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Analysis of Land Use Change in Langsa City, Aceh Province in 2013 – 2021

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ABSTRACT

However, this significantly impacts land conversion, reducing environmental quality. Analysis of changes in land use in Langsa City needs to be carried out as a basis for determining development policies. This study aims to analyze changes in land use in Langsa City from 2013 – 2021. The data used in this study are Landsat 8 OLI-TIRS imagery in 2013, 2017, and 2021. These images were analyzed using a supervised classification technique based on band combinations for each land use. The classified land uses are settlements, paddy fields, ponds, mangrove forests, and mixed vegetation. The results showed a significant increase in the settlement area in the center of Langsa City. Meanwhile, other land uses have changed but have yet to change consistently. This study concludes that a significant increase in settlement area is due to rapid population growth. The rise in settlement areas also impacts changes in other land use types. The researcher recommends revitalizing regional spatial plans, and detailed spatial plans.

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1. INTRODUCTION

Langsa City is one of the cities located in Aceh Province. Langsa City has now transformed into a dense urban centre in the eastern coastal region of Aceh. This condition was caused by the growth of trade and services, which showed a positive direction, thus causing an increase in population every year. The rapid development in the city of Langsa will impact changes in land use in the vicinity, such as the development of infrastructure, agriculture, and other industrial sites. According to data from the Central Statistics Agency (BPS) for Langsa City 2022, population growth for Langsa increases yearly. This statement is based on the results of population statistics for 2019 totalling 176,811, people (Mirdaolivia and Amelia, 2021). The increase in population, which is not accompanied by the availability of sufficient land, creates problems such as land use that needs to be following ecological principles, which has an impact on reducing environmental quality (Indrianeu, 2017; Meyer, and Turner, 1992).

Land change in Langsa City needs to be analyzed as a basis for establishing policies for stakeholders in urban development planning (Niang et al., 2020; Jarosław and Hildebrandt-Radke, 2009). However, until now, there is no map of the dynamics of land use in Langsa City. Land use dynamics maps are needed to determine land use patterns that occur from year to year so that they can become part of the Langsa City Spatial Planning program and support the carrying capacity of the environment (Mutia et al., 2020; Shabane et al., 2011).

The land is an essential part of the life of living things on the earth's surface. Land can have different meanings for everyone, depending on the perspective and interests of the land itself (Anggita et al., 2020). The land is a development resource with relative availability or extent characteristics due to changes in area due to natural processes (sedimentation) and artificial processes/reclamation. The suitability of land use in accommodating community activities also tends to be specific. The land has different physical characteristics, such as topography, mineral content, and rocks. So land is dynamic or inconsistent with management carried out by people who use land in areas with specific characteristics.

Land use can be interpreted as a goal in which human efforts to exploit land cover are used for the benefit of the people who use the land (Solihin et al., 2020). "Land use is inseparable from human intervention, either passively or dynamically, towards a group of artificial resources and natural resources, which as a whole is called land, with the aim of meeting material and spiritual needs. Land change can be directly influenced by human activities, which often do not follow ecological rules (Noeraga et al., 2020). The form of land use in an area is related to population growth and activities. This will cause changes in land use to increase (Kharisma, 2020). Land use in Langsa City can be interpreted as a result of passive interaction, balance, and dynamics between residents' activities on the land and the land's limitations (As-syakur et al., 2010; Mutia, et al., 2022; Junianto, 2023).

Langsa City has significant dynamics of land use. Land use change is a phenomenon of increasing or decreasing the type of land use from one land use to another over a different period. Changes in land use in Langsa City affect local ecological systems such as floods and clean water crises (Mutia, 2020; Bretzke et al., 2012). Not only that, land use changes can also impact climate conditions, thereby reducing biodiversity (Shrestha et al., 2013). Factors that cause changes in land use in Langsa City are forest conversion activities into agriculture, plantations, and continued settlements until development into urban areas.

Land use change is caused by high population growth and migration, which significantly impact land use (Noeraga et al., 2020). Land use change involves shifting land use to a different land use or converting to current land use. Land use change is a form of transformation of the allocation of land resources from one service to another. Changes in land use can occur at any time, either naturally or as a result of human activity. Natural

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changes can be caused by natural disasters such as landslides, erosion, and floods. Activities drive changes due to human activities to meet basic needs (Kelvin et al., 2019).

In general, changes in land use can change: (a) the hydrological characteristics of the area concerned, (b) the amount of river runoff, (c) the characteristics of the river flow in the area concerned (As-syakur et al., 2010]. This happens because land use increases, encouraging them to change land. Land use is dynamic at any time and can change according to the needs of the designated land use (el-sadek,2022). A land use policy occurs when land is defined in terms of quality and quantity so that land use increases, and will automatically change according to land use that is enabled to fulfill human livelihoods spiritually and materially. The changes that occur are changes in the structure of land use through the process of changing land use, including: (1) Behavioral change; (2) Location changes; and (3) Development change. Land change can occur due to the influence of government policies in developing areas want to be set, such as industrial, mining, and settlement development which are separate from the environmental quality and population quantity (Aslinda, 2016; Bart, I. L. 2010, Ribeiro, et al., 2010).

The current conditions of use in Langsa City have changed from year to year, such as river bodies and land use changes around the watershed. Besides that, the conversion of forests to plantations has also become more intensive in Langsa City. This impacts reducing the catchment area as a medium for groundwater recharge. Changes in land use in Langsa City lead to environmental damage, which reduces the environment's carrying capacity for development. This land change needs to be analyzed as a policy basis for stakeholders in urban development planning. But until now, there has yet to be a map of land change in Langsa City. Land use dynamics maps for Langsa City should be carried out to anticipate the negative impacts of land changes that occur from year to year, so that the development can support environmentally sustainable functions (Mutia et al., 2020; Kelvin, 2019). Based on the problems, it is necessary to study land use changes in Langsa City. This analysis needs to be carried out with the support of technological developments in the field of Geographic Information Systems (GIS). This shows that mapping always exists in the scientific area, especially regarding spatial analysis (Anurogo et al., 2020). Therefore, this study's land use change analysis uses Remote Sensing technology and Geography Information System to produce an accurate scientific report.

2. METHODS

This study uses a quantitative method with a spatial approach through the application of Quantum GIS (QGIS) version 3.28. The application is used to identify land use in Langsa City and to analyze each land use area. Data analysis will produce information about the condition of changes in land use. This research was conducted in Langsa City, Aceh Province, whose location can be seen in Figure 1. The study area consists of 5 sub-districts, namely Langsa Kota, Langsa Lama, Langsa Baru, West Langsa and East Langsa. Langsa City is one of the cities located on the east coast of Aceh province which has many tributaries that flow into the Malacca Strait.

2.1. *Data Collections*

This study uses Landsat 8 OLI-TIRS (Operational Land Imager and Thermal Infrared Sensor) image data downloaded from the USGS Earth Explorer website. Then the image is visually interpreted using a supervised classification technique using the Semi-Automatic Classification Plugin in the Quantum GIS application to obtain an accurate land use

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composition (Wiweka et al., 2012). Furthermore, the data were tested for accuracy to determine the accuracy of the results of land use analysis in 2013, 2017, and 2021. In addition, administrative boundary data were obtained from the Geospatial Information Agency on the Ina-Geoportal website

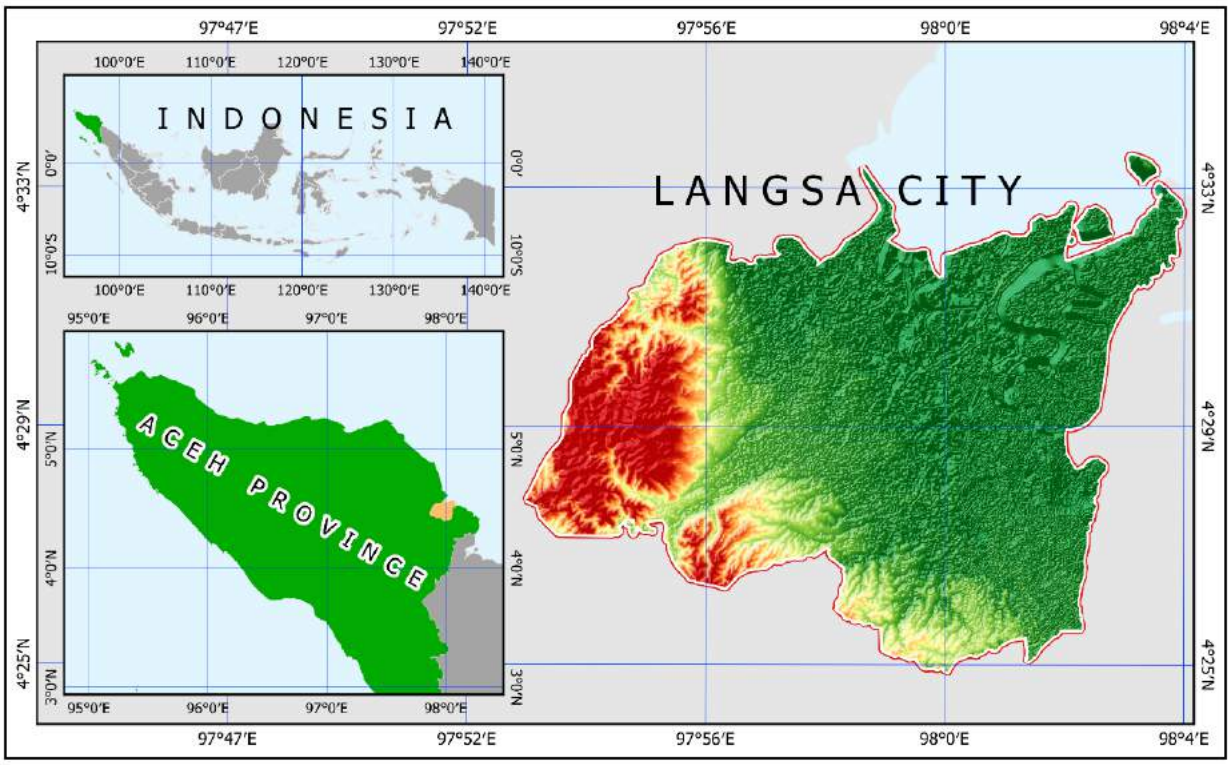
2.2. *Data Analysis*

The stages of data analysis include the preparation stage, image management, image analysis, the final analysis in the form of image data processing and field data collection to confirm the type of land use based on the results of the image analysis that has been carried out. The supervised classification method is the primary analysis technique used to classify land use types in Langsa City on Landsat 8 imagery. Each land use is analyzed using composite bands as presented in table 1. After the image is classified, the area of each land use type is calculated. So that changes in the site can be calculated each year. A field survey was carried out after the analysis was conducted to confirm that the land use in the image is the same as the land use in actual conditions.

Table 1. Composite Bands for Land Use Classification in Langsa City

No	Composite Band	Land Use
1	764	Settlement
2	654	Mangroves
3	564	Fishponds and Rice Fields
4	654	Dense Vegetation
5	654	Sparse Vegetation

Source: Research Data, 2022



Source: Research Data, 2022

Figure 1. Research Locations in Langsa City, Aceh Province, located on Aceh's east coast.

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3. RESULTS AND DISCUSSION

Langsa City is located at an altitude of about 0-25 meters above sea level. However, most of the area of Langsa City in the southwest is coastal alluvial land, with elevations ranging from about 8 meters above sea level (Mirdaolivia and Amelia, 2021; Mutia, 2020; Anggita et al., 2020). The southern part is a moderate wave mountain fold, with a height ranging from 75 meters above sea level. At the same time, in the eastern region, there are swamp deposits with a reasonably wide distribution. The supervised classification analysis of the Langsa City image yields six types of land use, namely: (1) mangroves; (2) dense vegetation; (3) sparse vegetation; (4) rice fields and fishponds; and (5) settlements.

3.1. *Mangroves*

Mangrove land is an ecosystem that lives in coastal areas and river estuaries with muddy substrates, which are influenced by river mouths and sea tides. It can also live in areas with exceptionally high salinity (Thoha et al., 2022). Mangroves are tropical plant species that live in coastal regions of the sea and river estuaries that can adapt to high seawater salinity. Mangrove land will find it challenging to grow in areas with large wave currents and steep seacoast conditions because it does not allow the sedimentation process to occur, which is a habitat for mangroves to grow. Mangrove land is very vulnerable to changes in growth and extent. This is because one of them is human activities that exploit mangrove land excessively. Mangrove forests have benefits as providers of environmental services, as well as supporting the surrounding community's economy. As a provider of environmental services such as preventing abrasion/erosion of the coast, holding back tidal floods when the tide is high, a place for marine and land animal breeding to live and a producer of oxygen.

Based on the supervised classification analysis results, Langsa City has dynamic changes in mangrove areas. There has been an addition and reduction of mangrove land between 2013 and 2021. In 2013 the area of mangroves in Langsa City was around 61.78 million m2 or approximately 617.8 hectares. Then in 2017, there was an increase in the mangrove area to 719.4 hectares. Whereas in 2021, the site of mangroves will decrease to 475.8 hectares. The area in 2021 has significantly reduced, even though the area is lower than in 2013. The increasing mangrove area has been driven by mangrove planting programs carried out by the government and Non-Governmental Organizations (NGOs).

Meanwhile, the land reduction was due to the logging of mangroves by local people who worked as firewood sellers. In addition, the community converted the function of mangrove land into fishponds and rice fields, so the mangrove area experienced a significant decline. The expansive dynamics of the Langsa City mangrove area can be seen in Figure 2.

3.2. *Change of Settlement*

Settlement areas are part of the environment outside the protected area, both in the form of rural and urban areas, which function as a place to live or a residential setting and activities that support livelihoods (Aslinda, 2016; Kharisma, 2020). Settlements are a collection of housing with all the elements contained therein, such as interactive activities and regular activity patterns. The components of residential land, are: (1) networks where people and goods move; (2) place of business or work; (3) residence or residence; (4) public facilities such as education, worship, and other public facilities; (5) a place for creation, entertainment, relaxation for the community.

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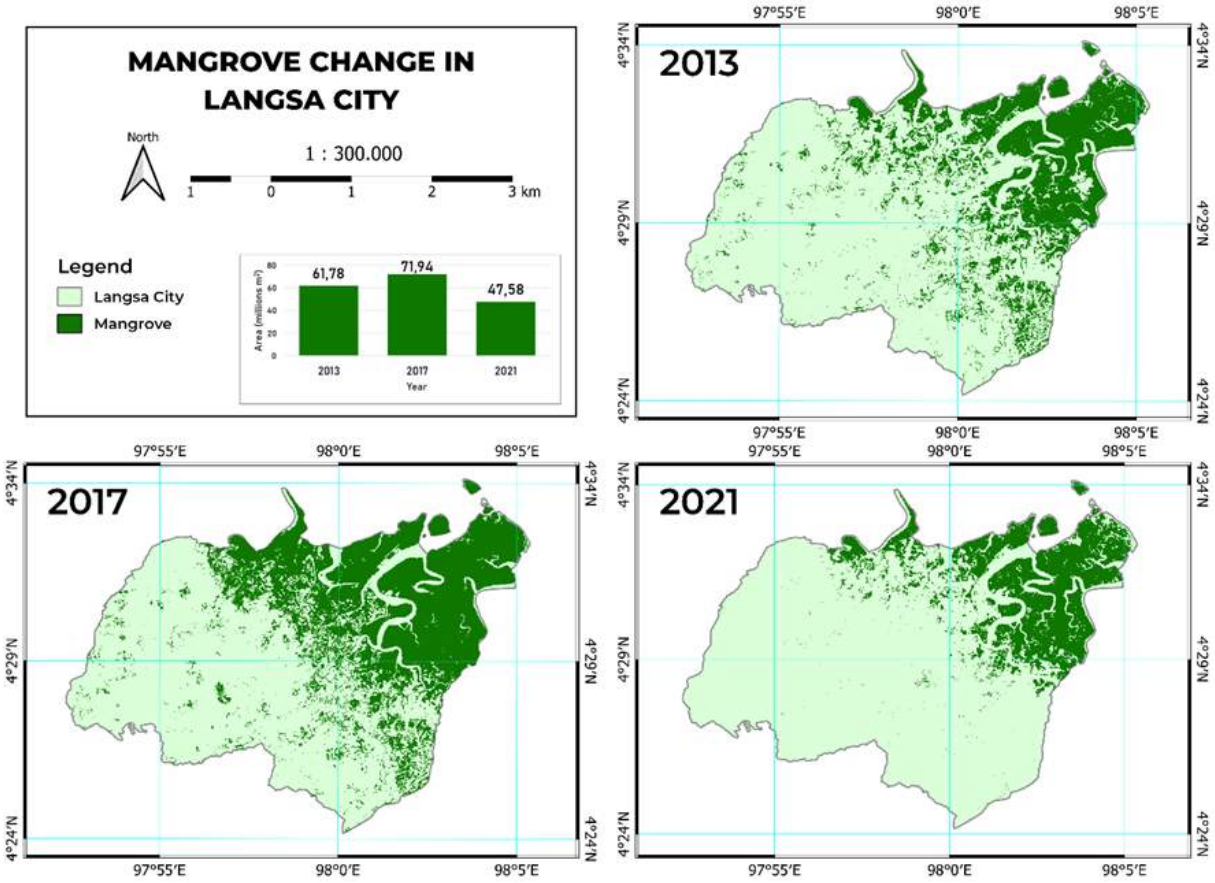
Settlements can be categorized into urban and rural settlements (Handayani and Cahyono, 2014). Urban settlements are an environment with a dense population, regular housing patterns, buildings, industrial sites, a network of roads, and a lighter color at night. At the same time, village settlements are irregularly mixed with separate vegetation appearances. The dynamics of settlements in Langsa City have a consistent pattern, which always increases yearly. Based on the dynamics of residential areas in Langsa City in Figure 3, from 2013 to 2021, residential areas are continually growing. In 2013 the settlement area was around 300 hectares, then in 2017, it increased to approximately 450 hectares, and in 2021 it will rise again to 550 hectares.



Source: Research Data, 2022

Figure 2. Changes in mangrove area in Langsa City in 2013 – 2021.

The increase in the residential area indicates a significant increase in the population of Langsa City. This increase can come from natural growth or total growth involving population migration. Langsa City is a city that is growing on the east coast of Aceh and is close to North Sumatra Province, so the potential for regional development is even more tremendous. Conversion of land use in the form of agricultural areas into settlements and urban areas has been seen in Langsa City. The concentration of settlements is in the middle of Langsa City, which is the center of the economy and government administration.

3.3. *Fishponds and Rice Fields*

Fishponds and rice fields are two different types of land use. However, in this study, fishponds and rice fields were included in one discussion because they have similar characteristics: land covered with water. Fishponds are a type of land used as a place for

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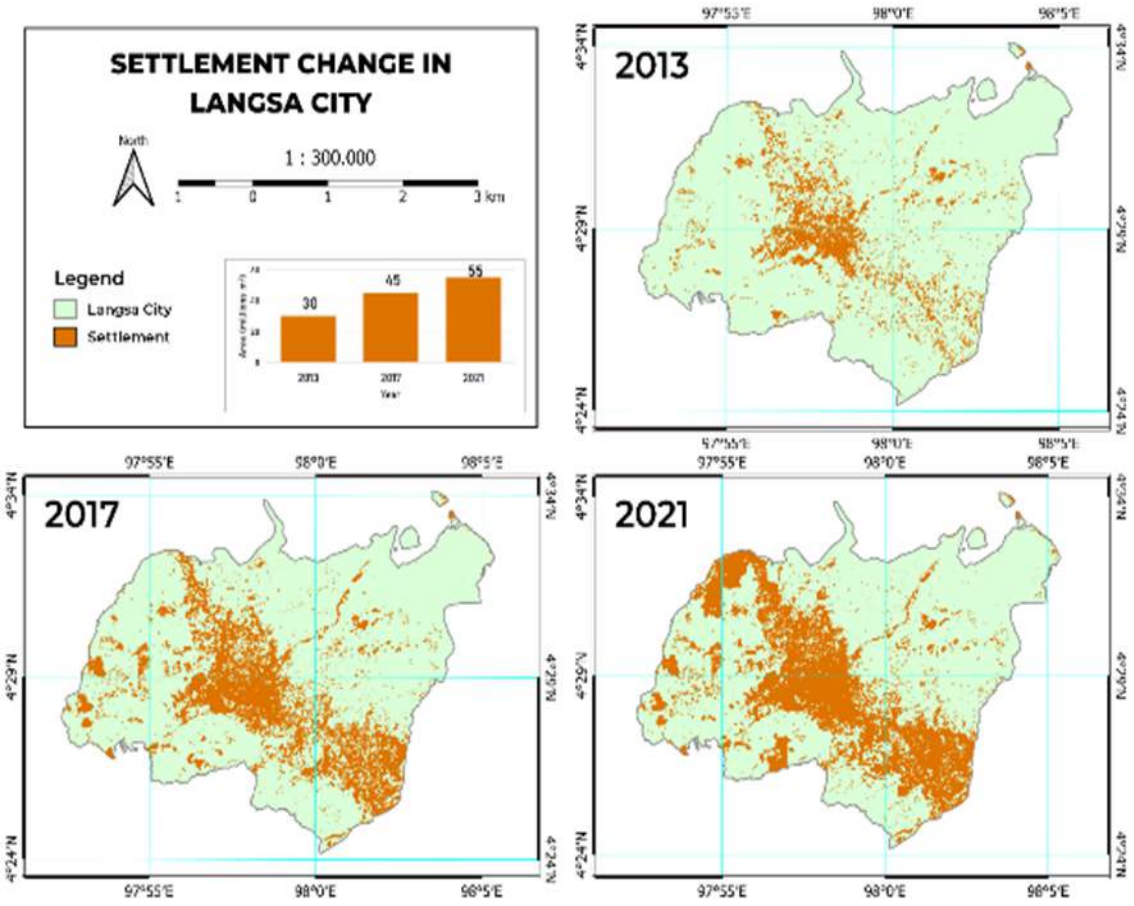
brackish water cultivation activities in estuaries and coastal areas. Fishponds are man-made landforms in the form of artificial fishponds usually located on low land, generally found in estuary areas and coastal areas that function as aquaculture facilities (Abd el-sadek et al., 2022).

Rice fields have an essential meaning in efforts to maintain food security. Along with the times, population growth, and economic demands, the existence of food fields began to be disturbed. One of the most severe problems currently related to food land is the increasingly widespread conversion of food land to other uses (Kelvin et al., 2019). One of the impacts of the transformation of rice fields which is often in the spotlight of the wider community, is the disruption of food security. In addition to the positive function, rice field management that pays little attention to the principles of conservation and preservation of environmental ecology can potentially cause negative impacts or processesthat pays little attention to the principles of conservation and preservation of environmental ecology can potentially cause negative impacts or processes.



Source: Research Data, 2022

Figure 3. Changes in settlement area in Langsa City in 2013 – 2021.

Fishponds and rice fields in Langsa City are located close to the mangrove area, around the coast to the northeast. In 2013 the area of fishponds and rice fields was 420.2 hectares. Then in 2017, there was a reduction in the area of fishponds and rice fields due to planting mangroves. The size of fishponds and rice fields in 2017 was 223.1 hectares. Then in 2021, there will be another increase to 488.7 hectares. Changes in fishponds and rice fields in Langsa

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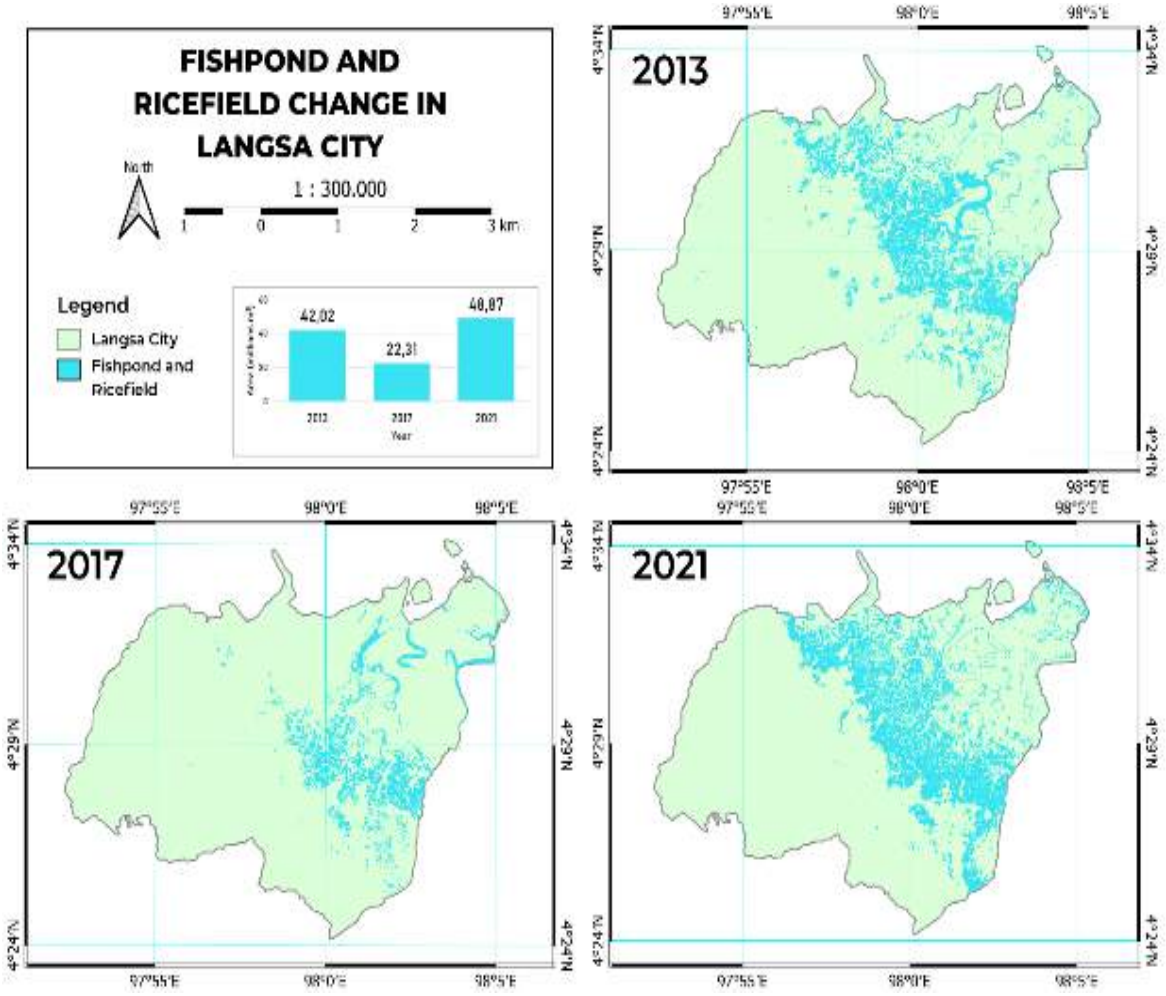
City are closely related to changes in the mangrove area. Mangroves have good ecological functions but need to be utilized economically by local communities. Meanwhile, rice fields and fishponds have an economic role for the local community but have a low ecological function. Therefore, the community needs to be fostered so that they have high environmental awareness as well as relevant skills to be able to preserve mangrove areas without neglecting economic benefits.

3.4. *Dense and Sparse Vegetation*

Vegetation land use in this study has been simplified into two categories: sparse and dense. According to Asdak, vegetation is a system consisting of a large group of plants that grow and inhabit a particular area. Vegetation structure can be defined as the organization of individual plants in a space that forms broad stands forming plant associations. The form of vegetation is limited by three main components (Ma'rifah and Suryadarma, 2015). namely: (1) the horizontal distribution of the types of vegetation that make up the position between individuals; (2) many individuals of a particular type of vegetation, such as shrubs, agriculture and plantations that are not regular, such as dry fields with a non-clustered pattern that will be combined with other types of vegetation; (3) Vegetation stratification is a constituent layer consisting of trees, shrubs, poles, seedlings, shrubs, saplings and herbs. Dense vegetation can be in the form of forests, while sparse vegetation can be in the form of plantations and shrubs.



Source: Research Data, 2022

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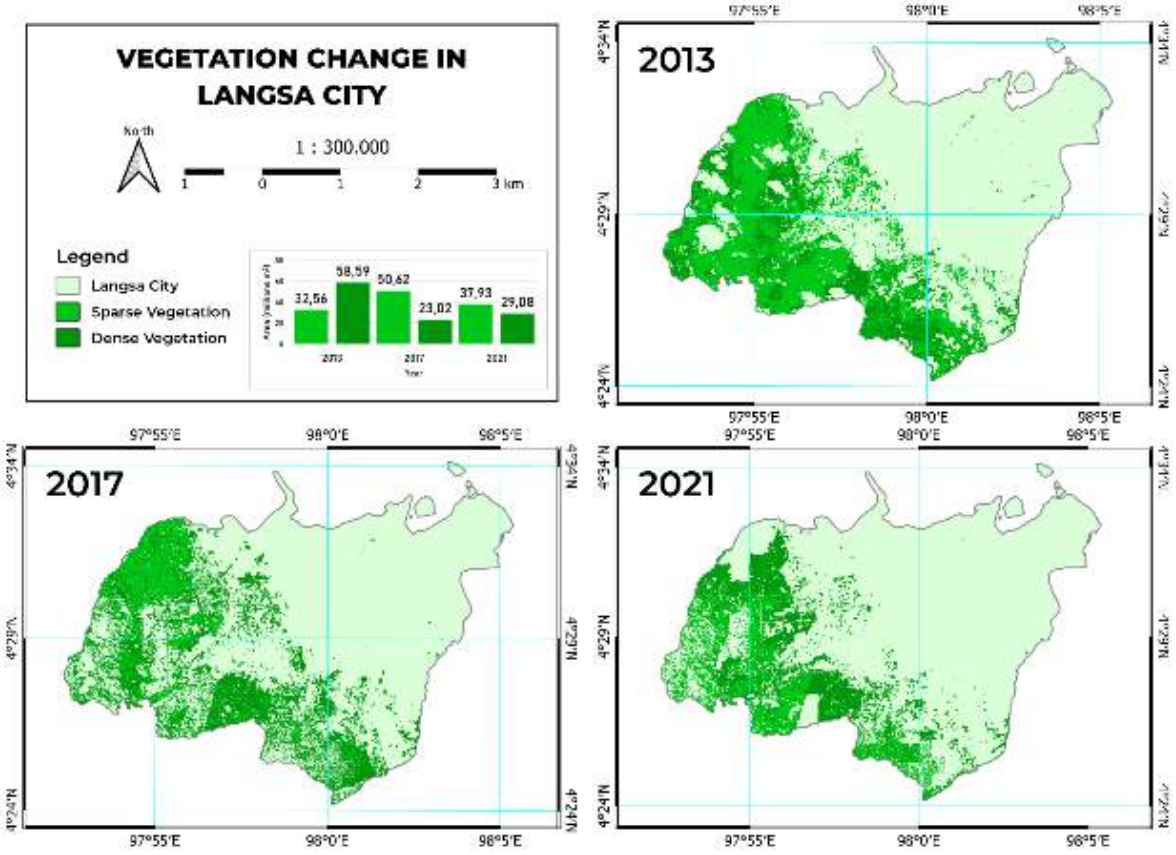
Figure 4. Changes in the area of fishponds and rice fields in Langsa City in 2013 – 2021

Plantations are plant stands deliberately made by planting and cultivating or reforestation. Usually for commercial, economic purposes and only in the form of plants. Based on this understanding, plantation land can use several criteria as follows: (1) not colored like open land when it has not been planted; (2) there are clear boundaries within an area; (3) the color of plants tends to be lighter when the plants have reached their maximum limit (because of the high greenness); (4) the presence of broad and even vegetation colors; (5) plants grown for commercial purposes, so close to settlements; (6) not fixated on topography (depending on the type of plant).

Figure 5 presents changes in land use vegetation in Langsa City. There are two levels of vegetation, namely dense vegetation, and sparse vegetation. Dense vegetation tends to decrease from 2013 to 2021. Meanwhile, medium-density vegetation experiences dynamic changes from 2013 to 2021. However, the combination of dense and sparse vegetation has a decreasing trend. This can be caused by land conversion from vegetation to settlements. This phenomenon was caused by a relatively high increase in the population of Langsa City.



Source: Research Data, 2022

Figure 5. Changes in the area of dense and sparse vegetation in Langsa City in 2013 – 2021

The dynamics for the five types of land use have different characteristics. Each land use has various driving factors, so the area changes from 2013 to 2021. Figure 6 presents a comparative graph between the five types of land use. Based on figure 6, the mangrove area has the most significant percentage among other land uses in Langsa City in 2013 and 2017. However, in 2021, the largest portion will be filled by settlements. These data prove that population growth can drastically change land use composition. In 2013, settlements

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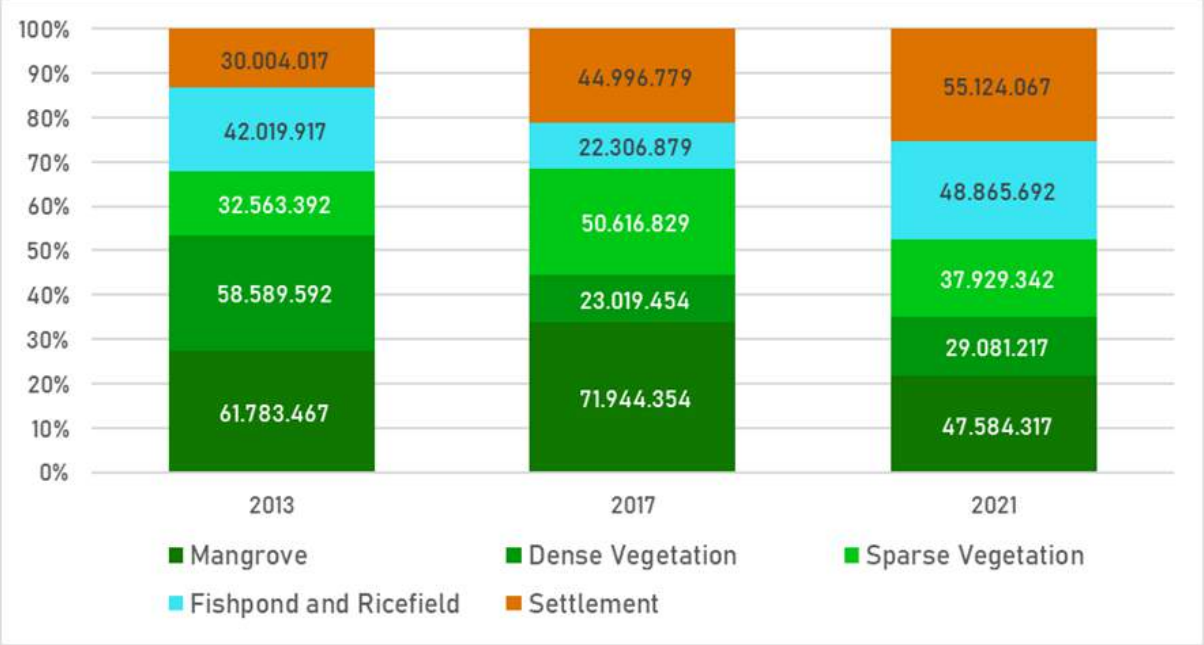
had the smallest area compared to other land uses. But in 2021, settlements have the highest percentage among mangroves, vegetation, fishponds, and rice fields.

If these conditions are not controlled as quickly as possible, then the potential for disruption of the ecological functions of Langsa City may decrease. This impacts natural disasters such as floods, landslides, and clean water crises. Although settlements have not dominated land use in Langsa City, these disasters have occurred on a small scale.



Source: Research Data, 2022

Figure 6. Land Use Change in Langsa City

Therefore, preventive measures need to be taken as early as possible. The first step that can be taken is revitalizing the Regional Spatial Plan, which is explained more specifically in the Detailed Spatial Plan. Urban development should be controlled as best as possible through careful urban planning and strict supervision. This is done for the sake of the survival of the people of Langsa City and the surrounding area. Figure 7 presents the results of a survey to see the actual conditions of several types of land use in Langsa City. Based on the survey results, Langsa City still has space for vegetation which plays a role in maintaining the environment's carrying capacity for residents.

(A) (B)

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(C) (D)

(E) (F)

(G) (H)

Source: Research Data, 2022

Figure 7. Field survey results to confirm land use in Landsat 8 image analysis consisting of: (A and B) Mangrove and pond land use; (C and D) Sparse vegetation (plantations) and dense vegetation (forests); (E and F) Use of pond land and sparse vegetation; (G and H) Residential land use and sparse vegetation.

4. CONCLUSION

Changes in land use in Langsa City occurred from 2013 to 2021. This is evidenced by changes in the area for five types of land use, namely (1) mangroves; (2) vegetation; (3) settlements; (4) ponds; and (5) paddy fields. Reductions in mangrove land and vegetation occurred between 2013 and 2021. Meanwhile, settlements experienced a significant increase in the area—several factors, such as population growth and land conversion by the community influenced changes in land use. Settlements had the most minor land area in 2013, but in 2021 settlements have the most prominent area compared to other land uses.

5. RECOMMENDATION

Based on the results of this study, the growth of residential areas is a threat to natural preservation in Langsa City. This will affect the decrease in the environment's carrying capacity, which can cause various natural disasters, such as floods, landslides, and clean water crises. Analysis of changes in land use needs to be carried out periodically. Even future land use needs to be predicted so that the government and other parties can anticipate possible possibilities. The results of this research can help the Government of Langsa City prepare a

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wiser Regional Spatial Plan to maintain natural sustainability. The government needs to make an effort to revitalize regional spatial planning and detailed spatial planning so that changes in land use can be controlled. In the end, the environment's carrying capacity can be maintained or even improved for the better.

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