmosphere that is not conducive to both movement and breathing. As a hot area, with increasing density, people suffocate in its atmosphere. Its character also needs more control and order often negatively affected by irregularly built stalls and buildings, which also change the function of land.

A comparison of the level of urban density shows that it does not make people's lives healthier. This is worsened due to the increasing shift or increase in population, Indonesia being a country with the fourth largest population in the world. As Seliari, (2024) points out that it is necessary to have physical arrangements and environmental improvements, to maintain the ecosystem of all the living creatures. They should not be carried out brutally Indeed, occupational patterns of the Javanese people also show more sensible characteristics that suit the needs of those who live there. If followed, there will be continuity and a sense of comfort in the cities and all settlements.

This paper is based on the premise that it is very important to design houses and spatial management to have sensible layouts based more on culturally appropriate patterns (Marlina, 2024). In this context, this research examines this phenomenon related to the shapes, arrangements and structures of the human settlements in Indonesia. Its aim

is to uncover the factors that influence them in order to reveal the factual conditions and predict the future trends.

Its objectives are as follows:

1. To produce a reference for the Government to manage the urban structure of Sentani City, Jayapura, more meaningfully.
2. To provide information for the community, especially Sentani City, about urban development in the area.
3. To determine how the morphology of the settlements in Sentani City, Jayapura, has changed.
4. To determine changes in land use and settlement patterns in Sentani City

Theoretical Framework

Morphology comes from the word morph, which means shape, so morphology is also defined as the physical appearance of an area (James & Bound, in Putri, et.al, 2016). The product of social change in the physical area is known as morphology. Morphology is the physical appearance of an area in terms of the structures that form certain forms of appearance. The physical appearance of morphology is not just shaped but also the relationship between regions (Dahal, Benner & Lindquist in Putri, et al., 2016).

One of the factors that influences city development is the shape and pattern of the city. The pattern of a city can describe the direction of development and physical form of the city. The spatial expression of city morphology can generally be divided into compact and non-compact forms (Yunus, 2001). Variations in the spatial expression of city morphology include square shapes (Nelson in Yunus, 2001), rectangular shapes, fan shapes, round shapes (Nelson in Yunus, 2001), ribbon shapes, octopus shapes, and patternless shapes (Northam in Yunus, 2001). In looking at morphology, there are three components: regional land use, which reflects regional activities; circulation patterns or road network patterns that connect between regions; and building patterns and their functions (Soetomo, 2009). Morphological components are structurally differentiated into road networks, plots and buildings.

They have a relationship or connection with one another. Morphological forms are divided into compact forms and non-compact forms. Compact shapes include square, rectangular, round, fan, ribbon and octopus shapes. Non-compact forms include fragmented, chain, split and stellar forms (Yunus, 2005). The characteristics of land use appearance in peripheral areas are built-up land with residential, service and industrial functions (Yunus, 2008). Land use in morphology is viewed from the composition of land use, which reflects mixed land use or not (Burtondalam Putri, et al., 2016).

Morphological Concepts

Morphological studies of residential areas often involve spatial and visual analysis to understand spatial patterns, distribution and relationships between elements in the area. This understanding aims to provide insight into the characteristics and dynamics of a residential area, which can be used as a basis for sustainable urban planning, development and management.

Understanding settlement morphology

Residential area morphology refers to the study of the shape structure and spatial patterns of a residential area, including the residential, commercial and public areas associated therein. This definition includes various physical and spatial elements of a residential area, such as a building layout, street patterns, open space arrangement, and architectural characteristics. Morphology of residential areas also considers how these elements develop over time and how they interact with each other. This involves understanding the historical development of the area, the social, economic, and political

changes that influenced its physical structure, and the environmental factors that has played a role in shaping that morphology.

Relationship between morphology and settlement

The relationship between morphology and settlements is important because morphology is a visual representation of a structure and spatial patterns of a residential area. This relationship can be explained in several aspects:

- **Spatial Planning and Building Layout**: The morphology of residential areas reflects a well-organized spatial layout and organized building layout. Good spatial planning can create a comfortable and functional environment for residents, while an orderly building layout can facilitate access and mobility within the area.
- **Land Function and Use**: The morphology of residential areas also reflects the existing land function and use. This can be reflected in building distribution patterns, activity zones (residential, commercial and industrial zones), and available public open spaces.
- **Social and Cultural Characteristics**: Morphology can also reflect the social and cultural characteristics of the people living in it. For example, traditional or modern architectural designs, open space arrangements, and cultural symbols in building designs can strengthen a community's identity and social ties.
- **Influence of the Natural Environment**: The morphology of residential areas is also influenced by natural environmental factors, such as topography, climate and vegetation. Residential areas in lowland areas may have a different layout pattern than mountain areas. Likewise, climate extremes may influence the design of buildings and the infrastructure used.

Morphological Theory

This research uses morphological theory of Trancik (?) to determine physical identification supported by the typo-morphological theory, which contains the architectural form of an area. As a city develops, urban morphology will also change following the town's development. Trancik's theory says that the theory of physical city space consists of figure-ground, linkage, and place, and these three theories complement each other.

The process of forming city morphology (urban morphology) is forming city life. Morphological theory refers to a collection of principles, concepts, and approaches used to understand and analyze an area or region's structure and shape patterns. In the context of settlements or cities, morphological theory focuses on the study of the physical, spatial, and functional structure of the area. It helps researchers, urban planners, and architects to understand the complexity of residential regions and cities. It provides a basis for making decisions in planning, developing, and managing cities that are more effective and sustainable.

In this context, a road network pattern is a collection of connected road networks that form a model. There are six road network patterns: grid pattern, radial pattern, radial ring pattern, spinal pattern, hexagonal pattern, and delta pattern (Morlok in Putri et al.,2016). Buildings are one of the morphological components; there are three patterns: homogeneous, heterogeneous, and diffuse (Zahnd Bound in Putri, et al, 2016).

To understand morphological changes, elements that influence them must be understood. In this connection, Shirvani (1985) points out that a morphology is based on physical elements in the form of land use, shapes and the masses of buildings, circulation and parking, open spaces, pedestrian paths, activity supports, information management and preservation. Salat (2012), adds that cities are founded on the perspective quality, public space design, plots of land, road networks, and visual sequences. Salat develops urban composition by showing the relationship between urban quality and typology,

making the city a place of memory and history and its buildings. However, in this research, only four morphological elements will be taken based on these opinions: land use, roads, buildings and open spaces.

Literature Review

Research into morphological changes are rare. Among them, Matin (2022) stand out. He examines the spatial structure pattern of Balikpapan City using a morphological approach. He employs a historical approach based on studying past literature and analysis of the Geographic Information System of Balikpapan City. He has found that the shape pattern of the city is compact with a linear orientation following the water edge of Balikpapan Bay. The morphology of the city structure is oriented towards the economic center, namely the Pertamina Oil Refinery. However, the visual morphology of Balikpapan City does not have any notable landmarks apart from the Islamic center mosque, sports center dome, and the Balikpapan stadium.

On the other hand, Martiono (2022) offers an nalysis of Batam City of Sei Jodoh Village. He shows that morphology is an approach to understanding the physical form of urban space and areas where in its realization, the concept of urban morphology can be seen as a change from the city history. The metamorphosis of Kampung Jodoh, which at the beginning was a traditional fishing village with thousands of stilt houses with plank walls and thatched roofs, now stand with a significant shift making Kampung Jodoh a busy center and traditional trading center in Batam.

These studies into cities show that they are already progressing and modern. Meanwhile, more morphological research into towns still need to be developed.

Research Methodology

Approach

This research employs a case study and aims to explain changes in the morphology and patterns of residential areas in Sentani City. It employs purposive sampling: the location is a selected residential area with urban characteristics in the Sentani City area. It generates qualitative spatial data. The variables used to determine changes in city morphology are land use, road patterns, buildings and open spaces. The analysis uses qualitative descriptive methods applied through geographic information system (GIS) analysis.

In fact, it examined the deepening of the periodization of city history (historical reading) or diachronic reading. It also carried out the synchronic analysis of the typo-morphology of city element data (representative data) in historical periodization (tissue reading), which was supported by interpretive analysis of remote sensing data using Landsat imagery. It also carried out data studies from the results of field surveys of residential objects (physical reading).

Data Collection Method

This research uses spatial data collected through a field survey process, utilizing the Global Positioning System (GPS), importing survey coordinate data. It then identified satellite images in the form of aerial photos and adjusted them to the results of data collection via GPS. Data is then processed using a computer equipped with Arc GIS software, by using the results of aerial photo interpretation and data compilation from the field surveys.

The data and the results of the analysis are presented in the form of an overlay map, namely an overlay of 1994 data obtained from the Ministry of Environment and Forestry, data from spatial planning documents, land use data from field surveys in 2022 and data from Google Earth in 2023. The results of overlapping these maps produce a new map where the interpretation of land changes is explained descriptively.

Data Analysis Techniques

The data analysis method in this research is to study changes in land use and identify morphological patterns or forms. In the initial stage, an analysis of changes in land use in Sentani City was carried out. This analysis is used to see changes in land use from 1994, 2003, 2013, and 2023 using maps in spatial planning documents and Google Earth imagery. The analysis used is a spatial analysis using overlay techniques. The resulting image map data is then overlaid for 10 years, so the results are in the form of data or a map of changes and land use patterns in Sentani City. Through this analysis, land use changes that occur in the Sentani City area can be identified, such as the addition and reduction of buildings, and the city's morphological form or physical changes can be identified.

The Case Study

Sentani City, the research location, is in the Jayapura Regency, Papua Province. Administratively, Sentani City is part of the Sentani District, which consists of three sub-districts and six villages. These sub-districts are Sentani Kota Subdistrict, Hinekombe Subdistrict and Dobonsolo Subdistrict.

Changes in the morphology of the city cannot be separated from the influence of its existence in the context of the surrounding settlements or the region. The city is located between the provincial capital and several districts in Papua Province. Thus, the position of the city is a transit city experiencing quite rapid development.

Meanwhile, the vernacular villages in Sentani District are Sereh Village, Hobong, Ifale or Ajau, Yoboy or Kehiran, Ifar Besar and Yobeh Village. However, this research was limited to Sereh, Kehiran, Yobeh and Ifar Besar villages. This is because the current condition of these villages has urban characteristics and is close to the three sub-districts in Sentani District.

The city is located on flat to wavy topography: between (0-30%) and steep (more than 30%). Its height is 0-2000 meters above sea level. Areas above 2000 sea level are mountains, where the Cyclops Mountains stretch. There are also valleys and water areas, namely Lake Sentani. Administratively, the area of Sentani District is 98.00 km².

As the capital of Jayapura Regency, Sentani City is designated as an Order I City, which means that this area acts as a regional center, and hierarchically, Sentani District is directed as a large urban area. With this determination, the city will develop more rapidly. This requires an in-depth study of urban characteristics so that the pattern or form of development can be known. In this research, morphological changes will be reviewed from aspects of land use, road patterns, changes in building form and open space, which will be studied from 1994 to 2023.

Findings

1. Period from 1990 to 2000

a. Land Use

Land use or use describes the interrelated relationship between circulation and density of activities or functions in an area. Thus, land use is a generator of activity systems that can determine the direction and growth of an area, and this is a main component in the growth and development of an area. In the 1990s, Sentani City was at the start of urban development. The pattern formed is a settlement grouped based on kinship and ethnicity with a communal system. The development process is marked by physical developments along the main road of Sentani City.

Land conversion activities began to be carried out afterwards. Initially, people's gardens or sago areas into settlements or housing. A comparison of land use in 1994 and 2003 are as follows.

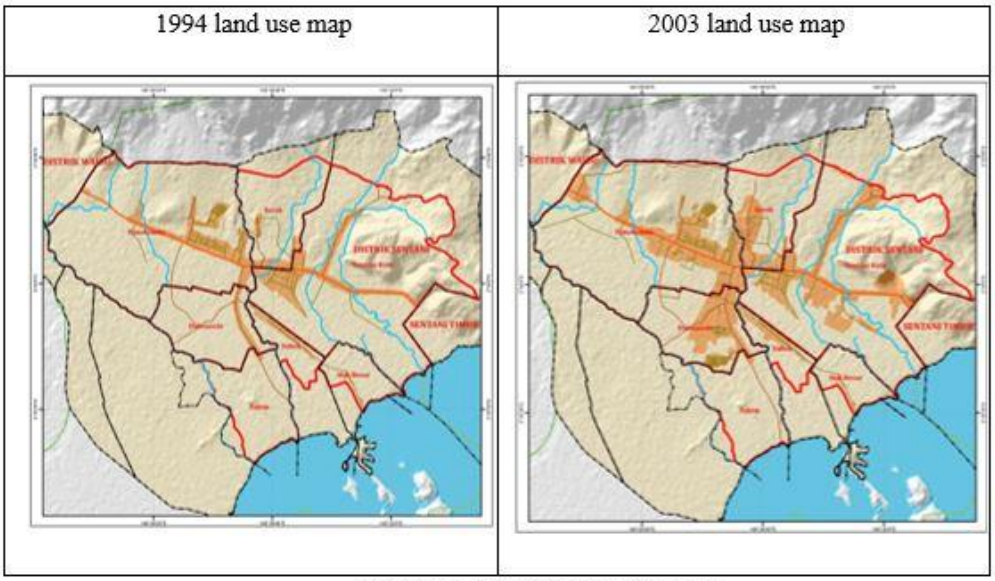

Figure 1. 1994 map and 2003 map
Source: Sentani City Spatial Planning Document, 2023

The 1990 map shows that land use is still dominated by open space. Settlements are still concentrated along the road. The main growth center areas are in the Sentani Kota and Hinekombe sub-districts. At the same time, the Dobonsolo sub-district only has a small part of its area as a residential area. This is due to the unequal distribution of the population and the need for more public facilities in this sub-district. Generally, public facilities are located in locations that are centers of growth. In this condition, the facilities and infrastructure are centered on the Sentani Kota and Hinekombe sub-districts.

Existence of these infrastructure facilities is an attraction for residents to choose to live in that place. Apart from that, easy access is a factor in choosing a residential location. Overtime, land use continues to increase, with an increase in the area of land use seen in 2003. The population concentration is still in the Sentani Kota and Hinekombe sub-districts. Increase in land use area can be seen around the Sentani Airport location. For Dobosolo Village, only a few points experienced changes in land use. Meanwhile, in the surrounding villages, there were no significant land changes. This is because in these villages, some people who live there are the traditional Sentani tribe.

Based on the population statistics of the Sentani District in 1994, there were 20,348 people, which grew to 36,064 people in 2003. This increase in population also had an impact on increasing the area of residential areas, from 305.95 Ha in 1994 to 660.66 Ha in 2003. Following land use table shows the details.

Table 1: Land use in 1994 and 2003
Source: Author, 2024: analysis results

No	Land Use in 1994	Land Use in 1994	Land Use in 1994
1	Body of water	7,25	7,25
2	Primary swamp forest	64,22	64,22
3	Shrubs	120,36	118,42
4	Open ground	1.046,12	1.024,34
5	Swamp thickets	127,82	124,21
6	Dryland farming	79,48	79,48
7	Secondary dry land forest	134,21	134,21
8	Secondary swamp forest	154,78	154,78
9	Mixed dry land farming	1.055,63	667,63
10	Settlement	305,95	660,66

From the table above, it can be seen that several land uses decreased in area in 1993 compared to 2004. The reduced land use included mixed dry land agriculture, secondary forests and settlements. The land area that has decreased the most is mixed dry land farming. For the graduates, the biggest increase is in land use for residential areas. At the research location, the development trend is faster on the main road network.

This is because the road network contains trade and service activities which are then followed by the formation of residential areas around the location. The pattern or physical shape of the city is linear, namely the shape of the city follows the road. This condition cannot be separated from the topographic characteristics of Sentani City, located between mountains and lakes. So, the growth and development of the city leads to the southern region which tends to be flat.

b. Road

In analyzing or studying city morphology, the road network is the most important factor in the formation of a city. A space can develop dynamically because of the road network. All elements that form urban space are related to the road network. The shape or pattern of the road network varies according to the historical development of a city. Apart from that, it also depends on the results of planning or based on city development without a plan.

In general, the road network pattern in the 1990s consisted of macro and micro patterns. Macro patterns are movement between regions within a wider scope over relatively long distances. The roads connecting the areas are the Jayapura – Sentani road towards Waiya and the Jayapura – Sentani – towards Genyem road, supported by adequate road conditions. This road network has the main function of providing access to service networks outside the city. Meanwhile, micro patterns have the function of connecting movements within the city or internally. This road network is all collector and environmental roads in the Sentani City area. At the research location, it can be seen that the trend of development is faster on the main road network.

A comparison of road network patterns between 1994 and 2003 experienced little change except for locations with housing development in the Sentani Kota and Hinekombe sub-district areas. Residential development in 2003 tended to expand and be on collector and neighborhood roads apart from increasingly congested arterial roads. This is because the road network contains trade and service activities which are then followed by the formation of residential areas around the location.

The pattern or physical shape of the city is linear, namely the shape of the city follows the road. This is inseparable from the topographic characteristics of Sentani City, located between mountains and lakes. So, the growth and development of the city leads to the southern region which tends to be flat.

c. Building

In analyzing morphology, two aspects can be studied: mass arrangement and building architecture. Building components are a reflection of the typology so that the mass arrangement is related to the distribution of buildings within the site along with its density and intensity. Meanwhile, building architecture is more about the physical manifestation of spaces and buildings that depict the cultural, historical and creative elements of a community.

Buildings have spread across a site have shapes or patterns that can be studied. Building patterns in the form of homogeneous, heterogeneous and spread out are morphological components that can be explained based on their characteristics. The shape of the building formed is influenced by the density of the building itself. Likewise, at the research location, the composition of buildings at the beginning of the city's development appeared to be spread out unevenly and centered at certain points. The locations of development centers are in service and trade areas along the road. This can happen because the location has easy access.

The concentration of buildings is along arterial, collector and environmental roads. The existing building forms are generally permanent buildings along main roads and semi-permanent on neighborhood roads. The use of buildings along the main road is dominated by commercial areas and a small portion is for residential areas. Likewise, building density consists of low to medium or medium density. Low density buildings are located far from activity centers. Meanwhile, medium-density buildings at service center locations, such as trade and service areas located on main road routes.

d. Outdoor

In the study of city morphology, the open space aspect is one element that forms cities apart from land use, roads and buildings. Open space is a place or space in an area, city or even a wider area, either in the form of a region or in the form of an area without buildings and is open. Based on Minister of Public Works Regulation Number 05/PRT/M/2008, open space is divided into two types: green open space (RTH) and non-green open space. Green open space (RTH) is divided into public green open space and private green open space.

Private green open spaces in the form of courtyards or gardens owned by certain institutions or individuals are used on a limited basis and planted with plants. In contrast to private open spaces, public open spaces can be accessed and used by the wider community. This makes public open spaces closely related to community activities. So that public open space becomes a space for social interaction in urban communities. Apart from functioning as a space for social interaction, public open space can also be used to carry out community ritual activities.

Public open spaces can be squares, parks, sports fields, plazas, pedestrian paths, cemeteries and roads. As one of the elements that form a city, open space can also provide an image of a city. In this way, open spaces contribute to a city's pattern or physical form.

The open space at the research location consists of sago areas, which are a source of food, garden land owned by the community and bushes that have yet to be managed. Apart from that, open space can also be in the form of parks, fields, pedestrian paths, road medians, etc. Likewise, at the study location, the built-up area and open land, especially residential areas, experienced changes between 1990 and 2000, namely an area of 374.93 Ha.

2. The period from 2003 to 2013

a. Land use

Land use in the study area consists of uses intended for residential areas, small-scale agriculture and plantations, trade and services, open spaces in the form of bushes, swamp forests and others. A comparison of land use from 2000 to 2010 shows that city development no longer follows the road but is starting to spread to the rear areas. Furthermore, it can be seen in the following land use map.

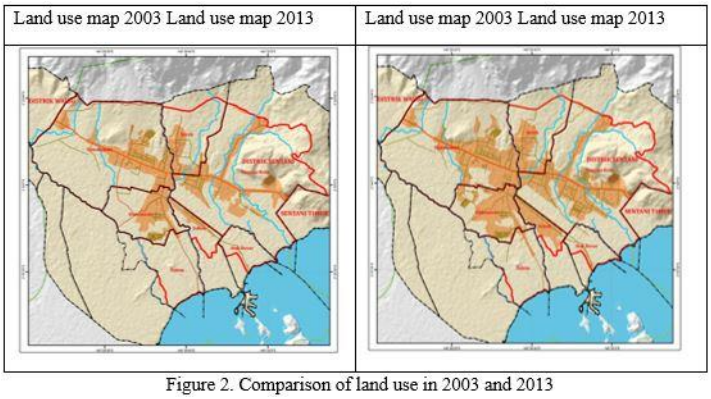

Figure 2. Comparison of land use in 2003 and 2013

Source: Sentani City RDTR Document, 2022 - Google earth map and analysis results, 2023

In the map above, it can be seen that there has been an increase in the area of land use within 10 (ten) years. Land use has changed from previous years where the development trend is spreading to the southern area following existing roads. Most of the changes in land use are for settlements inhabited by indigenous Papuans and immigrants. The native Papuan population is divided into 2 (two), namely the Sentani tribe, which is the original community holding local customary rights and other Papuan tribes who come from outside Sentani, for example, the Biak, Serui, Merauke and so on. Meanwhile, the migrant tribes in question are the Bugis, Padang, Batak, Javanese, etc.

From the map above, it can also be seen that there are several areas that are growing rapidly, namely in Sentani Kota and Hinekombe sub-districts. This condition is caused because this location is the center of socio-economic activity in the capital city of Jayapura Regency. This location has several activity centers such as Sentani Airport, education, military areas, trade and services, and other public facilities.

On a district, sub-district or Sentani District scale, it is a service center that serves all areas in Jayapura Regency, both socially, economically, culturally and politically. Thus, this is one of the factors that causes the population to be more spread out in this area. In this period the development of Sentani City experienced quite rapid development. This is due to the designation of Sentani City as the district capital. This condition was different before the central government of Jayapura Regency was moved to Sentani District in 2000. Meanwhile, the Dobonsolo Subdistrict and outlying areas such as Yoboy, Sereh, Ifar Besar and Ifale villages are still developing slowly. This is also due to the relatively low population distribution and the need for existing public facilities.

The increase in land use is also the impact of increasing population growth. Based on population data from 2003 to 2013, the population of Sentani City has increased. In 2003, the population of Sentani City was recorded at 36,064 people, which increased to 44,779 people in 2013. The comparison of land use areas between 2003 and 2013 can be seen in the following table:

Table 2: Comparison of land use in 2003 and 2013
Source: Results of land use map analysis for Sentani City, 2023

No	Land use	Year 2000 (Ha)	Year 2010 (Ha)
1	Body of water	7,25	7,25
2	Primary swamp forest	64,22	64,22
3	Shrubs	118,42	74,33
4	Open ground	1.024,34	907,00
5	Swamp thickets	124,21	103,35
6	Dryland farming	79,48	91,54
7	Secondary dry land forest	134,21	124,71
8	Secondary swamp forest	154,78	154,78
9	Mixed dry land farming	667,63	460,55
10	Settlement	660,66	1.040,84

From the table above, it can be seen that land use experienced changes between 2003 and 2013. The reduction in land occurred in almost all uses except for residential areas, which increased from 660.66 Ha to 1,040.84 Ha in 2013. From these figures, it can be concluded that the increase in area The residential area is almost double the area recorded during the 10 (ten) year period from 2003 to 2013.

This is also because Sentani City is designated as the capital of Jayapura Regency. This determination impacts changes to the social and economic aspects of society. From an economic perspective, new business opportunities have a positive effect on the community's economy. It also impacts increasing trade between regions both in and out of and into Papua Province. Meanwhile, from a social perspective, there has been

an increase in population. So,in the end, there will be an increase in development, both in terms of facilities and infrastructure and in residential areas, which are increasing in size.

Developing residential areas can be classified into two types: settlements that developed due to historical factors and settlements that developed because they were created or planned. The first type of settlement is a settlement that developed before a region or city developed very rapidly.

This type of settlement is generally considered the starting point for developing a region or city that develops naturally. As in the study area, land use intended for residential use is mostly in residential areas developed by developers. Currently, many developers are building housing because of the need due to the increase in population. Several locations have the potential to become dense residential areas because of their strategic location.

The availability of land is increasingly limited while the need for land for development continues to increase. Little by little, the sago and empty land that originally functioned as catchment areas are decreasing. Settlements continue to develop, especially around collector roads and neighborhoods. Its strategic location and easy accessibility mean that the residential area continues to experience development.

The city development pattern formed is linear, and most is a concentric or centralized pattern. A linear pattern is formed following the road leading to Yahim Pier, although the density is low. Meanwhile, the concentric pattern is formed due to residential centers developed by developers and those built by the community. The availability of large areas of empty land makes this sub-district potential for development.

Several aspects that can influence settlement development include social, economic and physical aspects. Socio-economic aspects that influence settlement development include population factors, accessibility, completeness of facilities and land location. Meanwhile, physical aspects influencing settlement development include topographic aspects, water sources and land use.

b. Road

As explained above, land use at the study location is dominated by trade and services along arterial roads. The construction of trade facilities in shophouses continues to develop over time. The existence of business opportunities and strategic location causes people to be more inclined to invest in this business. High mobility and trade and service activities give rise to quite high movements of people and goods.

Apart from using land for trade and service facilities, several locations on this arterial road are also used for private and government office facilities. Land use is also intended for religious and educational facilities. Apart from that, several residential houses are also found on land along this main route. However, if you look at the development trend, the land function will change from residential to public facilities, trade and services.

c. Building

Changes in the physical appearance of Sentani City certainly affect the mass of existing buildings. The scattered buildings are heterogeneous in shape and spread out according to the characteristics of the study area. The composition of the building is spread out and centered at certain points. Development centers are located in service and trade areas along roads with easy access. The following is an overview of several buildings functioning as public facilities in Sentani City.

Building density consists of low to medium density. Low-density buildings are located far from activity centers. Meanwhile, medium-density buildings are located at service centers, especially in trade and service areas. The mass concentration of buildings is along arterial, collector and environmental roads. The existing buildings are generally

permanent buildings along main roads and neighborhood roads, a small number of semi-permanent buildings are located in locations far from the center of activity. Usually, these semi-permanent buildings are owned by indigenous people who live on the outskirts of urban areas.

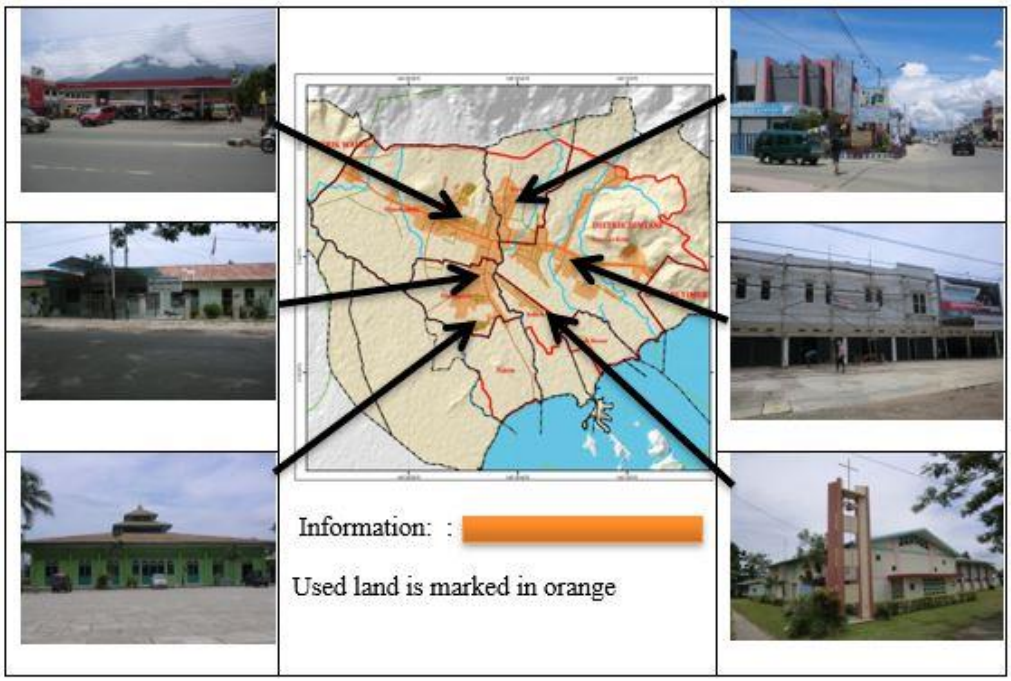

Fig. 4: Sentani City Building Density
Source: analysis results, 2023

d. Outdoor

One of the functions of open space is as a catchment area that absorbs water into the ground so that water is not stored in one place, which can cause puddles or flooding. The impact of increasing land requirements means that the existing catchment areas are decreasing. Of course, it would be a shame if all the land along arterial roads was built for trade and service facilities without providing open space. The catchment area functions as land and even floods. The poor condition of the drainage system contributes to the flood disasters that often hit, Sentani City.

3. Period from 2013 to 2023

a. Land use

Demands for land use are increasing in line with the increase in population while the available land area is limited. The existence of the Cyloop Nature Reserve area and Lake Sentani is an obstacle to the city's physical development. So that the City of Sentani can see developments from shifts in land use patterns, many previously empty lands have now been developed. The following is a comparative table of land use from 2013 to 2023.

Table 3: Comparison of land use in 2010 and 2023
Source: Results of land use map analysis for Sentani City, 2023

No	Land use	Year 2010 (Ha)	Year 2023 (Ha)
1	Body of water	7,25	7,25
2	Primary swamp forest	64,22	31,37
3	Shrubs	74,33	42,30
4	Open ground	907,00	800,70
5	Swamp thickets	103,35	98,46
6	Dryland farming	91,54	54,52

7	Secondary dry land forest	124,71	42,94
8	Secondary swamp forest	154,78	39,90
9	Mixed dry land farming	460,55	441,09
10	Settlement	1.040,84	1.562,91

The results of the land use comparison can be seen in the table above that land use for settlements has increased from 1040.84 Ha to 1,562.91 Ha, while for other land uses it has decreased. Rapid physical development requires land to meet community needs, especially for settlements. Reality is that the need for and availability of land needs to be balanced, increasing land prices, especially those close to activity centers. The difficulty in getting strategic land cheaply in Sentani Kota and Hinekombe sub-districts causes people to choose to look for land far from service centers.

Availability of empty land and its location close enough has led to development heading to the southern area of Sentani City, namely in several locations in Dobonsolo Village. The following is a comparative map of land use in 2013 and 2023.

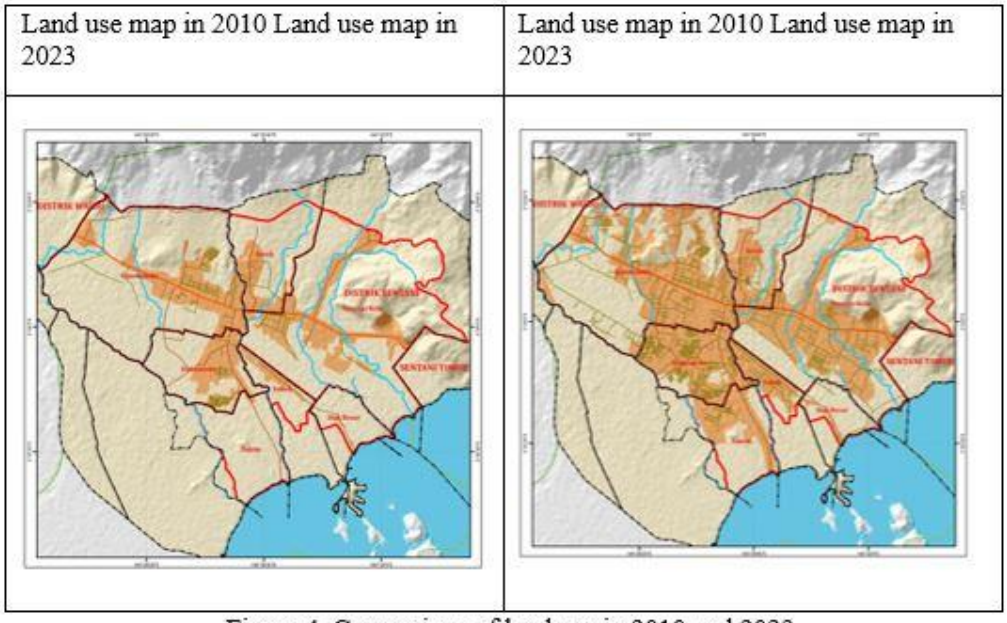

Figure 4. Comparison of land use in 2010 and 2023

Source: Peta Google earth and Analicis, 2023

In the city center area, the direction of land use is a linear form, with the center of development being Jalan Raya Sentani with the direction of development towards the south, namely the area bordering Lake Sentani and development towards the north towards the buffer area of the Cyclops Mountains. Several public facilities have changed. Apart from that, there are facilities and trading activities that can be found almost along the road. People take advantage of strategic positions on the left and right sides of the road as a place to sell.

As time goes by, changes occur, which increase land requirements. Development developments and land requirements that put pressure on sago areas around Lake Sentani must be controlled to be in harmony with Lake Sentani's function as a balancer in the ecosystem. Pressure on protected zones must be a serious concern and a further consideration for planning and directing this development pattern.

b. Road

Road Pattern The road network is an important aspect of supporting the development of a city. Locations that are traversed by the road network usually tend to develop more quickly because they have easy accessibility, so these locations have

higher economic value than locations that are far from the road network. The development of Sentani City is increasingly rapid, especially on the main routes, which means that its development now not only leads to a linear pattern that follows the road network, but the pattern that is formed is also a concentric pattern that is concentrated at several points.

This linear pattern is a straight line, pattern that connects two important points, where this pattern tends to easily experience traffic congestion or congestion. Apart from the above, the existing linear pattern is also due to the conditions or characteristics of the Sentani City area, located between the Cyclops Nature Reserve area and Lake Sentani. The development pattern of the city, especially Sentani, which is heavily influenced by the main road, causes the capacity of the road at certain times (school and office entry times) to experience congestion or queues, which causes travel times to be longer.

Apart from the linear patterns described above, concentric patterns also develop in several places in the Sentani City area. Concentric (clustered) patterns are found in certain areas, such as around Sentani City, and several residential centers, especially housing built by developers or housing developers. So that the development of the city that is formed is not only concentrated in one or a few locations but becomes wider and more evenly distributed.

c. Building

The forms of buildings in the study area are generally permanent buildings along the main road or on neighborhood roads. Only a small number of buildings are semi-permanent and located far from the center of activity. Judging from the density, the existing buildings at the study location have a low to high-density level. This can be seen in several locations that do not have empty land and have been built, whether intended for residential or other uses.

Buildings with a high-density level are located in trade and service areas and residential areas close to community activity centers. Settlements with medium to low density are located in residential areas further from activity centers. The form of distribution of buildings has a pattern of heterogeneous, homogeneous and spread over an area that almost covers 3 (three) sub-districts in Sentani District. Even in the Dobonsolo sub-district area, it can be seen that the distribution of buildings is almost even in the area, as far as Yobeh, Yahim and Ifar Besar villages.

Most of the built-up areas in the Dobonsolo Village area are housing developments built by developers. This sub-district area has the potential to be built for housing because it has flat topography so that the pattern formed is homogeneous and spread out. Meanwhile, for Sentani Kota, Hinekombe and Kampung Sereh subdistricts, the pattern formed is heterogeneous and spread out.

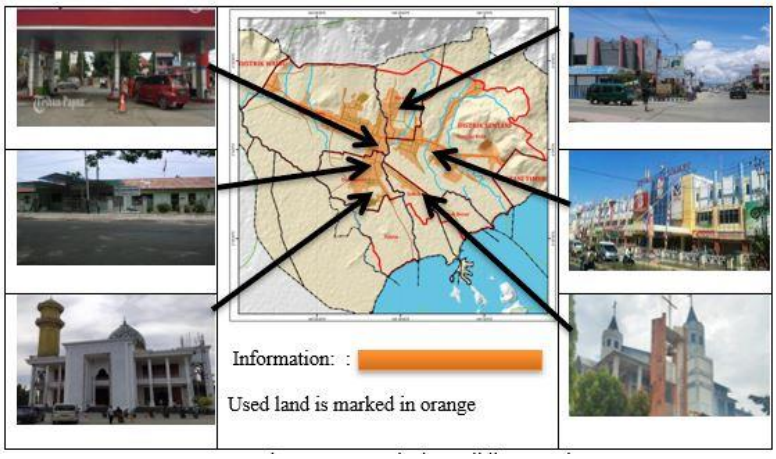

Fig. 5: Sentani City Building Density
Source: Field survey, 2023

The changes to the buildings in the picture above illustrate that the buildings are being expanded and require larger land. Buildings with a high-density level are located in trade and service areas and residential areas close to community activity centers. Settlements with medium to low density are located in residential areas further from activity centers. The physical or morphological changes that occur result in changes to the spatial form of Sentani City. The same thing happens to the form of distribution of buildings. The form of distribution that occurs in Sentani City has a pattern of a heterogeneous and centralized form, which spreads over an area covering almost 3 (three) sub-districts in Sentani District.

The distribution pattern of buildings in Sentani and Hinekombe sub-districts is centralized. The form is centralized, especially in residential areas close to activity centers. Meanwhile, the heterogeneous pattern is in residential areas in the south, namely in Dobonsolo Village. The central building pattern can be seen from each building shape, which has a basic shape, namely a square or rectangle. This building pattern demands balance and order as well as varying densities. For the Dobonsolo sub-district area, the distribution of buildings is almost even, with varying building densities as far as Yobeh, Yahim and Ifar Besar villages. Most of the built-up areas in the Dobonsolo Village area are housing developments built by developers. This sub-district area has the potential to be built for housing because it has flat topography so that the pattern formed is homogeneous and spread out. Meanwhile, for Sentani Kota, Hinekombe and Kampung Sereh subdistricts, the pattern formed is heterogeneous and spread out.

d. Outdoor

One of the functions of open space is as a catchment area that absorbs water into the ground so that water is not stored in one place, which can cause puddles or flooding. However, due to demands for land, a zone, which is a catchment area, has been built. This has an impact on the reduction of existing catchment areas. Open space contributes to the shape or pattern of an area. The composition of built land use and open land provides a certain pattern or shape. The city of Sentani experienced changes in its spatial structure to form a pattern visually visible on the land change map.

On the existing land change map, it can be seen that the area of open space has decreased very drastically. The open space area is decreasing due to the development and use of land intended to benefit the community. Of course, it would be a shame if all the land along arterial roads was built for trade and service facilities without providing open space. Moreover, the poor condition of the drainage system contributes to the flood disasters that often hit, Sentani City. The government needs to pay attention to this to control city development. The approach taken is by providing education not to build in buffer areas and, of course enforcing regulations according to applicable rules.

Conclusion

This paper concludes that the spatial pattern of growth of residential areas in Sentani City, have been as follows:

a. The growth of residential areas Sentani City area from 1994 to 2003 have formed new areas and have led to growth in areas that have been formed or are in existing residential areas. The land use pattern of Sentani City is linear or follows the road. However, in 2003, this pattern has experienced a change, marked by a distribution at several location points, which later became the forerunners of new growth centers. Changes in land use can be seen from the amount of land used for settlements, which was 305.95 Ha in 1994 to 660.66 Ha in 2003. In the following period, from 2003 to 2013, the city has experienced quite rapid development, marked by an increase in land use, namely 660 Ha. .66 Ha to 1,040.84 Ha. Furthermore, city development and land requirements have continued to increase over approximately the last 10

(ten years). The land area for residential areas was recorded from 1,040.84 Ha in 2010 to 1,562.91 Ha in 2023.

b. The most rapid development of Sentani City was initially along the main roads and in trading areas, namely in Sentani Kota Village and Hinekombe Village. This is due to the existence of city facilities and infrastructure. Apart from ease of access, the growth in building density and activity is influenced by the role of the main road. Physical development needs to be faster in areas with access to branching roads. However, from 2003 to 2023, several locations, including Dobonsolo Village, Kampung Sereh, Yahim, Yobeh and Ifar Besar, experienced quite rapid development. One of the causes of this fairly rapid development is the designation of Sentani City as the capital of Jayapura Regency.
c. Other morphological elements, namely the building, also experienced visual development. With the development, the existing buildings in Sentani City have increased in quality and quantity. The dominant form of existing buildings is permanent ones, and only a small portion are non-permanent. The current level of building density is high, medium, to low.
d. As with the morphological elements discussed, land that constitutes open space decreases from 1994 to 2023. The land conversion that occurs due to the increase in the number of people who need land results in a reduction in open space.
e. The configuration between morphological elements, namely built space, which includes residential areas, buildings and roads as well as open spaces, forms a pattern that has its characteristics according to the characteristics of the Sentani City area.

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