Changes in land use and suitability of spatial planning on the paddy field in Gorontalo Regency

M Ekafitrawan¹, M H Jamil² and D Useng²

¹Regional Planning and Development Program, Graduate School of Hasanuddin University, Makassar, Indonesia
²Agricultural Faculty of Hasanuddin University, Makassar, Indonesia

Email: moh_eka@yahoo.com

Abstract. Agricultural land is the main and unique factor of agricultural production because it is difficult to replace in an agricultural business process. This research is intended to conduct a spatial study of changes in land use, especially paddy fields and the suitability of spatial use with the regional spatial plan (RTRW). In this study, an analysis of land-use change was carried out by comparing multitemporal land cover data (time series), and the suitability analysis of spatial use by comparing actual land cover data with the direction of spatial use specified in the RTRW document. Both of these analyses were carried out by overlaying maps using GIS (Geographic Information Systems) spatial data processing software. The results showed that within ten years (2007-2017), an increase in the total area occurred in the plantation (1.4%), built land (41.37%), dry land/fields (1.97%), and lake/body of water land-use class (11.14%). While the area of forest, paddy fields, and shrubs are reduced by 0.12%, 5.09%, and 6.68%, respectively. The results of overlaying actual land use maps with spatial pattern maps on Gorontalo Regency RTRW show that most (65.67%) land use in Gorontalo Regency is still following the direction of spatial use which has been specified in the RTRW. Whereas 34.13% of other land uses were identified as not yet suitable (30.57%) and not suitable (3.55%) with the RTRW. Land use that is not yet suitable is still possible to change to adjust the spatial Plan in the future. Regarding paddy fields, the land-use suitability matrix with the RTRW shows that 86.18% of the paddy fields in Gorontalo Regency are following the RTRW (located in the allotment of wetland agriculture areas), while the remaining 13.82% are not following the RTRW. There is also the potential for new paddy fields with a total area of 6,293 hectares.

1. Introduction

The agricultural sector has a strategic role in national economic development. One of the main capitals in the agriculture sector is land availability. Agricultural land remains the main and unique factor of agricultural production because it is difficult to replace in an agricultural business process. Philosophically, the land has a central role and function for an agrarian-style Indonesian society. This is because land, besides having economic value, also obtains social value, even religious.

Agricultural land has currently faced problems with increasingly massively of conversion the land-use and land degradation. Classical economic market law triggers a shift in activity on land from low-profit activities (land rent) to high-profit activities with higher land rent [1]. Agriculture’s position in generating land rent tends to be inferior to other sectors like industry, housing, trade, and service.
From this concept, land quality can be classified according to its quality, which is reflected by the level of surplus value known as rent [2].

Conversion of agricultural land functions, especially paddy fields, not only has an impact on the decline in food production capacity but also results in increasingly farming narrow cultivation, which has implications for decreasing the welfare of farmers. Maintaining the existence of agricultural land is also intended as an effort to maintain environmental quality stability (flood mitigation, controlling soil erosion, maintaining groundwater supply, and preserving biodiversity), as well as maintaining social-cultural values and rural attractiveness (rural amenity) [3].

The Indonesian Center of Agricultural Land Research and Development researched the conversion rate of paddy field use in primary rice production in nine provinces in the period of 2000-2015. The results show that the national paddy field conversion index is 0.0119 which demonstrates the potential of converting the rice field to about 96,512 hectares every year. If the paddy fields are allowed to sustain convert with its average conversion rate, then there will represent a significant decrease in paddy fields aggregately from 8.1 million hectares in 2013 to only about 5.1 million hectares in 2045 [4]. This tendency can threaten Indonesia's food security.

Gorontalo Regency represents the rice production center in Gorontalo Province. Rice production in Gorontalo Regency reached 70,173 tons/year and contributed 52.21% of Gorontalo Province in total. However, the statistics of Gorontalo Regency's paddy fields in the past five years show a fluctuating moving, which is in certain years there has been a decline in paddy fields area. Land conversion functions will certainly have implications for the availability of farms and food independence in the future.

Policies on spatial use and regional development, according to UU. No. 26 of 2007 is based on the Regional Spatial Planning (RTRW) document. The government of Gorontalo Regency has established Regional Regulation No.4 of 2013 about Gorontalo District RTRW 2012-2032. Demanding for land in this area continues increasing along with population, economic, and regional development activities. This has the potential to lead to uncontrolled use of land resources. Under the pretext of the interests of regional development and improvement of community welfare, frequently the spatial use activities of local governments or communities are actually in conflict (mismatch) with spatial plans. Therefore, this research will conduct a spatial study of changes in land use, primary paddy fields in the period 2007-2017 and the suitability of its spatial use with the RTRW of Gorontalo Regency in 2012-2032.

2. Methods

2.1. Location and focus
Administratively, the research area is in the Gorontalo Regency Gorontalo Province. Gorontalo Regency has an area of ±2,125.47 Km² which consists of 19 districts, 191 villages, 14 sub-districts, 66 neighborhoods, and 742 hamlets; with a population of ±374,923 people and population growth rate of 0.64 percent [6]. This study will focus on the assessment of the paddy fields use that produce rice. This research, in general, will conduct a spatial study of the actual condition of paddy fields, focused on changes in paddy field use between 2007 and 2017; and its suitability with the Gorontalo Regency spatial plan.

2.2. Collecting data
Data collection methods used in this study are: (1) Interviews with local government officials as policymakers to obtain an overview of spatial planning policies, primarily related to food agricultural land; (2) collection of secondary data in related institutions in the form of data relating to laws and regulations relating to spatial planning like government regulations, ministerial regulations, RTRW, RPJMD; then spatial data like administrative maps, land use maps, land use direction maps (spatial plan), land suitability maps; and statistical data, such as population data, land productivity data, and food consumption level.
2.3. Data analysis
Referring to the purpose of research, processing, and analysis of data in this study broadly includes two things; analysis of land-use conversion and analysis of the spatial use suitability. Analysis of land-use conversion is carried out to find out how much the converted land-use has occurred in an area within a certain period [5]. Analysis of land-use conversion is conducted by comparing land cover conditions in a multitemporal (time series). Data for land cover or land use that is compared within 10 years was the land use between 2007 and 2017.

Spatial use suitability analysis is to find out how far is the suitability between actual land uses compared to the spatial use direction (spatial plan) based on the Regional Spatial Planning document (RTRW). The provision of utilization can be in the form of activity and spatial allotments contained in the detailed plan or general provisions on zoning regulations contained in the District/City RTRW [6]. Both of these analysis processes, analysis of land use conversion and the analysis of the suitability of space use, are carried out by overlapping maps using the GIS (Geographic Information System) spatial data processing software.

3. Result
3.1. Land-use conversion
The results of the analysis of land-use conversion in 2007 and 2017 (Table 1) show that in Gorontalo District within a period of 10 years (2007-2017), the land-use types of garden/plantation, built-up land, fields/fields, and lakes/water bodies experienced an increased area, while the land-use types for forest, paddy and shrub was reduced. The land-use class that experienced the most significant area conversion was the developed land, where the area of land developed in Gorontalo Regency in 2007 was 3,639.96 hectares, increasing 41.37% to 5,145.97 hectares in 2017. Fields and lakes/water bodies also experienced an increase in area, each increasing by 491 hectares (1.97%) and 327 hectares (11.14%). The forest which is the most dominant land-use type, where the area reaches 36.7% of the total area, tends not to experience significant changes in the area. Paddy fields that support the food availability also decreased from 14,706 hectares in 2007, converted to another of 748 hectares (5.09%), so that in 2017 the area of paddy fields decreased to 13,957 hectares. Likewise, shrubs which also experienced the land conversion of ±2262 hectares (6.68%), so, that the area was reduced from 33,868 hectares to 31,607 hectares within 10 years.

| Type of Land use/ Landcover | Area (Ha) | Percentage (%) | Land-use Conversion (Ha) | Note |
|-----------------------------|-----------|----------------|-------------------------|------|
| Forest                      | 79,154.31 | 79,055.89      | 36.78 36.74              | -98  -0.12 | Decreased |
| Garden/ Plantation          | 55,947.44 | 56,731.69      | 26.00 26.36              | 784  1.40  | Increased |
| Constructed Land            | 3,639.96  | 5,145.97       | 1.69 2.39                | 1,506 41.37 | Increased |
| Paddy Field                 | 14,706.19 | 13,957.97      | 6.83 6.49                | -748 -5.09 | Decreased |
| Shrubland                   | 33,868.65 | 31,607.07      | 15.74 14.69              | -2,262 -6.68 | Decreased |
| Farm                        | 24,933.37 | 25,424.54      | 11.59 11.82              | 491  1.97  | Increased |
| Lake/ Water Body            | 2,934.00  | 3,260.80       | 1.36 1.52                | 327  11.14 | Increased |

Table 2 in the form of a matrix of land-use conversion, in more detail, shows the pattern of land-use conversions that occurred in Gorontalo Regency from 2007 to 2017. The matrix shows changes in land use from forests to drylands/fields (444 hectares), shrubs (64.4 hectares), gardens (10.4 hectares), and...
the developed land (4.05 hectares). Farm/plantation turned into developed land and paddy fields was covering an area of 1096 hectares and 211 hectares, respectively. While paddy fields are also converted into other like forests, developed the land, farm/fields, lakes/water bodies with a total area was converted to ±1,320 hectares. The conversion area from shrubs to the plantation was the largest compared to other. The conversion area occurred reached ±1890 hectares. While the fields are converted into gardens/plantations by 322 hectares, into wetland agriculture (rice fields) by 105 hectares, and turned into built-up areas by 65 hectares. The land cover like lakes/water bodies is relatively increased because of the conversion from others, that is from paddy fields (284 hectares) and shrubs (53 hectares). But, on the contrary, there are ±11.4 hectares of the Limboto lake turned into the forest (mangrove).

### Table 2. Matrix of change in land use/land cover in 2007 and 2017 in Gorontalo Regency.

| Land Use/Land Cover in 2007 | Forest | Garden/Plantation | Constructed Land | Paddy Field | Shrubland | Farm | Lake/Water Body | Amount |
|----------------------------|--------|-------------------|------------------|-------------|-----------|------|----------------|--------|
| Forest                     | 78,629.32 | 10.41             | 4.05             | 1.74        | 64.44     | 444.35 | 79,154.31       |
| Garden/Plantation          | 54,509.16 | 1,096.53          | 211.54           | 9.77        | 120.25    |      | 55,947.24       |
| Constructed Land           |        | 3,639.96          |                  |             |           |      |                |
| Paddy Field                | 415.17   | 263.79            | 13,383.27        | 358.98      | 284.98    | 14,706.19 |                |
| Shrubland                  | 1,890.06 | 76.23             | 256.17           | 31,529.73   | 63.24     | 33,868.65 |                |
| Farm                       | 322.06   | 65.41             | 105.04           | 3.12        | 24,437.73 | 24,933.37 |                |
| Lake/Water Body            | 11.40    |                   |                  |             |           |      | 2,922.60        | 2.93   |
| Amount                     | 79,055.89 | 56,731.69         | 5,145.97         | 13,957.77   | 31,607.07 | 25,424.54 | 215,183.72      |

3.2. Spatial use suitability

Evaluation of the Conformity of Land Use with RTRW in Gorontalo Regency (table 3) shows that the majority (65.67%) of land is still in accordance with the direction of spatial use stipulated in the RTRW. The land-use types that had the highest suitability rates were lakes/water bodies (100%), forest (91.18%), developed land (73.12%), and rice fields (86.18%). While the other two types, shrubs, and fields, their suitability to the RTRW is relatively small i.e. only around 13-17%.

The total area that was unsuitable with the identified RTRW is ±7,646 hectares or around 3.55% of the total area. This discrepancy is predominantly of built-up land that was built in the non-designation area, which includes in the designation of the protected area (144 hectares), plantation areas (561 hectares), wetland agricultural areas (266 hectares), and dryland agricultural areas (405 hectares). In addition, mismatches in spatial use also occur in gardens/plantations area of 3,507 hectares, fields 2,411, and rice fields area of 350 hectares which were all located in the allotment of protected areas.

Unsuitable land and modifiable to adjust the RTRW in the future, the total area reaches ±65,791 hectares or around 30.57% of the total area. Land use types that are considered unsuitable and have the opportunity to improve to adjust the RTRW include shrubs with a total area of 27,361 hectares (86.57%) and fields with a total area of 18,590 hectares (73.12%). The shrubland mentioned is not yet in accordance with the Spatial Plan, most of the shrubs in the allotment of plantation area (11,255
hectares), allotment of dryland agricultural area (8,407 hectares), and allotment of production forest area (7,082 hectares). Whereas uplands/fields that are not in accordance with the Spatial Plan are uplands/fields that were in the designation of the production forest area (10,275 hectares), plantation area (7,269 hectares), as well as of the wetland agricultural areas (840 hectares). Spatially, the suitability of the substantial land use with the RTRW is presented in figure 1.

### Table 3. Evaluation results of the suitability of land use with RTRW in Gorontalo Regency.

| Land Use / Land Cover | Suitable | Suitable Yet | Unsuitable | Amount |
|-----------------------|----------|--------------|------------|--------|
|                       | Ha  | %   | Ha  | %   | Ha  | %   | Ha  | %   |
| Forest                | 72,085.18 | 91.18 | 6,970.69 | 8.82 | 0 | 0 | 79,055.88 |
| Garden/Plantation     | 41,939.42 | 73.93 | 11,284.91 | 19.89 | 3,507.36 | 6.18 | 56,731.69 |
| Constructed Land      | 3,762.93 | 73.12 | 5.32 | 0.10 | 1,377.71 | 26.77 | 5,145.97 |
| Paddy Field           | 12,028.84 | 86.18 | 1,578.57 | 1.31 | 350.56 | 2.51 | 13,957.97 |
| Shrubland             | 4,245.47 | 13.43 | 27,361.59 | 6.57 | 0 | 0 | 31,607.07 |
| Farm                  | 4,423.44 | 17.40 | 18,590.10 | 73.12 | 2,411.01 | 9.48 | 25,424.54 |
| Lake/Water Body       | 3,260.80 | 100.00 | 0 | 0 | 0 | 0 | 3,260.80 |
| **Amount**            | 41,746.08 | 65.87 | 65,791.20 | 0.57 | 7,646.64 | 3.55 | 215,183.92 |

Figure 1. Suitability Land Use with RTRW Map.

The paddy fields suitability and new paddy fields potential (table 4) show that paddy fields are spatially in accordance with the spatial plan use in the RTRW reach 86.18% (12,028 hectares) which were predominantly located in Tolangohula (2,326 hectares) and Mootilango (1,654 hectares). Moreover, unsuitable paddy fields with RTRW, mostly located in Tolangohula (316 hectares), Asparaga (248 hectares), and Mootilango (128 hectares). There is also the potential for new paddy
fields area is ±6,293 hectares, that is, lands in the RTRW have been designated for paddy fields, but in evidence were not used for paddy fields.

Table 4. Suitability of wetland and potential of new wetland in Gorontalo Regency.

| District       | Paddy Field Potential Spatial Allocation in RTRW (Ha) | Paddy Fields (Existing) | New Paddy Field Potential (Ha) |
|----------------|------------------------------------------------------|-------------------------|-------------------------------|
|                | Suitable with RTRW (Ha) | Unsuitable with RTRW (Ha) |                               |
| TELAGA         | 422.37                               | 362.82                  | 54.45                         | 40.11                          |
| TELAGA BIRU    | 436.55                               | 349.12                  | 113.03                        | 24.08                          |
| TELAGA JAYA    | 270.76                               | 145.65                  | 26.32                         | 58.05                          |
| TILANGO        | 1,52.50                              | 0.00                    | 0.00                          | 121.00                         |
| LIMBOTO        | 1,565.98                             | 1,227.81                | 221.25                        | 290.01                         |
| LIMBOTO BARAT  | 1,362.97                             | 1,310.83                | 121.79                        | 48.04                          |
| TIBAWA         | 708.75                               | 638.14                  | 230.34                        | 58.89                          |
| PULUBALA       | 963.52                               | 108.30                  | 49.32                         | 849.05                         |
| BONGOMEME      | 1.66                                 | 1.66                    | 0.86                          | 0.00                           |
| BATUDAA        | 122.54                               | 37.82                   | 5.94                          | 81.99                          |
| TABONGO        | 1,712.55                             | 1,195.31                | 142.98                        | 492.45                         |
| BATUDAA PANTAI | 0.00                                 | 0.00                    | 0.00                          | 0.00                           |
| BILUHU         | 0.00                                 | 0.00                    | 0.00                          | 0.00                           |
| DUNGALIYO      | 700.58                               | 636.63                  | 60.24                         | 54.13                          |
| BOLIYOHUTO     | 2,096.74                             | 1,414.54                | 202.47                        | 658.76                         |
| MOOTILANGO     | 3,857.83                             | 1,654.65                | 128.89                        | 2,142.18                       |
| TOLANGOHULA    | 2,975.92                             | 2,326.23                | 316.47                        | 774.81                         |
| ASPARAGA       | 861.64                               | 600.66                  | 248.45                        | 244.98                         |
| BILATO         | 376.70                               | 18.65                   | 6.32                          | 355.23                         |
| Amount         | 18,589.55                            | 12,028.84               | 1,929.13                      | 6,293.76                       |

4. Discussion
This study shows that the various land-use types in Gorontalo Regency over a decade (2007-2017) experienced extensive changes in varying amounts, and most of the land-use patterns are still in accordance with the direction of spatial use stipulated in the Regional Spatial Planning (RTRW).

The constructed land represents a land-use type that has experienced significant changes in the area. In ten years, the area increased by 41.37%. This is a consequence of the Gorontalo Regency as the provincial capital. That why the Gorontalo City area is administratively limited, the process of fulfilling land needs has shifted to suburban areas. As a result, there is a tendency to shift urban functions to suburban areas. The suburban area will undergo a process of spatial transformation of settlement densification and socio-economic transformation as a further impact of the spatial transformation process. The process of settlement densification that occurs in suburban areas is a realization of the increasing need for space in urban areas. Increased demand for space in urban areas is encouraging the development of suburban areas (urban fringe) and the random development areas (urban sprawl) [7].
The expansion process of the city to the periphery will result in physical changes such as converted of land-use, demographics, ecological balance and socio-economic conditions. Some districts in Gorontalo Regency such as Telaga, Telaga Biru, Telaga Jaya, Tilango, and Limboto whose territory is directly adjacent to Gorontalo City have experienced an increase in the need for land, especially for housing, education, office, trade & service facilities. In this region, land conversion occurs from agricultural land (rice fields, gardens, and farms) into non-agricultural lands such as settlements, offices, and other constructed lands. This also explains why the increase in the area of constructed land is quite significant.

In addition, the constructed land and others that also experienced considerable changes in the area are shrubs. In contrast with the developed land which shows an increasing trend, the shrubs number in 2017 decreased compared to 2007. The physical characteristics of the use of shrubland that is relatively flexible and easily changed which makes this land cover types are easily converted into other land cover types. The most dominant change in shrubland cover is the conversion of shrubland to the plantation. This happened along with the entry of investment in oil palm plantations in this area. Based on data from the Gorontalo Province National Land Agency Regional Office (BPN) there are at least three large-scale oil palm companies that have started operating in the Gorontalo Regency, namely PT. Heksa Jaya Abadi, PT. Tri Palma Nusantara, and PT. Agro Palma Katulistiwa, where each company has a location permit of ±20,000 hectares [8]. Moreover, not only converted into garden/plantation, shrubland but also converted into wetland agriculture (rice fields). The Gorontalo Regency Office of Agriculture's annual report for 2012-2013 stated that there were activities to expand paddy fields using Regency funds (APBD) in some locations in Gorontalo Regency like Asparaga, Tolangohula, Boliyohuto, and Mootilango.

Paddy fields in Gorontalo Regency based on the conversion area analysis between 2007 and 2017 illustrated a declining trend. The area of paddy fields in 2017 fell 5.09% from 2007. In 2007-2017, paddy fields were converted into forests (mangrove), constructed land, farms and lakes/water bodies. View number of paddy fields around Lake Limboto because the lake overflow turned into mangroves/swamp and unexpectedly became a lake/water body. This happens due to the continuous sedimentation process at the bottom of the lake and shallower than before, if the rain intensity is high then the lake can overflow (flood) and inundate the surrounding rice fields, so, the paddy field no longer is used as its function.

In the suitability matrix between land use and the RTRW’s space utilization, it is recognized that there are several numbers of lands (area ±6,293 hectares) which are allocated as agricultural areas in wetlands or paddy fields but actually were used for other like gardens/plantations, farms, shrubs and constructed land. The type of this land-use in spatially has the opportunity (potential) to switch functions into new paddy fields, adjusting the spatial direction in the RTRW.

Paddy fields and potential of new paddy fields are mostly in Tolangohula (2,326 hectares) and Mootilango (1,654 hectares). This is due to the fact that the two areas also received the largest allocation of wetland agricultural land allocation in the RTRW, which was allocated space of 3,857 hectares and 2,975 hectares. Potential of new paddy fields with a total area of 6,293 hectares are spread out in almost all areas of Gorontalo Regency. Mootilango has the greatest potential with an area of 2,142 hectares. The geographical condition of Mootilango which is relatively flat and supported by the availability of adequate irrigation facilities makes this area very potential to be developed for wetland farming. Meanwhile, several districts, like Bongomeme, Biluhu, and Batudaa are unrecommended for food crop development, especially rice (rice). Moreover, geographical barriers and irrigation facilities, that area is also not supported by spatial planning policies (RTRW).

5. Conclusions
Within 10 years (2007-2017), the paddy field area in Gorontalo Regency had decreased by ±5.09%. The decline in the area was principally due to the conversion of paddy fields to constructed land as a result of the increased need for space in urban areas that led to the development of suburban areas (urban fringes) and arbitrary regional developments (urban sprawl). Analysis of the spatial use
suitability shows there are ±1,926 hectares of paddy fields that have the potential to convert because the location is not in accordance with the spatial use direction which was stipulated in the RTRW. Managing the land use through consistency in the implementation of the Spatial Plan, increasing production results with the use of agricultural technology, and land clearing for new paddy fields obtain efforts that can be done by the local government, to maintain the availability of paddy fields to be able to support the food needs in Gorontalo Regency.

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