

# Analysis of Agricultural Land Use Changes Using Remote Sensing and Geographic Information System in Kendari City

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## ABSTRACT

Along with its development, the area of agricultural land in Kendari City has declined. This study aims to determine the extent of agricultural land in 1997, 2007 and 2017 and the causes of the conversion, in addition to know the projected area of agricultural land in 2027. This research is based on remote sensing systems and geographic information systems by observing and interpretation the satellite images. These results indicate that the area of agricultural land in the past 10 years continues to decline. In 1997 the area of agricultural land amounted to 9,294.04 Ha, in 2007 was 4,797.81 Ha and in 2017 was 3,424.15 Ha. Factors that cause conversion are the population increase, urban growth, economic, socio-cultural and government policy. This study uses a geometric projection method and overlay analysis. Based on the calculation of geometric projections obtained by the agriculture area in Kendari City in 2027 amounted to 2443.78 Ha. The prediction of the largest agricultural land area in 2027 is in Puuwatu District with a land area of 851.46 Ha and the lowest is in Wua-wua District with an area of 0.02 Ha of agricultural land.

**Keywords:** *land conversion, agriculture*

## 1. INTRODUCTION

Land conversion is a change in the function of part or all of the land area from its original function to another function which is a negative impact on the environment and the potential of the land itself. Land conversion in terms of changes in allotment of use, is caused by factors which broadly include the need to meet the needs of the increasing number of population and the increasing demand for better quality of life [1].

The need for land is increasing rapidly with the increasing of population and development resulting in land conversion is inevitable. The availability and the land area basically did not change. Although the quality of land resources can be increased in quantity in each area is relatively fixed. In these conditions, an increase in land requirements for a production activity will reduce the availability of land for other production activities [2].

One concept that develops is land as space or spatial. Thus land is a spatial natural resource that refers to spatial elements (area, position and dispersion), the phenomenon of agricultural land conversion occurs in the context of structural economic and demographic transformation. The process of converting agricultural land to non-agricultural

use also involves a socio-economic dimension on a micro scale [3].

High economic growth led to very rapid growth in several economic sectors. In the results of the empirical study by the growth also requires wider land so that there is an and are identified in italic type [4]. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them. You may note peculiarities. For example, the head margin in this template measures proportionately more than is customary. This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations. Some components, such as multi-leveled equations, graphics, and tables are prescribed.

increase in land requirements for development in various sectors, especially the industrial sector. The importance of land for these various sectors makes the demand for land use increase, this is in line with the increasing population growth, but the availability of land is relatively limited, because land is a production factor that cannot be produced by humans or often called non produced input. empirically the agricultural land that is most vulnerable to conversion is rice fields.

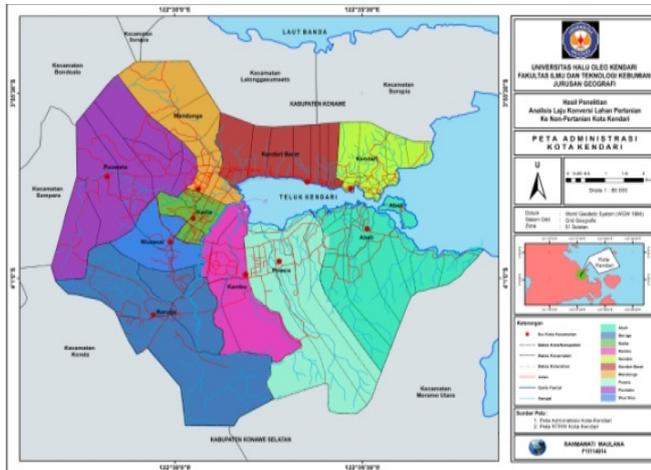
The land conversion process can be carried out by farmers themselves or by other parties, land conversion carried out by other parties has a greater impact on decreasing food production capacity because the land conversion process usually covers a fairly wide expanse of land, mainly intended for the construction of residential areas. The land conversion process carried out by other parties usually takes place through two stages, namely the release of farmers' land ownership rights to other parties and the use of the land for non-agricultural activities [5].

This study aims to determine the rate and extent of conversion of agricultural land to non-agriculture in 1997, 2007 and 2017, to find out the causes of conversion of agricultural land to non-agriculture, and to know the predictions of agricultural land area in 2027 in Kendari City.

**II. METHODS**

*2.1 Study Area*

This research was conducted in the city of Kendari, Southeast Sulawesi. Kendari City is located in the Southeast of Sulawesi Island. The land area is located on the island of Sulawesi around Kendari Bay. There is one island in the Kendari City area known as Bungkutoko Island. The total land area of Kendari City is 295.89 km<sup>2</sup> or 0.7% of the land area of the Southeast Sulawesi Province. Kendari City consists of 10 Regional Territories (Figure 1).



**Figure 1.** Study area

*2.2 Data Analysis*

The data processing of Landsat satellite image using the ENVI 4.5, ArcGis 10.2 and Google Earth application. The image data used are Landsat 5 images recorded in 1997 and 2007, as well as Landsat 8 images in 2017. The way to process the data is as follows.

*Geometric correction*

Geometric correction is the process of transforming satellite (digital) images into earth coordinates. At this stage geometric accuracy is greatly influenced by the GCP

(Ground Control Point) and data. Image geometric correction uses Landsat 8 imagery, because Landsat 8 images are geometrically corrected.

*Image Radiometric Correction*

Radiometric correction is done to eliminate radiometric errors such as errors due to the disturbance of electromagnetic radiation energy in the atmosphere. Radiometric correction uses a ToA (Top of Atmosphere) correction that includes ToA Reflection. ToA correction is an improvement due to radiometric distortion caused by the position of the sun. Correction of ToA Reflection is done by converting DN values to reflectance values [6].

$$P\lambda' = M\rho Q_{cal} + A\rho \dots \dots \dots (1)$$

Where;

$P\lambda'$  = ToA reflection, without correction for the sun's angle.

$M\rho$  = REFLECTANCE\_MULT\_BAND\_x, which x as the Band number

$A\rho$  = REFLECTANCE\_ADD\_BAND\_x where x as the Band number

$Q_{cal}$  = the value of digital number (DN)

*Spatial Analysis*

Spatial data analysis was carried out by image overlay used in this study, namely Landsat 5 imagery recorded in 1997, Landsat 7 footage in 2007, and Landsat 8 footage in 2017 to obtain the conversion rate of agricultural land to non-agriculture in the City of Kendari. The process of analysis using GIS software can be done by first inputting data from several images that have been corrected from the field survey data. Overlay is the ability to place a graph of a map above the map graphic above the other map graphics and display the results on a computer screen or on a plot.

*Prediction analysis*

The results of an extensive analysis of the conversion of agricultural land to non-agriculture in Kendari City in 2007-2017. Then find the rate of conversion of agricultural land that will be used in geometric projections using the following formula :

$$r = \left( \frac{\text{the area of agricultural land 2017}}{\text{the area of agricultural land 2007}} \right)^{\frac{1}{10}} - 1 \dots \dots \dots (2)$$

From the results of the formula above, by knowing the value of the rate will be used in calculating the geometric formula which aims to determine the projections of conversion of agricultural land to non-agriculture in Kendari City in 2027 which will be analyzed. The geometric projection formula is as follows

$$P_t = P_0 (1 + r)^n \dots \dots \dots (3) [7].$$

### III. RESULTS AND DISCUSSION

#### 3.1 The area of agricultural land from 1997 to 2007 in Kendari City

There were three agricultural fields in Kendari City, namely paddy fields, plantation land, and ponds. Based on the results of the analysis of landsat 5 and landsat 8 images carried out as well as interpretations of Google Earth imagery and direct field observations obtained the area of agricultural land in Kendari City from 1997-2007 and 2007-2017 continued to decline.

##### *The area of agricultural land in 1997*

The area of agricultural land in Kendari City in 1997 was 9294.04 Ha. The area of paddy fields was 433.06 ha, rice fields were only densely populated in the district of Puuwatu and in the district of Poasia. The plantation area was 8103.86 Ha, the largest plantation area was in Poasia District with an area of 3050.57 Ha. The land area of the pond was 757,123 Ha, the largest pond area was in the District of Poasia with an area of 687.55 Ha (Table 1)

**Table 1.** Agricultural land area in 1997 (Ha)

District	District Area	Agricultural land in 1997 (Ha)		
		Paddy Fields	Plantations	Ponds
Mandoga	6912	42,58	2551,87	61,78
Baruga	6649	-	1966,67	7,79
Puuwatu	12366	390,48	3050,57	687,55
Kadia	3662	-	534,75	-
<b>Total</b>	<b>29.589</b>	<b>433,06</b>	<b>8103,86</b>	<b>757,123</b>

Source: Data analysis

##### *The area of agricultural land in 2007*

**Table 2.** Agricultural land area in 2007 (Ha)

District	District Area	Agricultural land in 2007		
		Paddy Field	Plantation	Pond
Mandoga	2333	42,58	314,4967	58,74
Baruga	4579	390,48	662,8542	0
Puuwatu	4915	-	1125,923	0
Kadia	761	-	0,073214	0,93
Wua-wua	973	-	350,7559	0
Poasia	5551	-	383,8136	222,38
Abeli	4698	-	770,3181	0
Kambu	2117	-	101,4998	239,15
Kendari	1421	-	128,9421	0
Kendari Barat	2241	-	4,870339	0
<b>Total</b>	<b>29.589</b>	<b>433,06</b>	<b>3843,55</b>	<b>521,20</b>

Source: Data Analysis

The area of agricultural land in Kendari City in 2007 was 3426.15 Ha. The area of paddy fields in Kendari City in

2007 was the same as the paddy field area in 1997 which was 433.06 Ha. Kendari City experienced expansion from initially 4 to 10 districts. where rice fields are located in

Mandonga District in the Baruga District. Land area for plantation was 4797.81 ha, the largest plantation area in 2007 was in the District of Puuwatu with an area of 1125.92 Ha. The land area of the pond was 521.20 Ha, the largest pond area was in Poasia District with a land area of 222.39 Ha (Table 2).

##### *The area of agricultural land in 2017*

The area of agricultural land in 2017 in Kendari City is 3426.15 Ha. The area of paddy fields in Kendari City in 2017 has decreased, so that the area of paddy fields becomes 432.10 Ha, rice fields are still found in the Districts of Puuwatu and District of Baruga. Plantation area of 2784.97 ha, the largest plantation area in Kendari City in 2017 is still in the District of Puuwatu with a plantation area of 979.12 Ha. The land area of ponds in Kendari City is 209.07 Ha, the widest farm area in 2017 is still in Poasia District with a land area of 124.77 Ha (Table 3)

**Table 3.** Agricultural land area in 2017 (Ha)

District	District Area	Agricultural land in 2017		
		Paddy Field	Plantation	Pond
Mandoga	2.077	41,63	178,45	-
Baruga	4.800	390,48	432,73	-
Puuwatu	3.772		979,12	-
Kadia	671		-	-
Wua-wua	1.116		2,80	-
Poasia	3.774		299,52	124,77
Abeli	4.383		692,81	-
Kambu	2.463		85,22	83,05
Kendari	1.568		109,45	1,24
Kendari Barat	1.911		4,87	-
<b>Total</b>	<b>26.737</b>	<b>432,10</b>	<b>2784,97</b>	<b>209,07</b>

Source: Data Analysis

#### 3.2 Conversion of Agricultural Land to Non-Agriculture in Kendari City

The area of agricultural land in 1997–2007 decreased by 3,306.05 ha or 11.16% of the total area of Kendari City while the area of agricultural land in 2007–2017 also decreased by 1,373.66 ha or 4.64% of the total area of Kendari City.

##### *Agricultural land in 1997*

The classifications of landsat 5 images recorded in 1997 and interpretation of images from Google Earth, as well as observations directly in the field so as to produce a 1997 agricultural land map that is scattered in each Subdistrict, in Puuwatu District, Baruga District, Poasia District and Kendari District (Figure 2).

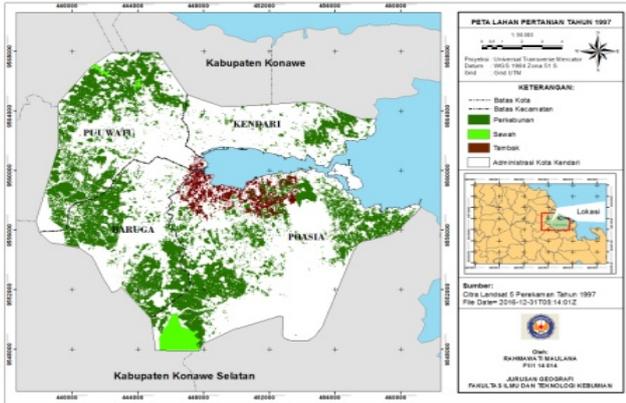


Figure 2. The agricultural land in Kendari in 1997

*Agricultural land in 2007*

There was a decrease in the area of agricultural land in Kendari City in 2007. Plantation land and farm land has decreased, while the paddy fields from 1997 to 2007 have remained large (Figure 3).

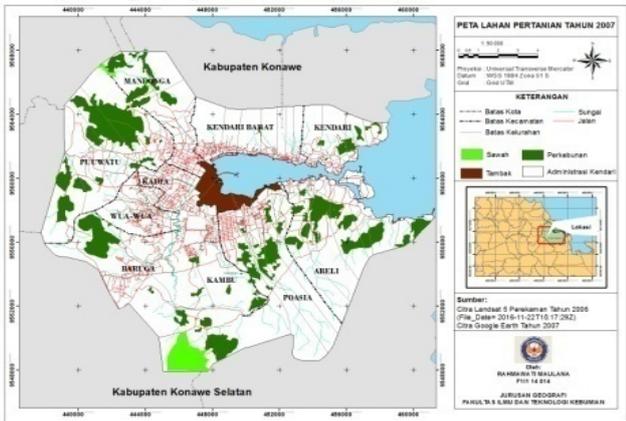


Figure 3. The agricultural land in Kendari City in 2007

*Agricultural land in 2017*

Agricultural land in 2017 has decreased in area. Where in 2007 the wetland area did not experience a decline but in 2017 it decreased. While plantation land and farm land continue to decline (Figure 4).

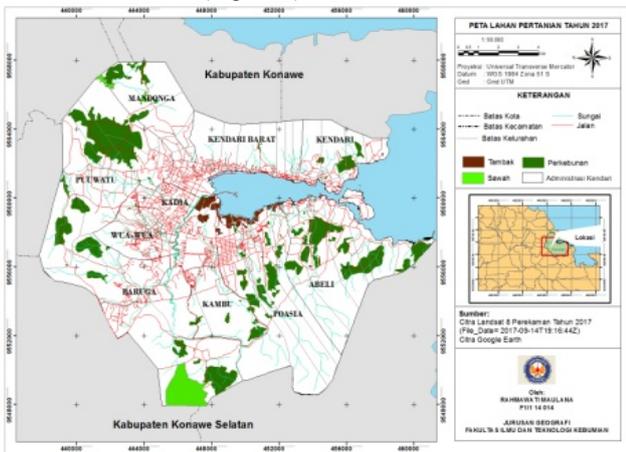


Figure 4. The agricultural land in Kendari City in 2017

*Paddy Fields in Kendari*

Paddy fields from 1997-2007 did not experience changes in land area, based on the results of direct observation at the study site. While in 2007-2017 there was a decrease in land area precisely in the Labibia Sub-District of Mandonga District. Some of the paddy fields are converted into livestock food fields by the owners of the paddy fields (Figure 5)

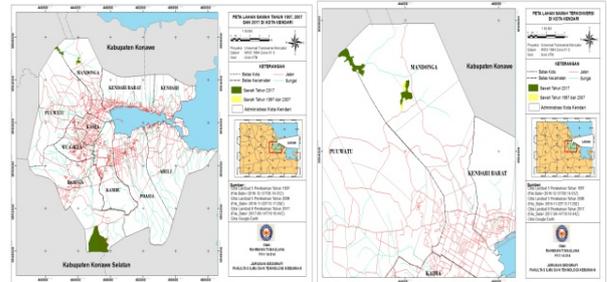


Figure 5. Paddy Fields in 1997, 2007 and 2017

*Plantation land*

The decrease in plantation area from 1997-2017 was equal to -767,025 Ha. The decrease in land area that occurs because some plantation land were no longer managed because the owners have not lived in the area, besides that the land that was once a plantation was converted into a settlement. The decrease in plantation area in 1997-2007 was 4260.28 ha while the plantation area in 2007-2017 had a decrease in land area of 1058.58 ha (Figure 6)

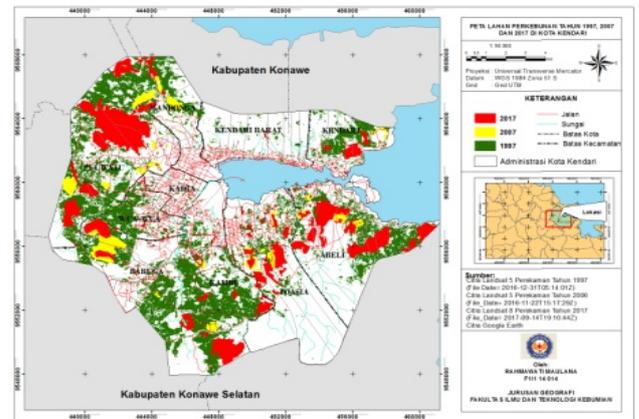


Figure 6. Plantation Land in 1997, 2007, and 2017

The district which has the largest decrease in land area in Kendari City was in Baruga District with a decrease in plantation area of 150,231 Ha. Meanwhile unconverted plantation lands from 1997-2017 were in Sambuli Sub-district, Abeli Sub-district and in Watulando Sub-District in Puuwatu District, where plantations in those sub-districts were planted with long-term crops such as coconut, cashew, and so on.

*Farm Land (Ponds)*

The results of overlaying maps of farmland in 1997, 2007 and 2017 resulted in a map of farmland. We can see the difference in agricultural land area from those three years.

Fishponds were converted in Poasiadistrict. Some are converted into settlements, vacant land, un-cultivated land and some are converted into mangrove plantations. In addition, the construction of new ponds in KendariCit, Puriranosubdistric is also not as extensive and has not been managed (Figure 7).

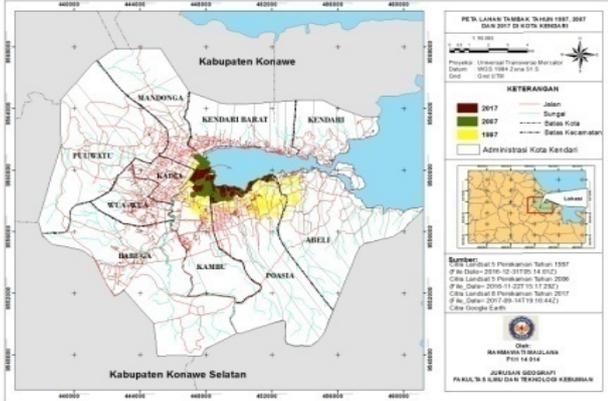


Figure 7. Ponds in 1997, 2007 and 2017

### 3.3 The causing factors of land conversion from agriculture to non-agriculture in Kendari

Many factors can cause the conversion of agricultural land to non-agriculture. Kendari City is the center of government, industrial, public facilities and so on. The city of Kendari continues to develop in order to support the needs of the community and the development of the city itself, so that a lot of land have to be converted for the community needs and for the development of the city. The center of the city is getting denser because of the developments carried out by the community and the Kendari City government. The development of the city will automatically spread to the edge of the city and land conversion is inevitable. The need for land continues to increase while the land area remains.

Agricultural land is in the suburbs, land conversion occurs on agricultural land, so based on observations obtained the agricultural land area in the city of Kendari continues to decline from 1997 to 2017 and the possibility of subsequent years will continue to decrease agricultural land even if the conversion is exhausted this land continues to be carried out.

These are some factors that caused the agricultural land conversion in Kendari;

1. Population growth
2. City growth
3. Economic factors
4. Socio-cultural factors
5. Policy

### 3.4 Projected Rate and Prediction of Agricultural Land Area in Kendari City in 2027

The area of agricultural land in Kendari City from 1997, 2007 and 2017 continues to decline. Where the area of

land converted in the period 1997-2007 was 4496.23 Ha and the area of agricultural land converted in the period 2007-2017 was 1373.66 Ha. From the results of the analysis carried out, the area of agricultural land in 2007 was 4797.81 ha and the area of agricultural land in 2017 was 3424.15 ha from the total area of Kendari, to find out the rate of conversion of agricultural land in 2007 and 2017 obtained from formula:

$$r = \left( \frac{\text{The area of agricultural land in 2017}}{\text{The area of agricultural land in 2007}} \right)^{\frac{1}{10}} - 1$$

$$r = \left( \frac{3424,15}{4797,80} \right)^{\frac{1}{10}} - 1$$

$$r = (0,71)^{\frac{1}{10}} - 1$$

$$r = -0,03316$$

$$= (-0,03316) * 100$$

$$= -3,32\%$$

From the result above obtained a value of -4.766%, this means that the rate of conversion of agricultural land did not increase but decreased by 4.766%. The value of this rate will be used in calculating the Geometric formula to determine the projected area of agricultural land in Kendari City in 2027. Then the results of the Geometric Projection formula will be obtained as follows:

$$P_t = P_0 (1 + r)^n$$

$$P_{2027} = 43424,15 (1 + (-3,32)^{10})$$

$$P_{2027} = 3424,15 (0,97)^{10}$$

$$P_{2027} = 3424,15 (0,71)$$

$$P_{2027} = 2443,78$$

$$= \frac{2443,78}{29.589} \times 100$$

$$= 8,26\%$$

From the results of the calculation of Geometric Projection and speed to determine the prediction of agricultural land area in Kendari City in 2027. The rate of change of agricultural land is obtained which is 0.0331 or -3.31%, this means that the area of agricultural land in Kendari in 2007-2017 continues to experience decreasing agricultural land which is 3.31%. And from the results of the Geometric projection, the prediction of agricultural land area is 2443.78 Ha or 8.26% of the total area of Kendari City.

The results of the calculation of the sub-district rate in Kendari are all minus (-). This means that from 2017 to 2027, the predicted agricultural land area in Kendari will decline, the decrease in agricultural land area in 2027 is low, where the difference in agricultural land in 2017 is predicted the area of agricultural land in 2027 is not so high, namely the difference of 980.37 ha. The largest agricultural land in 2027 is in the Puuwatu sub-district with an area of 643.36 ha (Table 4).

**Table 4.** Projected Rate and Prediction of Agricultural Land Area in Kendari City in 2027

District	Agricultural Land (Ha)		Prediction of Agricultural land	
	2007	2017	Rate (%)	Area (Ha)
Mandoga	415,82	220,07	-6,16	116,47
Baruga	1053,33	823,21	-2,43	643,36
Puuwatu	1125,92	979,12	-1,39	851,46
Kadia	1,0014	-	-	-
Wua-wua	350,75	2,80	-38,31	0,02
Poasia	606,20	402,30	-4,02	266,98
Abeli	770,32	692,81	-1,05	623,09
Kambu	340,65	188,28	-5,76	104,06
Kendari	128,94	110,69	-1,51	95,02
Kendari Barat	4,87	4,87	-	4,87
<b>Total</b>	<b>4797,81</b>	<b>3424,15</b>	<b>-3,31</b>	<b>2443,78</b>

Source: Image Analysis and Calculation of Geometric Corrections

#### IV. CONCLUSIONS

The area of agricultural land in Kendari City continued to decline from 1997-2007 and in 2007-2017. The type of agricultural land that has the lowest rate of land reduction in 2027 is rice fields with a rate of decline of 0.022%. In the prediction of 2027 where the rate of decline in the area of agricultural land in Kendari City in the period 1997 to 2007 was 7.19% or 449.23 ha. While the rate of decline in agricultural land area in Kendari City in the period 2007 to 2017 was 3.32% or 1373.66 ha. Prediction of agricultural land area in Kendari City in 2027 which has been analyzed using geometric projections obtained an area of agricultural land of 2443.78 ha or 8.25% of the total area of Kendari. The area of agricultural land is very likely to have a large decline, this can be seen from the large amount of development carried out and the growing population.

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