

IMPACT OF LAND USE LAND COVER CHANGE ON RURAL TOWN OF THOHoyANDOU, SOUTH AFRICA

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Abstract: *Over the years, various human activities such as housing, agricultural, commercial and industrial activities, have led to land use/land cover changes in space and time on Earth. The study utilises Geographic Information Systems and remote sensing techniques to detect the extent of land use land cover changes on the rural town of Thohoyandou. The analysis is based on satellite images of Thohoyandou between 2004 and 2013 using GIS tools and applications. The satellite images used to detect changes in land use land cover within the study area were of 2004, 2008, 2009 and 2013. Land use identification and classification techniques were also employed to map relevant changes that occurred within the year intervals. The findings reflect the extent to which residential and commercial activities have expanded in the town, and how this resulted in the present land cover change in the study area.*

Key words: Change Detection; Land use/Land cover; GIS and Remote Sensing

Introduction

The quest for human habitation and development leads to different anthropogenic activities, that in turn affect and change land use land cover patterns within different geographical locations (Meyer, 2005). This contributes to spatial patterns of such locations as seen from space at different time intervals (years). Land use and land cover changes, especially those caused by human activities are the most important components of global environmental change with possibly the greatest impacts of any other global changes (Turner *et.al.* 2007; Jensen, 2005). The rural town of Thohoyandou is experiencing significant influx of people from neighboring villages seeking employment and economic opportunities. The larger populations of these people are within the economic and working class group. They often see Thohoyandou as the nearest town where more opportunities and better living condition can be found when compared to their various villages. This resulted into changes in the spatial organisation of the town as well as changes in land usage by providing land areas for

residential, recreational and administrative purpose. The result from this research was presented orally by the first author at the 33rd IGU Congress 21 – 25 August, 2016 held at Beijing, Republic of China.

Aim and Objectives

The aim of the study was to evaluate the spatial land use land cover changes that have occurred in the rural town of Thohoyandou.

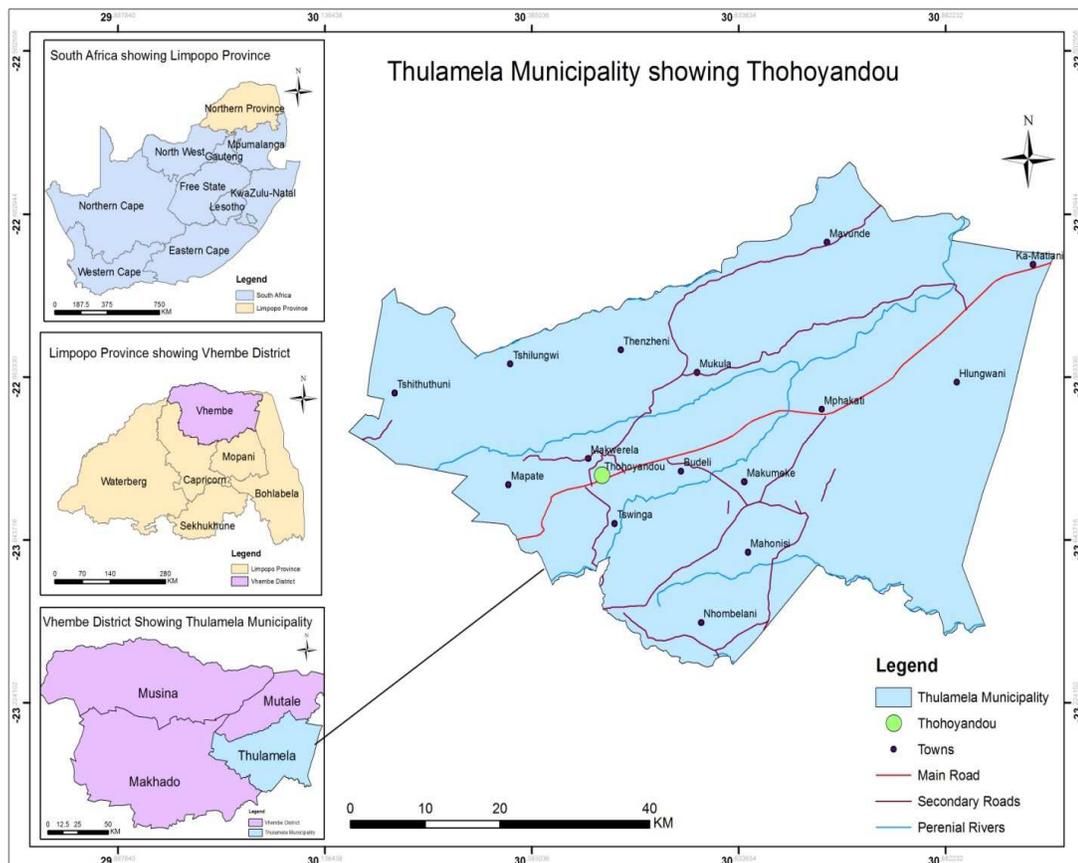
The research is geared towards achieving the following objectives, namely to:

- Identify and describe land use change patterns during the two five year intervals, (2004-2008 and 2009-2013);
- Evaluate the impact of these changes on overall rural expansion of the study area.

Study Area

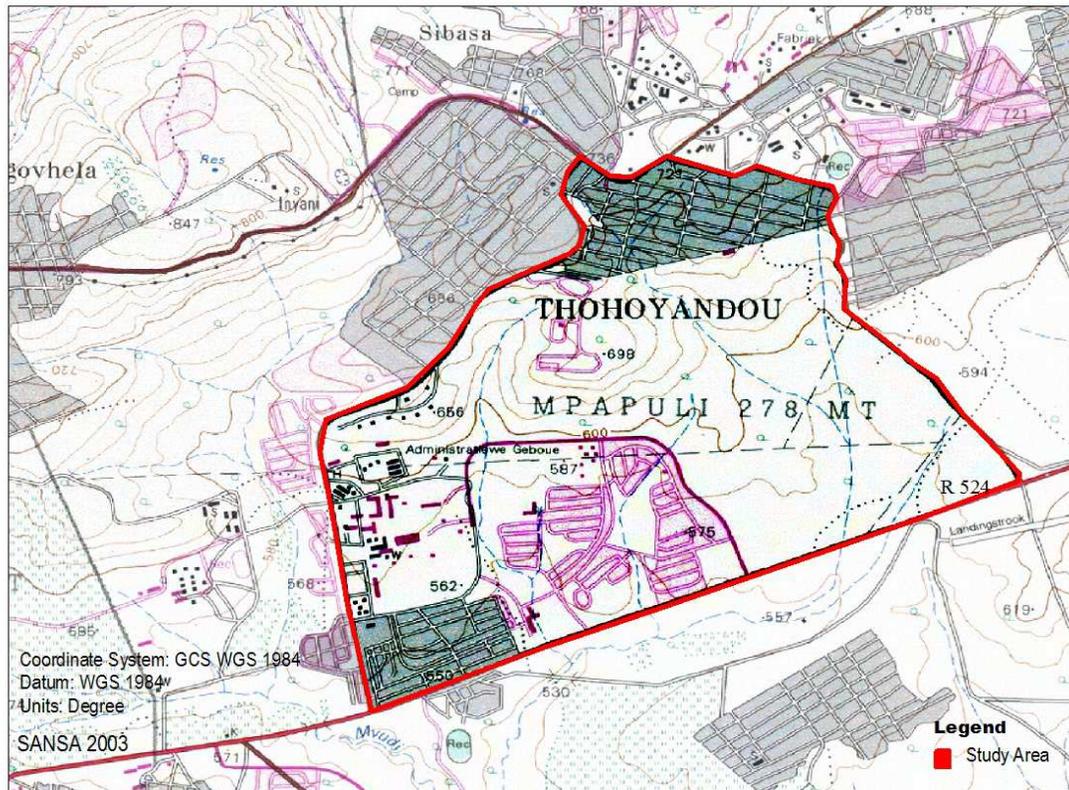
Thohoyandou is located in the Thulamela Local Municipality at the eastern tip of the Vhembe District in the Limpopo Province of South Africa. It is situated along the northern side of the Punda Maria route (R524) between Louis Trichardt and Kruger National Park. It is the second largest town in the Vhembe District. Figure 1 shows Thohoyandou's locational site in relation to the Thulamela Local Municipality, Vhembe District and Limpopo Province. The study area Thohoyandou (means head of the Elephant) lies approximately between latitude 22° 57'00" south and longitude 30° 28' 59" east. The elevation is about 734 meters (2408feet) above sea level.

Figure 1: Map showing the study area



Thohoyandou was chosen because it is a notable and the most important commercial rural town in the Thulamela Municipality, due to its social-economic growth and population increase. The population of Thohoyandou was about 39,756 in 2004 and 69,453 in 2011 (SA census 2011). The population growth rate pose challenging demand for open spaces to be converted into residential and commercial purposes in other to serve the need of the yearly growing population. The climate of Thohoyandou is characterised by hot to very hot summer months with afternoon thunderstorms. The winter months are also sunny but dry, with temperatures dropping considerably in the mornings and evenings. Daily temperatures vary from 17°C to 40°C in summer and between 4°C and 26°C in winter. Figure 2 shows the layout map of Thohoyandou in relation to the zoning demarcation of the town.

Figure 2: Layout map showing zoning demarcation of the study area



Methodology and Data set

The systematic sampling frame was the major transportation route of R524, R523 and D3717 road within Thohoyandou. All areas that fell within this sampling frame which are; the Central Business District, Unit D, P East, Block F, and Block G residential areas were taken as unit of analysis for this study. The changes observed over a particular period were in descriptive form. GIS and remote sensing techniques were used for assessing and analysing satellite images of the study area, to detect changes in land use during the study period (Olaleye 2006). For this study, four satellite image scenes for the years 2004, 2008, 2009 and 2013 with multi-spectral band and suitable radiometric resolution were used (see Table 1). This was guided by the available satellite image of the study area. GIS and RS techniques were used to analyse and study the spatial pattern land use changes in ArcGIS

10. The land area demarcation for the study area was 4263 hectares, and was considered throughout the study period.

Table 1: Satellite Image used in the study

Satellite Data	Date	Resolution	Band
SPOT 4	21 – 11 – 2004	30m	4
SPOT 4	30 – 08 – 2008	30m	4
SPOT 4	25 – 10 – 2009	30m	4
SPOT 4	27 – 09 – 2013	30m	4

Classification of Images

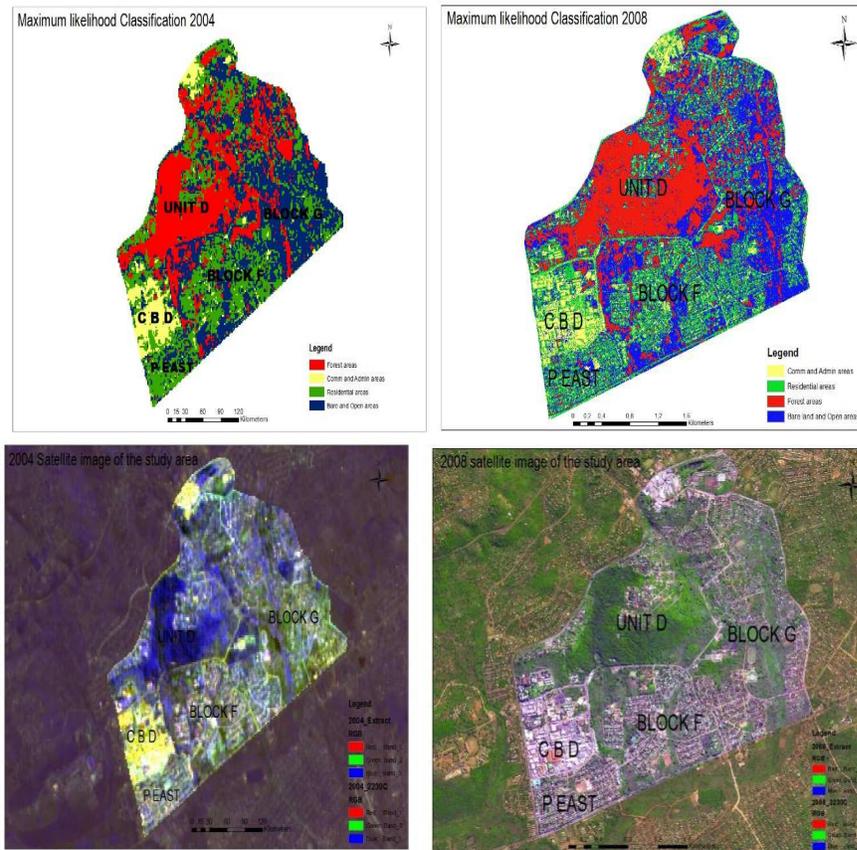
SPOT 4 satellite images of 2004, 2008, 2009 and 2013 obtained from South Africa National Space Agency (SANS) have been pre-processed and corrected for both geometric and radiometric correction. The images were then digitally supervised classified using maximum likelihood classification method. This was followed by a ground truthing field survey of the area. Prior knowledge of land use categories of the study area assisted greatly in achieving good and visible interpretation of the different satellite images considered for use in the research. Land use land cover map for different years were produced from classification output of satellite images and the result obtained from comparing the study year intervals (2004-2008) and (2009-2013). Extraction of the study area by mask was done to limit the satellite image of Thohoyandou to areas within the sampling frame. The classifications accuracy assessment was evaluated by the Kappa indexes (Mallupattu, *et.al* 2013). The land use classification Kappa index obtained was above 0.60 and about 67% accuracy. While the land cover classification Kappa index obtained was above 0.65 and accuracy above 70%. Finally, the results were presented in tables for easy numerical interpretation.

Results and Discussion

Change detection for the study period (2004-2008)

The change detection analysis was done using the map algebra raster calculator to produce raster change classification. The percentage of the difference was calculated from the output raster layer attribute table. The image of the study area for 2004 was regarded as the land use pattern before change, whereas the image for 2008 was regarded as showing changes which occurred between 2004 and 2008. In 2004 the CBD was seen as an area with few building structures, while residential areas of P East were clustered with building structures, Unit D, Block F and Block G were residential areas with fewer structures (see Figure 3). Forests and open areas had 29.43% and 36.33% of land usage respectively, while residential areas had 27.65% and commercial areas 6.59% of land usage. Changes detected during 2008, showed a gradual increase in the percentage of the land usage. Bare and open areas became 33.98%, forest areas 25.64%, while residential and commercial areas increased to 31.56% and 8.82% respectively.

Figure 3: Land use classification and satellite images for 2004 & 2008.



Land use Land cover analyses of the study area between 2004-2008

The land use/land cover change analysis of the first study period of 2004-2008 is presented in Table 2 below. It shows that during 2004, commercial and administrative areas occupied 280.93 ha and residential areas occupied 1178.71 ha of land, while 1254.60 ha and 1548.75 ha of land were occupied by forests and bare areas respectively. There were changes in the land cover in 2008 with 376.00 ha devoted to commercial land area, 1345.40 ha to residential land area, 1448.57 ha to bare /open areas and 1093.03 ha of land to forests. From Table 2 below, the study area witnessed a loss of 3.79% of forest area and 2.35% of bare /open area between 2004 and 2008. However, there was an increase of 2.23% and 3.91% land usage to commercial and residential area land cover respectively.

Table 2: Land use land cover consumption and change analyses (2004-2008)

Land use/land cover types	Land Areas in hectares (ha)		Land Area percentage (%)		Change Difference (ha)	Change Difference (%)
	2004	2008	2004	2008		
Commercial and Administrative	280.93	376.00	6.59	8.82	95.06	+2.23
Residential	1178.72	1345.40	27.65	31.56	166.68	+3.91
Forest	1254.60	1093.03	29.43	25.64	161.57	-3.79
Bare and Open	1548.75	1448.57	36.33	33.98	100.18	-2.35
TOTAL	4263	4263	100	100		

Land use Land cover analyses of the study area between 2009-2013

The period 2009-2013 (Table 3) enjoyed remarkable development; more residential and commercial activities occurred within the study area. In 2009, commercial land area occupied 421.61 ha, residential areas occupied 1484.38 ha, while forests and bare/open areas occupied 1016.72 ha and 1340.29 ha respectively. This followed the same trend in 2013, with 443.78 ha devoted to commercial areas and 1972.49 ha to residential areas. The forest cover area was 697.85 ha and the bare/open areas 1148.88 ha.

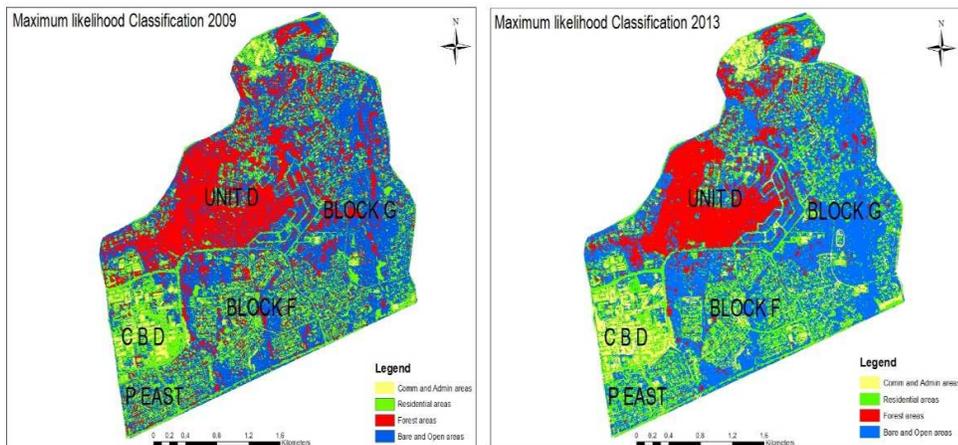
Table 3: Land use/ land cover consumption and change analyses (2009-2013)

Land use/land cover types	Land Areas in hectares (ha)		Land Area percentage (%)		Change Difference (ha)	Change Difference (%)
	2009	2013	2009	2013		
Commercial and Administrative	421.61	443.78	9.89	10.41	22.17	+0.52
Residential	1484.38	1972.49	34.82	46.27	488.11	+11.45
Forest	1016.72	697.85	23.85	16.37	318.87	-7.48
Bare and Open	1340.29	1148.89	31.44	26.95	191.41	-4.49
TOTAL	4263	4263	100	100		

Change detection for the study period (2009-2013)

In 2009, the increase in land usage resulted in the conversion of forests and bare areas into built up areas for residential and commercial purposes. The percentage usage was 34.82% for residential areas, 31.44% for bare and open areas, 23.85% for forest areas and 9.89% commercial areas. The sequence of land use activities continued with the same trend pattern seen in 2009, but more enormous changes had taken place in 2013 within the study area (see Figure 4). In 2013 residential areas had a percentage usage of 46.27% and bare and open areas 26.95%. Forest areas land usage became 16.37% and commercial areas, 10.41%. Though the percentage of commercial land area is small, it is enjoying a steady increase in land usage.

Figure 4: Land use classification and satellite images for 2009 & 2013.





Comparison of change analysis between 2004-2008 and 2009-2013

It can be said that many changes in land usage patterns occurred between 2004 and 2013. There were tremendous changes during the period of 2009-2013, compared to 2004-2008, more especially the conversion of forest land into commercial, administrative and residential purposes. It is statistically significant to note that all the land loss is from forests and bare areas converted to commercial and residential areas. The overall change comparison analysis is presented in tabular form (see Table 4).

Table 4: Change comparison between study periods (2004-2008) and (2009-2013)

Land use/land cover type	Area Change difference (ha) (2004-2008)	Area Change difference (ha) (2009-2013)	Change difference (%) (2004-2008)	Change difference (%) (2009-2013)
Commercial and Administrative	95.06	22.17	+2.23	+0.52
Residential	166.68	488.11	+3.91	+11.45
Forest	161.57	318.87	-3.79	-7.48
Bare and Open	100.18	191.41	-2.35	-4.49

Conclusion

The findings of the research showed that about 11% of forest land and 8% of bare and open spaces have been converted into residential and commercial land during the study period. It also reflected that forest land will, in future, be used up to accommodate the expansion of the town. Zoning and planning principles are not strict enough to ensure that land is properly distributed, especially within the Central Business District area. Due to the haphazard planning associated with the municipality's negligence, the aesthetic value of the Central Business District and some residential areas of the town, is very low. This also applies to the overall look and landscape of the town. The fragile ecosystem, biodiversity and vegetation are lost due to land use/land cover changes in Thohoyandou town. There were also land pollution and poor drainage challenges within the CBD and residential areas.

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