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Analysis of Paddy Field Conversion Using Geographic Information System (GIS) in Labuhanbatu Utara Regency, Indonesia

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ABSTRACT

The number of paddy production in Labuhanbatu Utara Regency, North Sumatera Province, Indonesia, continues to decline from year to year, partly due to the reduction in the area of paddy fields. This was caused by land conversion from paddy fields to non-paddy fields. This research aims to analyze the pattern of changes in the process of paddy fields to non-paddy fields in Labuhanbatu Utara Regency and its suitability on the regional spatial plan between 2017 and 2021. The research uses a descriptive qualitative method. The data was processed and analyzed using an overlapping method on biophysical data, existing conditions, and other thematic data, using Geographic Information System. The results showed that there had been a reduction in the area from paddy fields to non-paddy fields of 2,992.88 hectares from 2017-2021. It is dominated by conversion from paddy fields to oil palm areas of 2,795.58 hectares. The conversion suitability of paddy fields to non-paddy fields in 2017-2021 against Labuhanbatu Utara regional spatial plan is 21.92 percent, while 78.08 percent is not. To maintain food security in Labuhanbatu Utara Regency, the government should tighten supervision of the implementation of the regional spatial plan as well as increase the allocation of paddy fields

Keywords: : labuhanbatu utara regency, paddy field, regional spatial plan, spatial pattern

1. Introduction

Labuhanbatu Utara Regency occupies an area of 354,580 hectares which consists of 8 sub-districts and 90 villages. The sub-districts are Na. IX-X, Marbau, Aek Kuo, Aek Natas, Kualuh Selatan, Kualuh Hilir, Kualuh Hulu, and Kualuh Leidong [1]. The paddy production in Labuhanbatu Utara in 2021 is 118,749.5 tonnes with a harvested area of 21,129.8 hectares. This paddy production was lower than in 2017 at 189,134.6 tonnes with a harvested area of 35,760.5 hectares [2]. The decline in paddy production will reduce food security [3]. This is due to the massive land conversion from paddy fields to non-paddy fields (settlements and plantations).

Land Conversion of paddy fields to non-paddy fields is a complex problem viewed from the degree of overgrowth land use, topographical factors, the relation to social life culture, population growth, level of welfare farmers, irrigation, city expansion, and political will from the government and other stakeholders [4]. Several reasons for a high level of land conversion from paddy fields to non-faddy fields are low-level profit

in farming, disobeying spatial regulations (low enforcement law), willingness to get cash by selling the land, and low coordination between institutions and departments related to planning land use [5].

Regional Regulation of Labuhanbatu Utara Regency Number 5 of 2015 About the Labuhanbatu Utara Regional Spatial Plan 2015 - 2035 has not been able to control the available land with various problems. It also cannot protect paddy fields as food production in Labuhanbatu Utara Regency. This is because regulations aimed at controlling land conversion are generally only advisory and are not accompanied by apparent sanction. [6]. Therefore, to control the loss of agricultural land, especially paddy fields, the government needs to enforce laws on land conversion in regional spatial planning [7]. This policy will maintain and develop the food security of the Labuhanbatu Utara Regency.

The importance of maintaining paddy fields and food security motivate us to analyze paddy field conversion and the pattern of changes in the Labuhanbatu Utara Regency between 2017-2021. This research also analyzes the suitability of paddy fields conversion compared to the Labuhanbatu Utara regional spatial plan as an evaluation material for the government. GIS (Geographic Information System) was used in this study to process and analyze an overlapping method on biophysical data, existing conditions, and other thematic data

2. Method

The research was conducted in Labuhanbatu Utara Regency which is one of the regencies located on the East Coast of North Sumatra Province. Geographically, Labuhanbatu Utara Regency is located at 1°58' – 2°50' North Latitude, 99°25' – 100°05' East Longitude with an altitude of 0 – 700 m above sea level [8].
The data used in the study consisted of primary data and secondary data. Primary data was obtained from Landsat 8 imagery data in 2017 and Sentinel imagery data in 2021, field survey data, and interviews. Secondary data was obtained from the administrative data map, Geospatial Paddy Fields map, Spatial Planning map, and studies literature from various sources.

The research uses a descriptive qualitative method. The data was processed and analyzed using an overlapping method on biophysical data, existing conditions, and other thematic data. Overlay is a technique for creating a new data set that is combined with two or more data sets, resulting in a new layer [9]. By overlaying the two or more maps, changing conditions and deviations from current and previous land use conditions will be found [10]. Thus, overlay analysis is very useful in solving spatial problems in the field of land use [11].

Data processing is done by software Geographic Information System (GIS). GIS is part of an information system that is applied to geographic data or data base tools for the analysis and mapping of things that exist and occur on earth [12]. The data processed in GIS is geographically oriented, has a coordinate system, and has two important parts, namely location information (spatial) and descriptive information (attributes) [13]. Data processing is carried out with the methods of identifying and describing as well as analyzing data to understand form and use something land [14]. The data processing and analysis can be seen in the diagram be

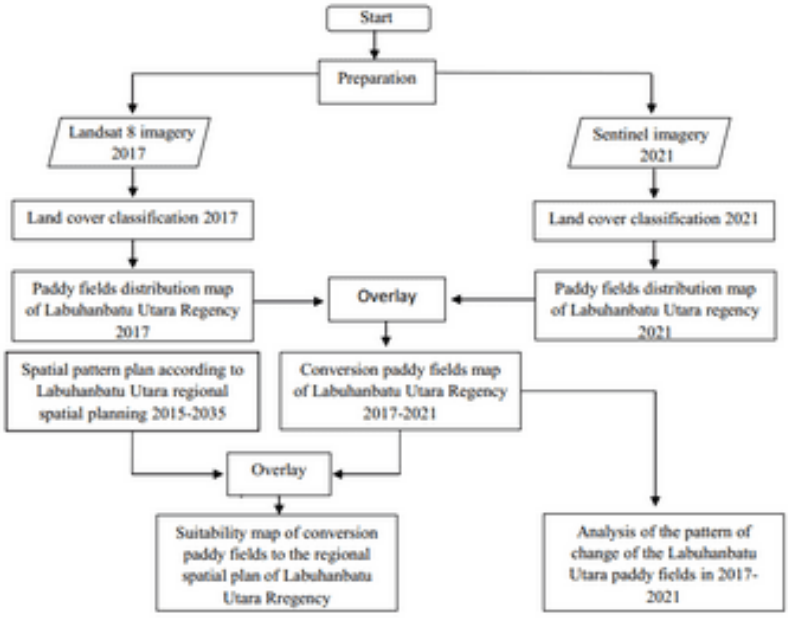


Figure 1. Research Process Diagram

Map of paddy fields and non-paddy fields in 2017 and 2021 are obtained through the interpretation of digital images or wish to classify land cover with a supervised classification method. The distribution maps of paddy fields and non-paddy fields in 2017 and 2021 were overlaid using geographic information system analysis to produce a conversion paddy fields map of Labuhanbatu Utara Regency 2017-2021 with distribution, pattern, and area of conversion. The regional spatial plan of Labuhanbatu Utara Regency map and conversion paddy fields map of Labuhanbatu Utara Regency were overlaid using geographic information system analysis to analyze the suitability map between the two maps.

3. Results and Discussion.

3.1 An Overview of Paddy Fields and Non-Paddy Fields in Labuhanbatu Utara Regency

Based on the spatial analysis using Landsat 8 imagery in 2017, it was found that the area of paddy fields in Labuhanbatu Utara Regency in 2017 was 13,845.93 hectares and the non-paddy field was 355,936.85 hectares. The largest area of paddy fields is in the Districts of Kualuh Hilir and Kualuh Leidong with an area of 9,586.05 hectares and 3,553.44 hectares respectively. The area of paddy fields is then located in South Kualuh sub-district, which is 592.59 hectares, Kualuh Hulu sub-district, which is 86.13 hectares, and Na IX-X sub-district, which is 27.72 hectares. The distribution of paddy fields and non-paddy fields in 2017 can be seen on the map below.

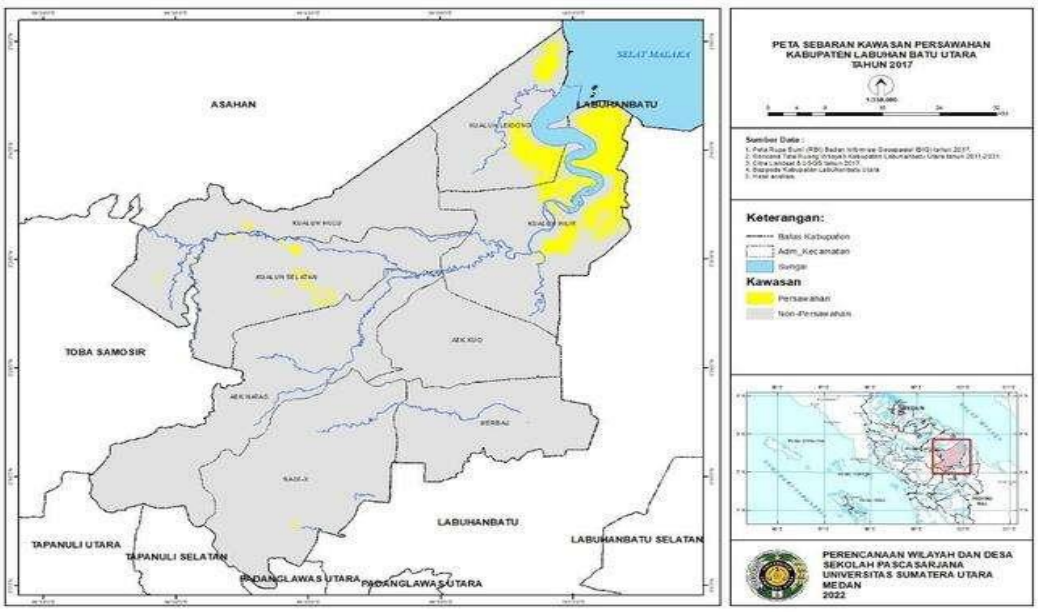


Figure 2. Map of Distribution of Paddy Fields in Labuhanbatu Utara Regency in 2017

Source: Landsat 8 imagery of 2017 Processed

While in 2021, the results of a spatial analysis using Sentinel imagery found that the total area of paddy fields in Labuhanbatu Utara Regency is 10,853.06 hectares and non-paddy fields are 358,929.74 hectares. The largest area of paddy fields in 2021 is also in the Kualuh Hilir sub-district, which is 7,478.79 hectares, and the Kualuh Leidong sub-district, which is 2,877.76 hectares. The area of paddy fields is then located in South Kualuh sub-district, which is 416.00 hectares, Kualuh Hulu sub-district, which is 66.86 hectares, and NA IX-X sub-district, which is 3.65 hectares. The distribution of paddy fields and non-paddy fields in 2021 can be seen on the map below.

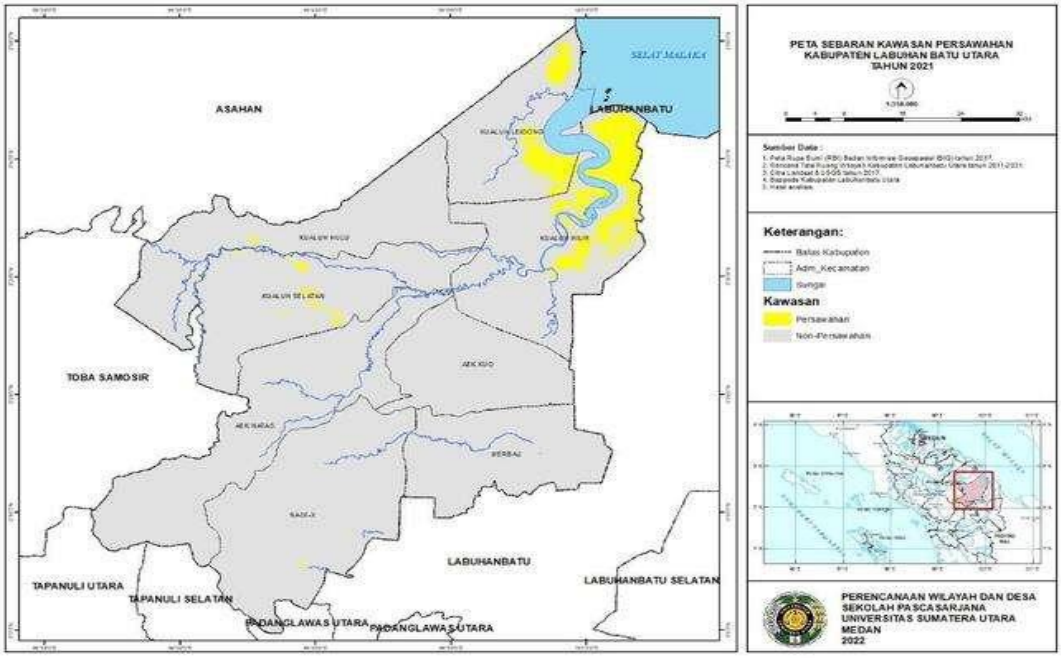


Figure 3. Map of Distribution of Paddy Fields in Labuhanbatu Utara Regency in 2021
Source: Sentinel Imagery of 2021 Processed

3.2. Conversion of Paddy Fields to Non-Paddy Field in the Labuhanbatu Utara Regency between 2017-2021

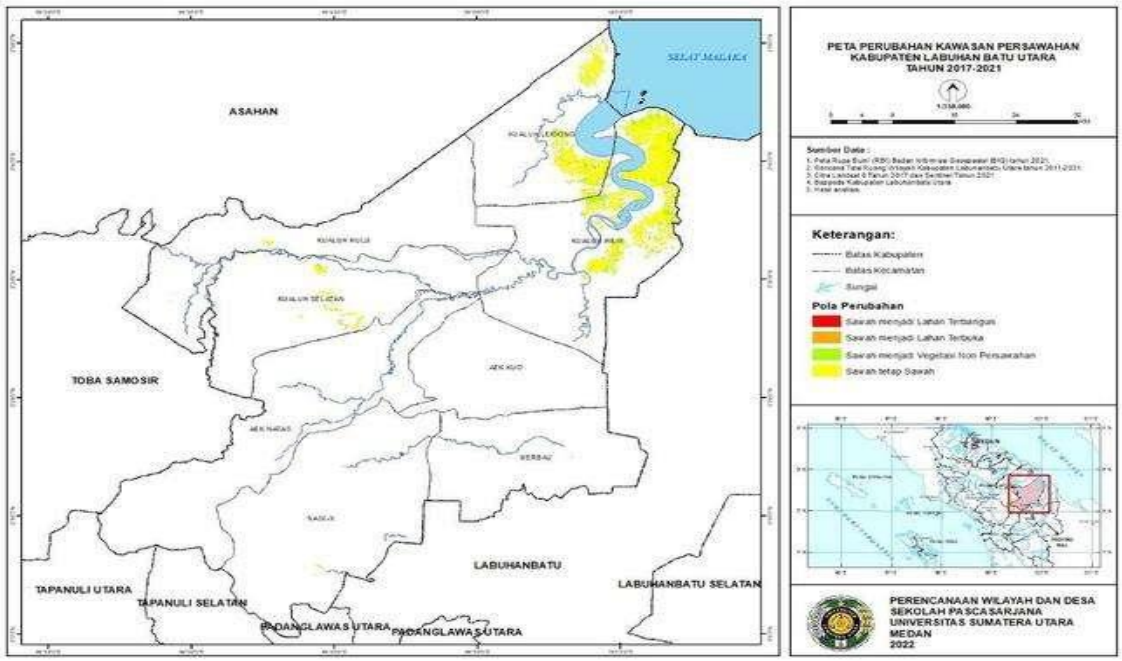


Figure 4. Map of conversion Paddy Field in Labuhanbatu Utara Regency between 2017 – 2021
Source: Landsat 8 imagery of 2017 and Sentinel Imagery of 2021 Processed

Based on the results of spatial analysis by overlaying the paddy fields distribution map in Labuhanbatu Utara Regency in 2017 and 2021, we obtained that the area of paddy fields that turned into non-paddy fields was 2,992.88 hectares. this is due to higher income from oil palm plantations with lower risks, the higher selling value of plantations, lower production costs for plantations, limited availability of water, expensive fertilizer prices, the location of paddy fields which is close to office centers, and new development areas as well as a lack of supervision of land use change.

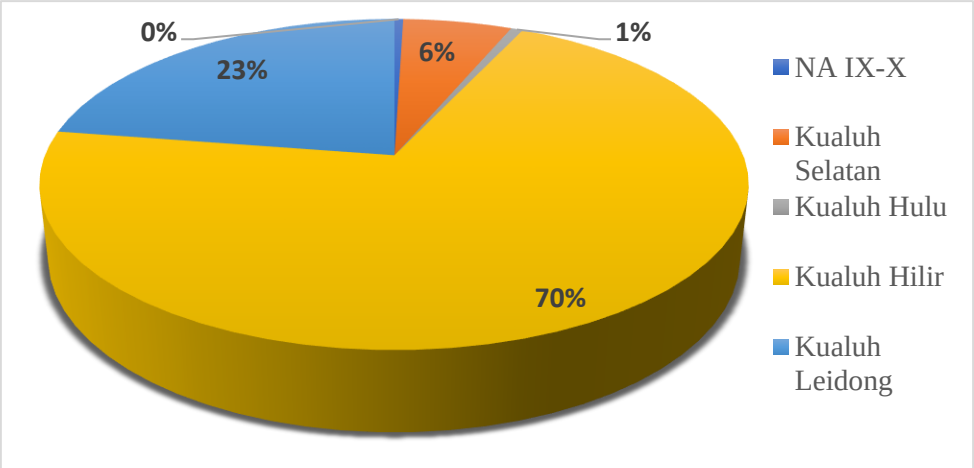


Figure 5. Percentage of conversion in paddy fields to non-paddy fields in Labuhanbatu Utara Regency by sub-district between 2017 - 2021

According to the region, the largest conversion of paddy fields to non-paddy fields is in the Kualuh Hilir sub-district, which is 70 percent of the total converted land between 2017-2021. The other region is in the Kualuh Leidong sub-district was 23 percent, South Kualuh was 6 percent and Kualuh Hulu was 1 percent.

3.2 The Pattern of Changes in the Function of Paddy Fields Year 2017-2021

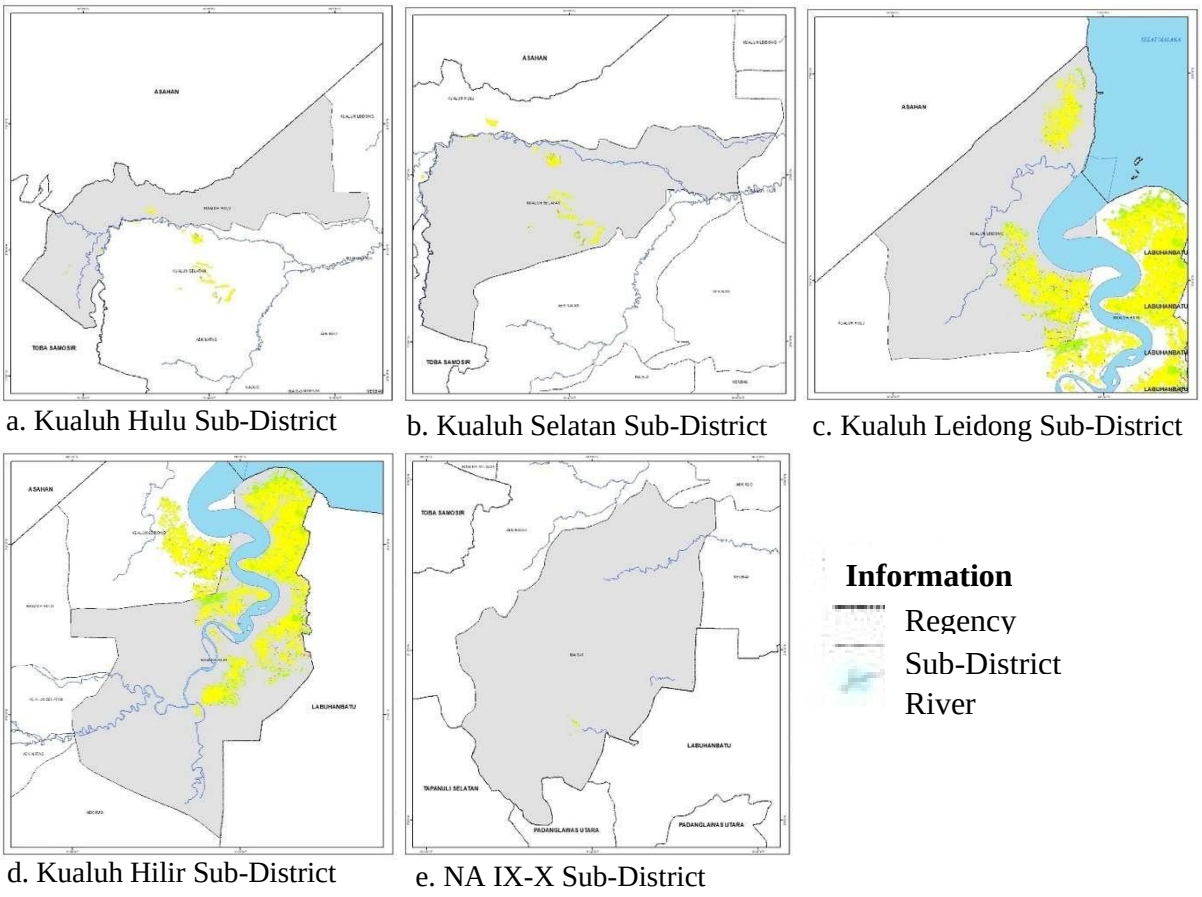
Spatial analysis of changes in the function of paddy fields in Labuhanbatu Utara district in 2017-2021 found three patterns of change which can be seen in the table below.

Table 1. Area of Change in Paddy Fields Labuhanbatu Utara Regency, 2017 – 2021

Land Change	**Area (Ha)**	
	Changed	**Not-Changed**
Paddy fields Become Forest	-	-
Paddy fields Become Built-up Land	111.22	-
Paddy fields Become Open Land	86.08	-
Paddy fields permanent Paddy fields	-	10,853.06
Paddy fields become a river.	-	-
Paddy fields Become Non-Paddy Vegetation.	2,795.58	-
Total	**2,992.88**	**10,853.06**

Source: Data processed, 2017 - 2021

The largest pattern of change is paddy fields to non-paddy vegetation land with an area of 2,795.58 hectare. This pattern of change occurred in the sub-districts of Kualuh Hilir, Kualuh Leidong, and Kualuh Selatan. These three sub-districts have many oil palm plantations both owned by companies and the community as well as palm oil processing factories. Paddy fields in this area which are surrounded by oil palm plantations have changed their function to become oil palm plantations. The smaller the value of direct benefits received by farmers will encourage the conversion of agricultural land easier to happen [15].



a. Kualuh Hulu Sub-District b. Kualuh Selatan Sub-District c. Kualuh Leidong Sub-District

d. Kualuh Hilir Sub-District e. NA IX-X Sub-District

Figure 6. Pattern of Change Map from Paddy Field to Non-Paddy Fields by District in Labuhanbatu Utara Regency between 2017-2021
Source: Landsat 8 imagery of 2017 and Sentinel Imagery of 2021 Processed

3.3 Analysis Suitability conversion of Paddy Fields to Non-Paddy Field Against Regional Spatial Plan of Labuhanbatu Utara Regency

The map of the Labuhanbatu Utara Regency Spatial Plan for 2015-2035 contained in the Regional Regulation of the Labuhan Batu Utara Regency Number 5 of 2015 can be seen below.

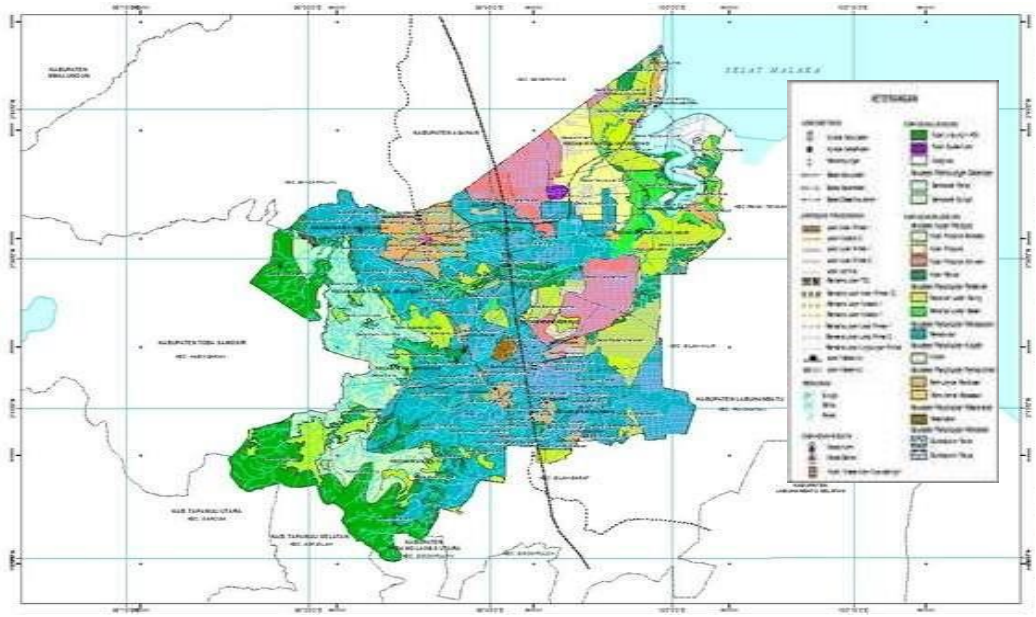


Figure 7. Map of the Labuhanbatu Utara Regency Spatial Plan for 2015-2035
Source: Badan Perencanaan Pembangunan Daerah 2015

The conformity analysis process is done by overlaying the spatial pattern map of the Regional Spatial Plan of Labuhanbatu Utara with a map of changes in the function of the paddy fields in 2017-2021, the results of the analysis between the appropriate criteria and the unsuitable criteria will be obtained as figure below.

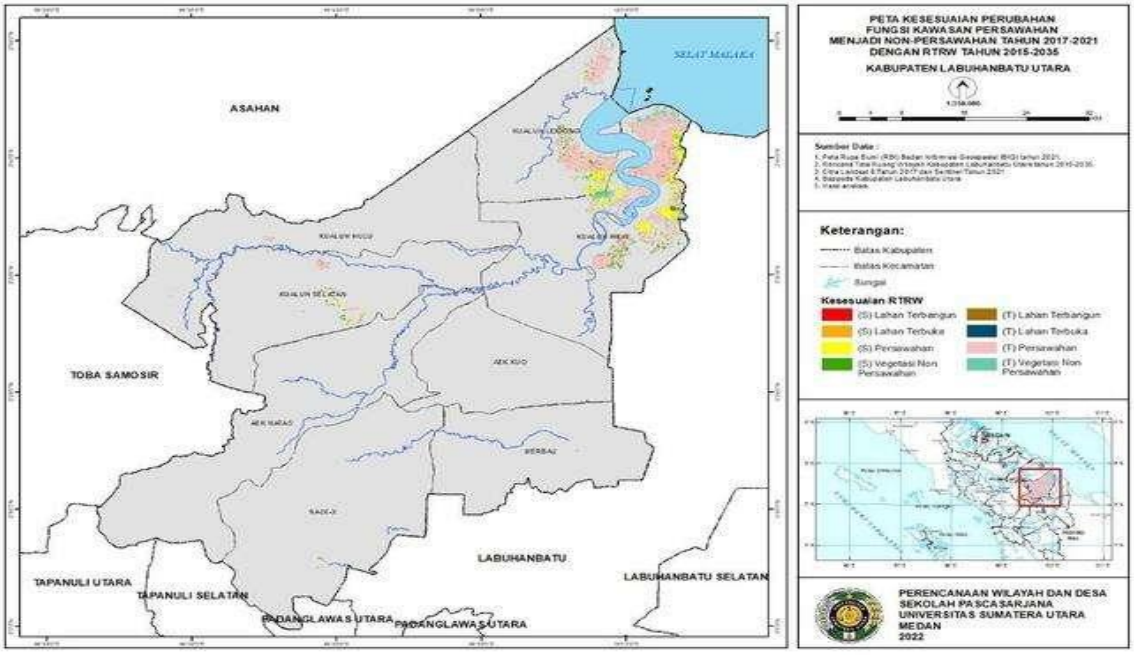


Figure 8. Suitability map of conversion paddy fields to the regional spatial plan of Labuhanbatu Utara Rregency between 2017-2021
Source: Map Processed

Based on the map on figure 8, we found that the change in the function of paddy fields to non-paddy fields between 2017-2021, which follows the RTRW of Labuhanbatu Utara Regency in 2015-2035 is 3,034.47 hectares, while 10,811.46 hectares is not.

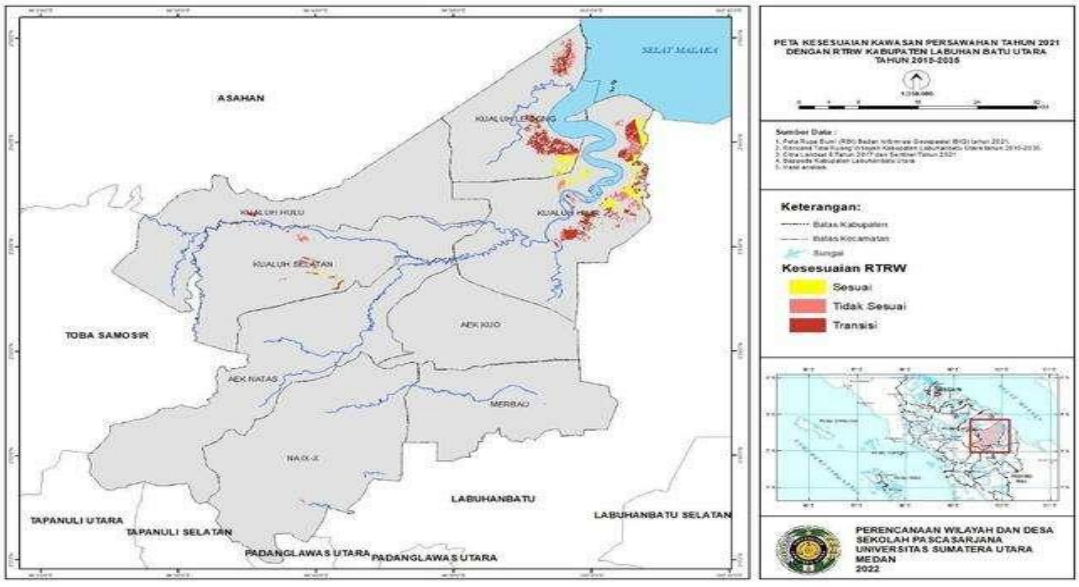
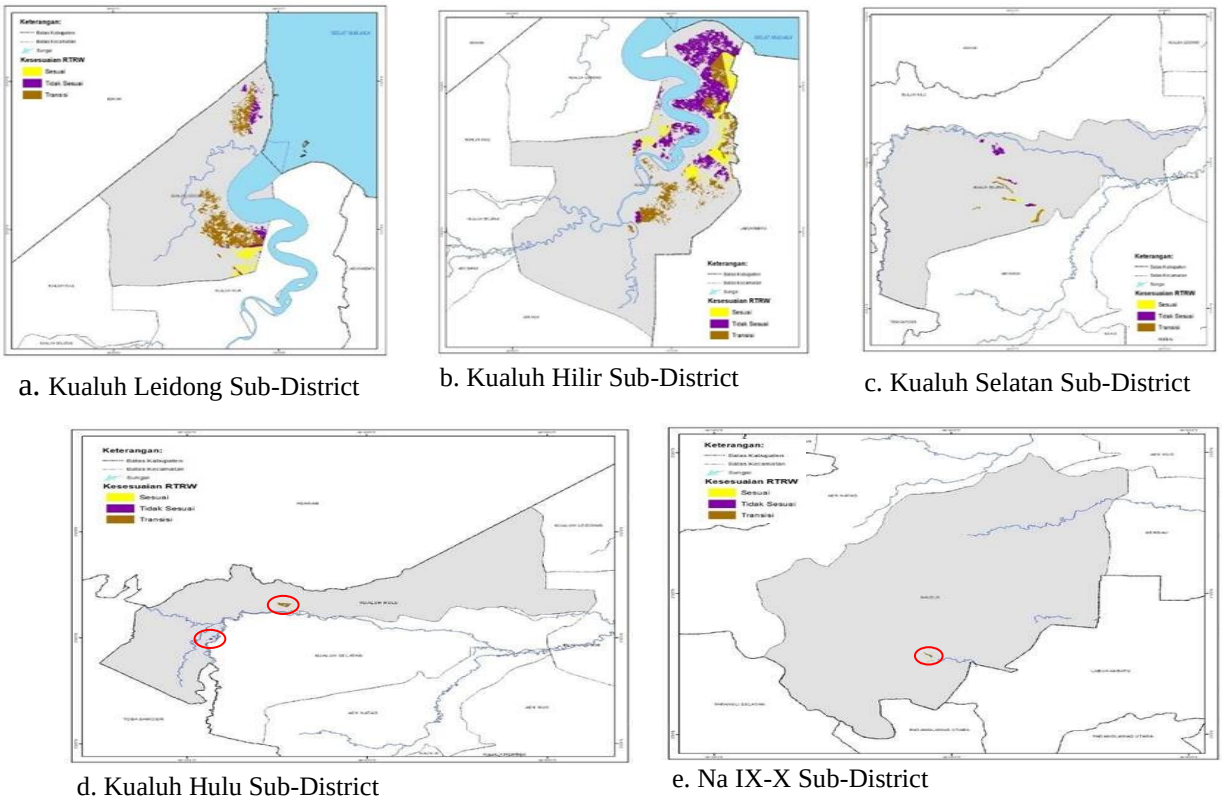


Figure 9. Map of Suitability of Paddy Fields in 2021 with the Labuhanbatu Utara Regency Spatial Planning for 2015-2035.
Source: Map Processed

Compared to the existing conditions in 2021, we found that the existing paddy field area in 2021, which was following the RTRW directives was 1,806.03 hectares (16.64%), while 4,566.89 hectares (42.08%) was not and the transition area was 4,480.14 ha (41.28%)



a. Kualuh Leidong Sub-District b. Kualuh Hilir Sub-District c. Kualuh Selatan Sub-District

d. Kualuh Hulu Sub-District e. Na IX-X Sub-District

Figure 10 Map of Suitability of Paddy Fields in 2021 with the Labuhanbatu Utara Regency Spatial Planning for 2015-2035 by sub-district.

Source: Map Processed

In general, the suitability of paddy fields in five sub-districts in Labuhanbatu Utara Regency 2021 is not following the spatial planning 2015-2035. The suitability of paddy fields in Kualuh Leidong sub-district is 410.51 hectare, while 457,20 hectares, is not. The suitability of paddy fields in Kualuh Hilir sub-district is 1,247.27 hectare, while 3,926,23457,20 hectare, is not, then the suitability of paddy fields in sub-district of Kualuh Selatan is 174.36 hectare while 193,39 hectares, is not. The discrepancy between the existing 2021 paddy field areas and the 2015-2035 spatial planning that occurs in all sub-districts shows that the government's lack of supervision and control over the implementation of spatial planning in Labuhanbatu Utara regency.

4. Conclusion

Based on the discussion and analysis above it is concluded that there had been a reduction in the area from paddy fields to non-paddy fields of 2,992.88 hectares from 2017-2021. It is dominated by conversion from paddy fields to oil palm areas of 2,795.58 hectares. This is due to higher income, lower risks, higher selling value and lower production costs for oil palm plantations. This conversion occurred mostly in Kualuh Hilir sub-district. The conversion suitability of paddy fields to non-paddy fields in 2017-2021 against Labuhanbatu Utara regional spatial planning is 21.92 percent, while 78.08 percent is not.

To maintain food security in Labuhanbatu Utara Regency, the government must tighten supervision over the implementation of regional spatial planning. This is related to rewards and punishments that are straightforward for the community. The government should also increase the allocation of paddy fields, implement agricultural intensification, and provide fertilizer assistance and agricultural tools that were right on target.

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