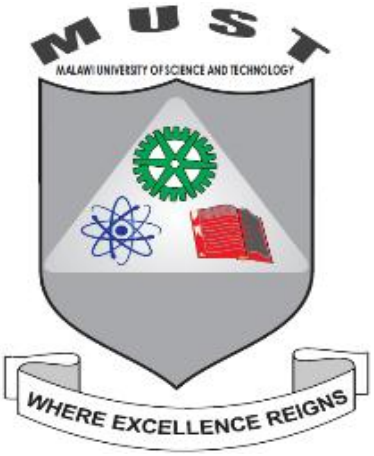


[ANALYZING IMPACTS OF URBANISATION AND LANDUSE OR LANDCOVER ON MTANDIRE AREA, LILONGWE DISTRICT]

[EVANS JIKA]
(GIS/019/16)
Thyolo, Malawi

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DISSERTATION APPROVED BY:

SUPERVISOR:

Miss E. Mabedi Signature: _____

ASSESSOR:
Mr, Maxwell, Evans Jika Signature: _____

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ABSTRACT

From 1998 to 2018, the population of Malawi have been increasing. Despite of the increase in birth rates, urbanization have played the role since there is a movement of people from rural areas to urban centres due to availability of better social services and job opportunities (Eurostat, 2016). This is so because city life is associated with better living standards compared to remote cultural life. Since a large number of people move to urban areas, there is competitive demand on life sustaining resources which leads to over exploitation (Mc Granaham, 2014). Therefore, Urbanization is becoming a megatrend of global land use or land cover changes.

Urbanization and land use or land cover changes leads to changes in climate pattern of an area (Ramesh, 2013). When areas are turned into settlements and agricultural fields, some of the vegetation are removed which influences surface run off during rainy season. Ramesh stated that land use or land cover for remote or rural area, remain constant for a long period of time while in urban area, it undergoes changes due to increase in population. This situation is very similar in Lilongwe district which is the capital city of Malawi. As population increases, there is pressure on land thereby making people move to other places like Mtandire, near Lingadzi River. These people search for suitable land to be used as agricultural fields and settlement. Some of them are turning the area into sand mining in order to generate income.

The impacts of urbanization and land use or cover on Mtandire area was analysed using census and satellite data. The census data provided by National Statistical Office (NSO) shows urban population growth of Mtandire area in 1998, 2008 and 2018. Based on internal-district migration, it clearly shows that the lifetime inflow of migrants to cities and other non-city districts is still increasing.

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I would like to thank GOD, The Creator of Heaven and Earth for the wonderful grace during the time of my studies at Malawi University of Science and Technology.

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ACRONYMS/ABBREVIATIONS

GIS	Geographical Information System
NSO	National Statistical Office
QGIS	Quantum GIS
LULC	Land Use Land Cover
DoDMA	Department of Disaster Management Affairs
OLI	Operational Land Imager
RS	Remote Sensing
EMT +	Enhanced Thematic plus
USGS	Unites States Geological Survey
PHC	Population Housing Census
STRM	Shuttle Radar Topography Mission
GLOVIS	Global Visualization viewer
ENVI	Environmental for Visualizing Images
DN	Digital Number
TM	Thematic Mapper

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CHAPTER ONE: INTRODUCTION

1.1 Background

It is widely recognised that land use or land cover (LULC) at local, regional and global scales is one of the crucial driving factors of global climate change. Human activities such as land conversion for settlement and agriculture, accounted for 90% of global warming (Sigh et al., 2015). Biogeophysical mechanism basically manifest the changes of physical features such roughness, surface albedo, soil moisture, vegetation coverage and structure which influence radiation, heat and moisture exchange process between the surface and the atmosphere(Mc Granaham, 2014).

In an urban area environment, natural and human-induced changes are concern today because of deterioration of environment and human health. The study of land use or land cover is very important because it provides better methods that help in proper planning and utilization of natural resources as well as their management. Technologies such as remote sensing and GIS provide data to study and monitor the dynamics of natural resources for environmental management (Gerten, 2015).

Eurostat et al. (2016) suggested that urbanization has been a megatrend of global land use change that can be observed in all parts of the world. By 2050, close to 70% of the global population will live in cities. Life in cities is associated with better prospects for prosperity and progress, access to better social services, education, and amenities as well as a richer cultural life. However, from a sustainability point of view, this promise may hold truth for the most attractive inner city locations where the distances are walkable, public transport is good, and there is a density of people and activities result in what is perceived as urbanity (Adli, 2017).

In analysing LULC change, remote sensing image classification is generally the initial step. Procedure for image classification involves several steps e.g. selection of appropriate images, pre-processing, selection of training samples, selection of suitable classification algorithm, post classification processing and accuracy assessment (Lu & Weng, 2007). Lu & Weng proposed that the use of ancillary data such as topography, soil, road and census data, may be utilized with remotely sensed data to improve classification performance. Lillesand, Kiefer & Chipman (2014) stated that change detection involves the use of multi-temporal datasets to discriminate areas of change between dates of imaging.

Mtandire is located on the western side of Lilongwe City. It is on public land and found in area 56(Malawi Homeless People's Federation, 2013). In 2015, it was heavily hit by floods which destroyed twelve houses and affected one hundred and thirty-one households thus approximately to 638 people (Richard et al., 2017). Therefore, it is better to investigate if human activities such as establishment of settlement, sand mining and brick moulding are affecting the area. These processes can lessen the carrying capacity of the stream by soil erosion that induces siltation of rivers, resulting in more surface runoff and hence more sudden floods due to blockage of drainage. This study analysed the impacts of urbanisation in connection to Land use or Land cover on Mtandire using satellite imagery.

1.2. Problem statement

Mtandire area is one the areas found in Lilongwe district usually affected by floods. In this area there is rapid land use conversion for establishing settlement as well as for brick moulding and sand mining processes. These land conversion processes influences soil erosion in Mtandire which affect Lingadzi River. However, this may be triggered by rapid population growth because more people move to this area which exerts pressure on land. Therefore, this study analysed the impacts of urbanisation in Mtandire area and how it is connected to various land use or land cover changes.

1.3. Main and specific objectives

The main objective of this research study was to detect and analyse the impacts of urbanisation and land use or land cover change in Mtandire area by using remote sensing (RS) and geographic information system (GIS) through satellite imagery. Therefore, the study also focused on achieving these specific objectives:

- To detect and analyze the rapid population growth trend in Mtandire area through 1998, 2008, and 2018.
- To assess land use or land cover taking place in Mtandire area.

1.4. Research questions

As the main and specific objectives have been previously indicated, the following were research questions indicated:

- What is the connection between urbanisation and land use or land cover?
- What are effects of Mtandire's land use or land cover change?

1.5. Significance of the study

The output of this research provided an understanding on the influence of urbanization and various land use or cover in Mtandire. This information will help to generate different methods on how to cope up with LULC challenges thereby reducing flood risks

CHAPTER TWO: LITERATURE REVIEW

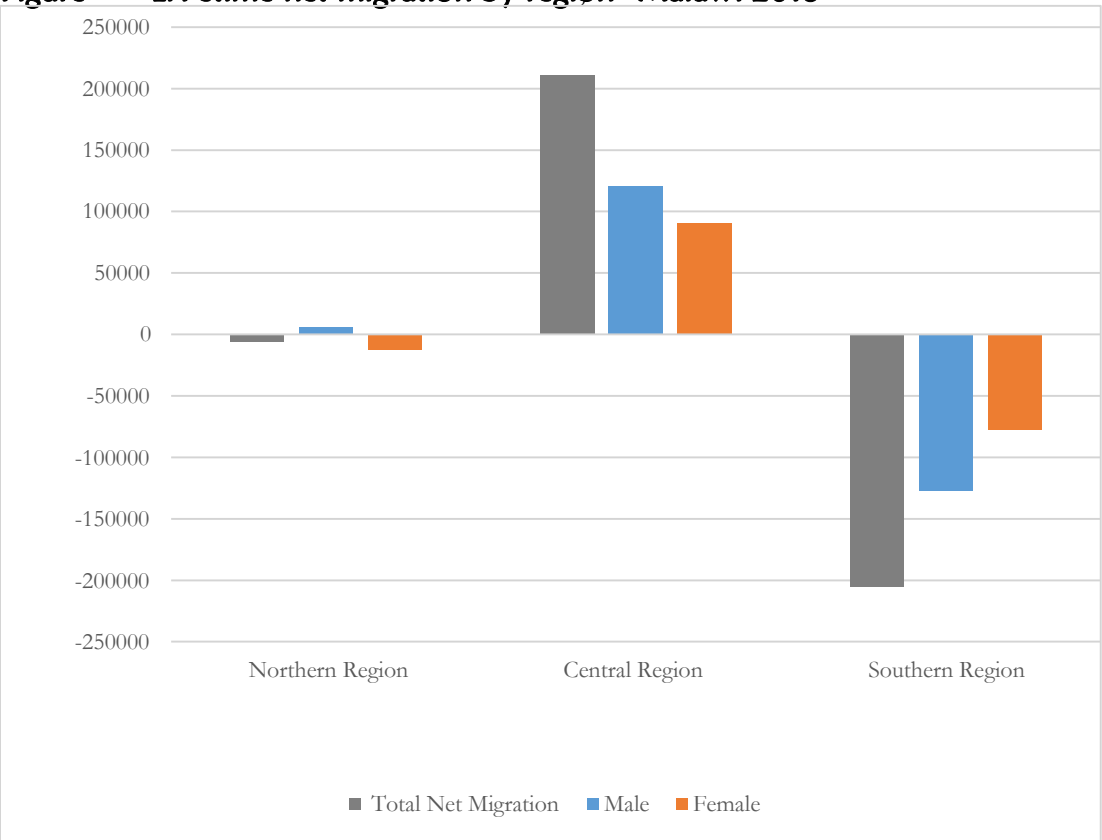
2.1. Urbanisation and population growth parameters

2.1.1. internal-district migration

Internal migration refers to as the movement of people across administrative boundary within a country. It is measured by volume and rate of in and out migration and others such as gross and net migration (National Statistical Office, 2020). Lifetime inter-district migration occurs between birth and time of census within the country. However, a lifetime inter-district migrant is the one whose current area of residence is mainly different from the place of birth (district or birth). It is described by either gross migration or net migration which is also referred to as lifetime in-migrant and lifetime out-migrant. This clearly shows the population growth of an area.

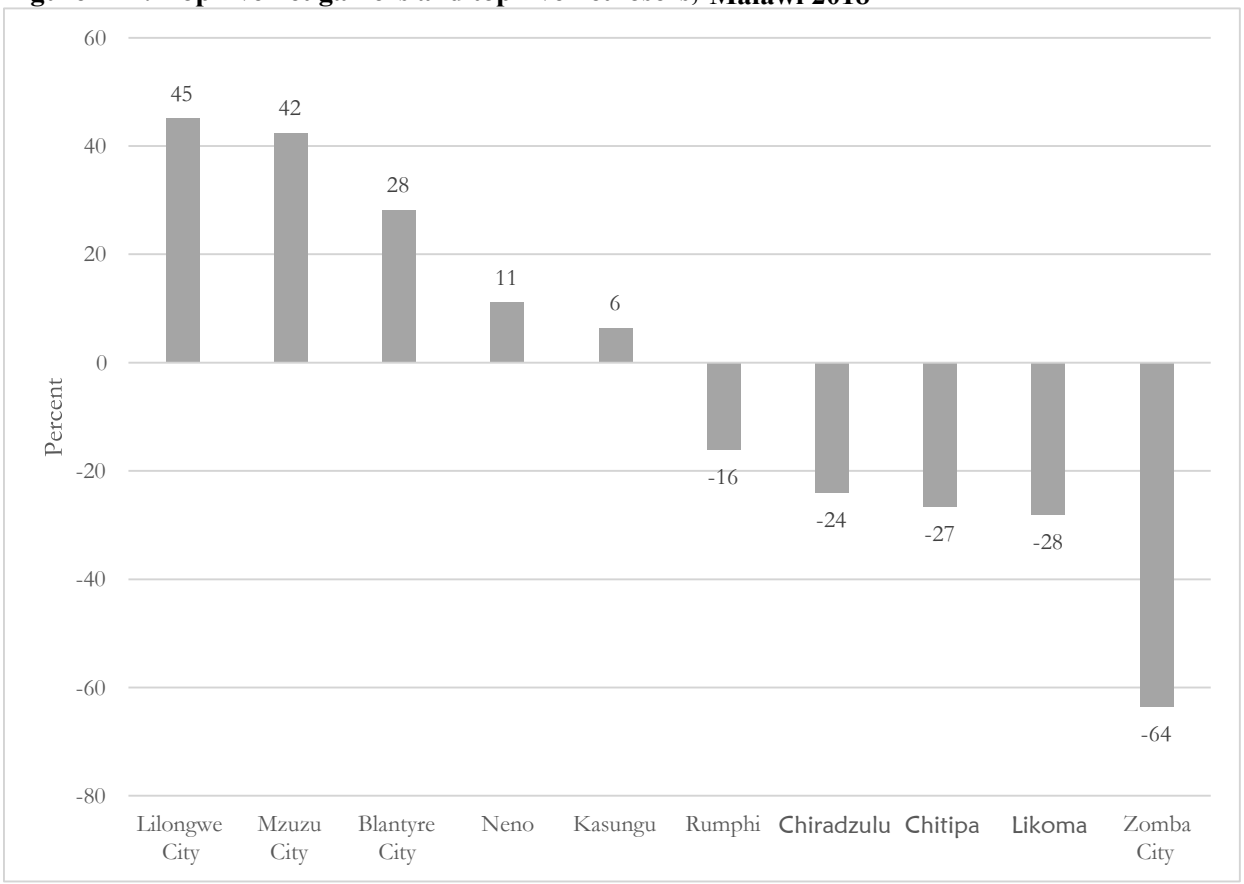
In terms of net life time migration which means the current movement of people from one region to another, northern region of Malawi has -6,131, central region 211,147 and southern region -205,016. Then central region is a net gainer of lifetime internal migrants while southern and northern regions are net losers of lifetime internal migrants. This pattern of net migration observed in 2018, is similar to the pattern in 2008 census. Figures below are showing lifetime net migration by region, and top five net gainers and top five net losers.

Figure 1 : Li Fetime net migration by region Malawi 2018



Source: 2018 Malawi Population and Housing

Figure 2 : Top five net gainers and top five net losers, Malawi 2018



Source: 2018 Malawi Population and Housing Census

2.2. Urbanization in Malawi

The 20% of Malawi population is basically classified as urban which makes it to a lowest urbanized country in Africa. But the country is experiencing a highest rates of urbanization in Africa at 6.3% per year. The towns and cities are growing at a faster rate hence urban population is expected to be double by the year 2020. It will actually undertake rural population growth (Urban Land Mark, 2013).

2.3. Agricultural activities

Munthali et al. (2015) explained how land use or land cover can be triggered in remote area. He explained that understanding the dynamics of LULC changes have been fundamental in rural land management especially for agriculture and forest management. Then he pinpoint shoots that the majority of the population living in rural areas of Central and Southern Africa depend on subsistence agriculture and other natural resources for their day-to-day needs. Munthali gave an example of Dzalanyama forest reserve which is one of the most affected by Land use or land cover changes in Malawi due tobacco curing, brick burning, firewood and charcoal selling that have intensified in the rural communities surrounding it. Gifted with vast natural resources essential for its socio-economic development, region's sustainable developments continue to be obscured by escalating deforestation and soil degradation rates due to population growth and poverty (Laisi, 2016).

Land resources are used for a various purposes which include agriculture land use, settlement, reforestation, near-surface water and eco-tourism. The increase in human population, threatens the future food production in an area. Construction of houses have reduces food security (Waithaka & Ogeshi, 2014) because most of the land which can be used for growing crops, it is used for the built up. The rate of population growth, land fragmentations for settlement, culture and norms of land tenure actually affects land use land cover changes and food production. Environmental degradation due to cutting down of trees for firewood and timber in the region, also interferes with water catchment areas and wetlands.

2.4. Satellite image analysis

This analysis involves digital image processing where manipulation and interpretation of satellite image data occur in specific computer programs basically in order to display the meaningful information concerning the surface of the earth. Therefore, digital image classification is the basic image analysis process governing LULC change detection (Paul, 2013).

In this image classification, the analyst identifies in the imagery, homogeneous representative samples of the different surface cover types (information classes) of interest. These samples are referred to as training areas (Chen, 2016). The selection of appropriate training areas is based on the analyst's familiarity with the geographical area and their knowledge of the actual surface cover types present in the image. Thus, the analyst is "supervising" the categorization of a set of specific classes. The numerical information in all spectral bands for the pixels comprising these areas are used to "train" the computer to recognize spectrally similar areas for each class.

The computer uses a special program or algorithm (of which there are several variations), to determine the numerical "signatures" for each training class. Once the computer has determined the signatures for each class, each pixel in the image is compared to these signatures and labelled as the class it most closely "resembles" digitally. Thus, in a supervised classification information classes are identified first then used to determine the spectral classes which represent them.

2.5. Impact of Land use or land cover changes

Land use or land cover changes have environmental consequences at local, regional and global scales. Some of them are global loss of biodiversity, disturbance in hydrological cycle, increase in soil erosion and land degradation. Population growth leads to urbanization, increase in cultivated land and residential areas. However, the high density in Malawi is pressuring natural resources thus leading to expansion of farming on marginal land and forests (Mzuza, 2018).

Different studies mainly show that changes in land use or land cover influenced by natural or anthropogenic activities have an impact on watershed processes. (Paul, 2013). These changes actually alter the balance between rainfall and evaporation which result in the runoff process (Costa et al., 2003). In addition, long-term discharge is altered primarily by precipitation variability and changes in LULC in the upstream basin.

CHAPTER THREE: METHODOLOGY

3.1. Research design

3.1.1 Location of the study area

Mtandire is found in North Western side of Lilongwe district. On Southern part, it is neighboured by Mtsiriza while Area 47 is at Eastern side. Mtandire settlement is zoned as Area 56. It covers an area approximately to 6.5 square kilometre. Mtandire area experiences cool to warm climate with annual temperature of 13 degrees Celsius. The district contains metamorphic and igneous rocks (Laisi, 2016). Below is the diagram showing study area.

THE STUDY AREA OF MTANDIRE

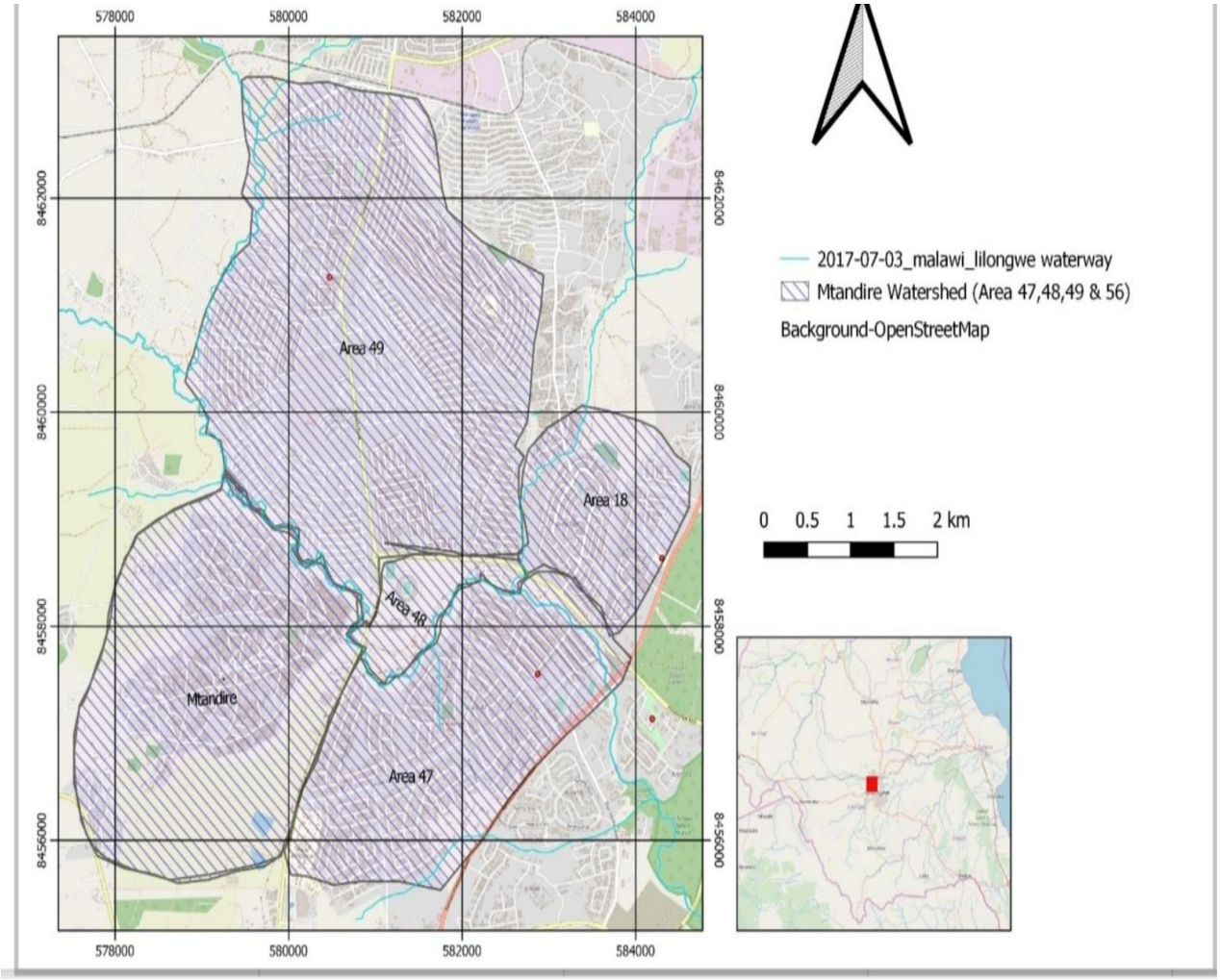


Figure 3: Showing the study area

3.2 Materials and methods

3.2.1 Data collection

The research study is mainly based on the analysis of satellite imagery and population growth of Mtandire area. First task was the selection of Landsat satellite images for the following reasons:

- Landsat data have been readily available since 1972 which means that data for every part of the world is stored. The study aims at detecting LULC in Mtandire area from 1998, 2008 and 2018 hence it is a best option.
- Landsat satellite has a repeat interval of 16 days and this makes data selection to be flexible as cloud cover is a limitation.

After considering these above reasons, three Landsat images were selected for analysis and it was downloaded on USGS:

1. **1998 Landsat 5 TM**: Represent early stage of land use or land cover in Mtandire.
2. **2008 Landsat 5 TM:** This represent the status at the beginning of land use or land cover changes.
3. **2018 Landsat 8 OLI:** Represent current status of land use or land cover change within Mtandire.

Table 1: Satellite imageries used in LULC change detection

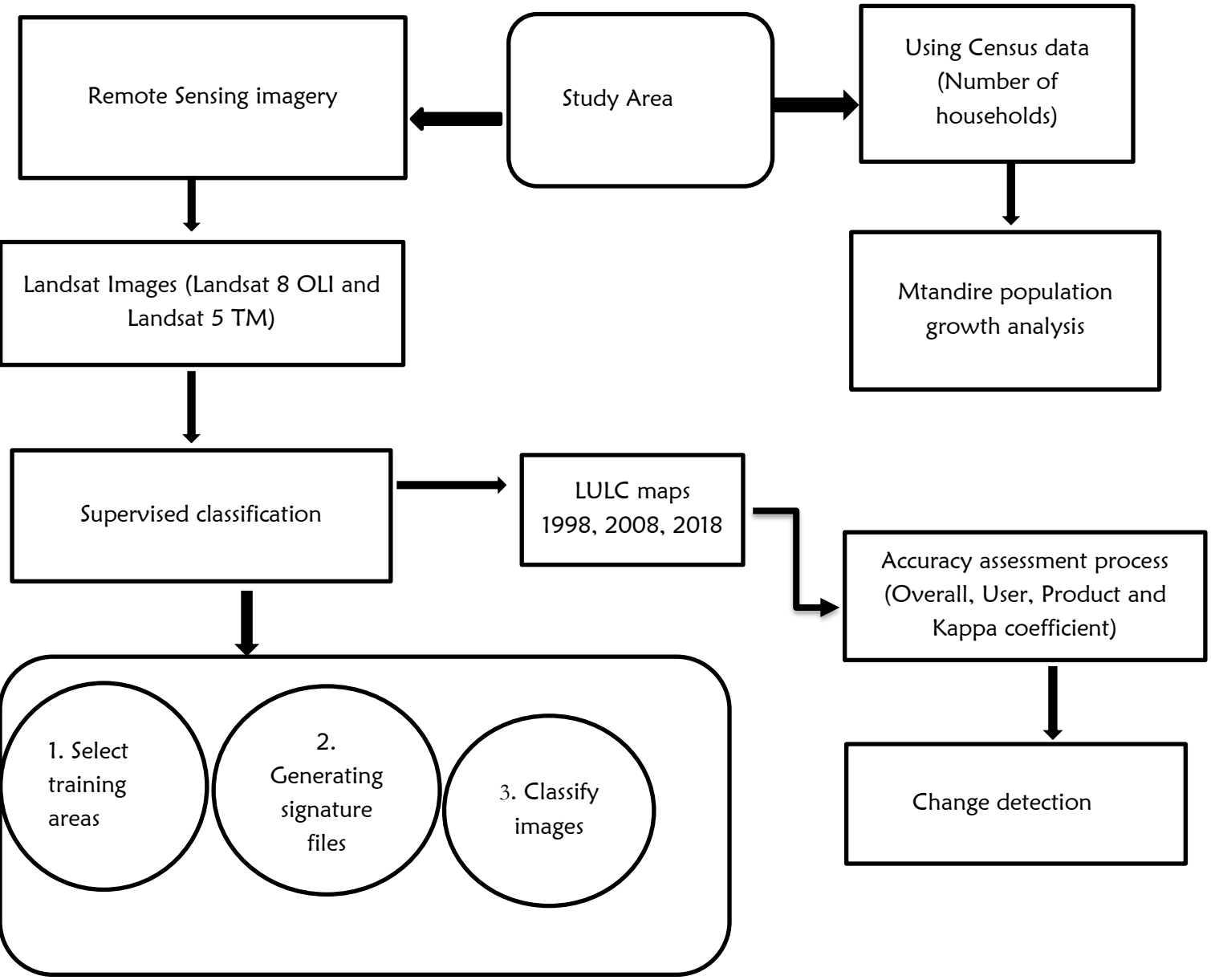
Year	Day	Path	Row	Satellite imagery	Spectral resolution	Spatial resolution
1998	21 October	168	70	Landsat 5 TM	7	30
2008	25 September	168	70	Landsat 5 TM	7	30
2018	28 October	168	70	Landsat 8 OLI	11	30

Then after selecting satellite imagery data, the number of households for Mtandire area in 1998, 2008 and 2018 were downloaded on the National Statistical Office in order to see the trend of population growth with relation to built-up settlements.

Table 2: The household population growth in Mtandire

Census Year	Owned	Rent	Total
1998	2,380	3,820	6,200
2008	5,004	9,696	14,700
2018	7,224	10,421	17,645

Below is the conceptual framework for the summary of whole methodology of this research study.


Remote Sensing imagery
Study Area
Using Census data (Number of households)
Landsat Images (Landsat 8 OLI and Landsat 5 TM)
Mtandire population growth analysis
Supervised classification
LULC maps 1998, 2008, 2018
Accuracy assessment process (Overall, User, Product and Kappa coefficient)
1. Select training areas
2. Generating signature files
3. Classify images
Change detection

3.2.2. Image pre-processing and analysis

All the downloaded Landsat images were pre-processed in order to prepare them for classification analysis. The bands were specifically downloaded as separate image files inform of (.tiff) but then were stacked together. However, these images were georeferenced to ARC1950/WGS84. Sem Automated classification plugin was used to perform atmospheric and radiometric correction.

3.2.3. Image classification

The supervised classification was done using Arc GIS 10.5. The pixels about thousand were obtained from every category of the selected training areas. These training areas were vegetation, bare land, built-up and water. Then each training area was contained by a signature file before the maximum likelihood algorithm run all the selected to formulate a LULC change map.

3.2.4. Accuracy Assessment

Assessing accuracy for digital image data is significant because it tries to point out all sources of error. In this case, overall classification accuracy, user's accuracy, producer's accuracy. Overall accuracy assessment is the ratio between the total numbers of correctly classified samples and total reference samples. User's accuracy actually corresponds to error of commission and it is found by dividing number of correctly classified samples in each category to total number of classified samples in that category (Row total). On other hand, producer's accuracy corresponds to omission errors. It is refers to how each category was correctly classified. Below are formulas:

Overall Accuracy = Total number of correctly classified samples (diagonal) X 100
Total number of reference samples

User's accuracy = number of correctly classified samples in each category X 100
Total number of classified samples in that category (Row total)

Producer's accuracy = number of correctly classified samples in each category X100
Total number of classified samples in that category (column row)

In addition, kappa coefficient was also assessed which estimates the agreement between a modelled situation and truth. In other words, it basically determines if results that have been displayed in error matrix are important than random results. It is found by:

$$K = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_i + Xx_{+1})}{N^2 - \sum_{i=1}^{r}(x_{ii} Xx_{+1})}$$

Where:

r = number of rows in error matrix

N = total number of observations in the matrix

Xii= number of observation in row i and column i (on major diagonal)

Xi+ = total number of observations in column i (shown as marginal total at bottom of matrix).

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1. Remote sensing imagery analysis

The LULC information for Mtandire area were produced after classification process. In 1998 image, the major part of study area was covered by bare land then built-up and with minimal number of vegetation. Figure below shows that bare land comprised the maximum of 64.4%, built-up 30.61% and vegetation 4.91%.

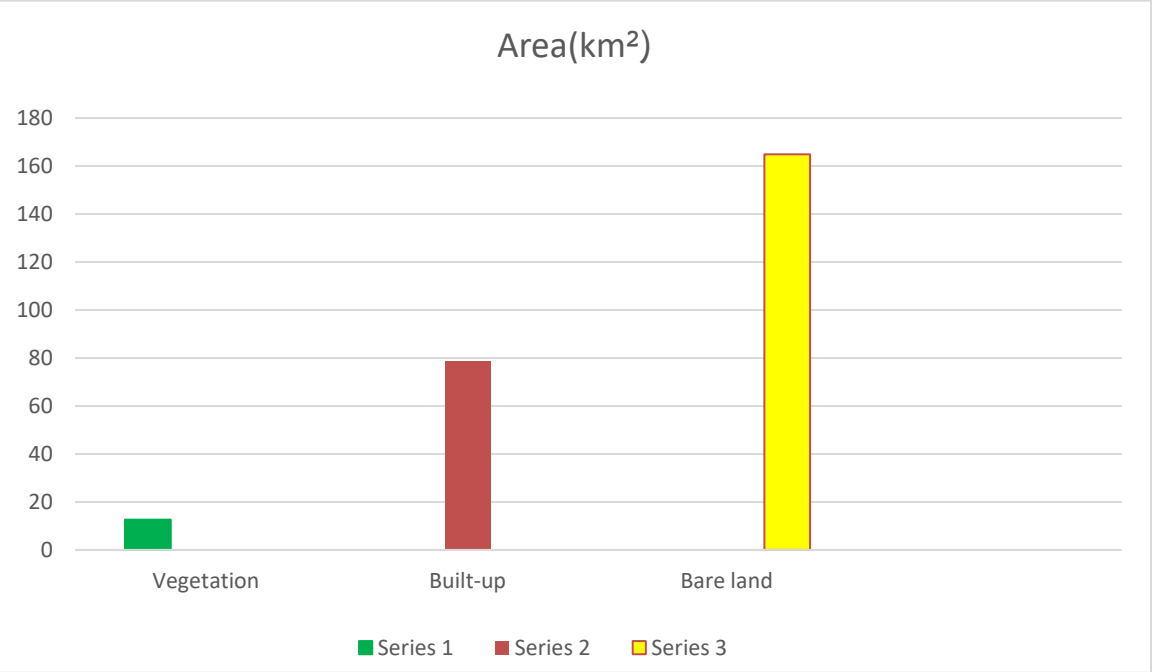


Figure 4. Area coverage by each category in 1998 LULC map

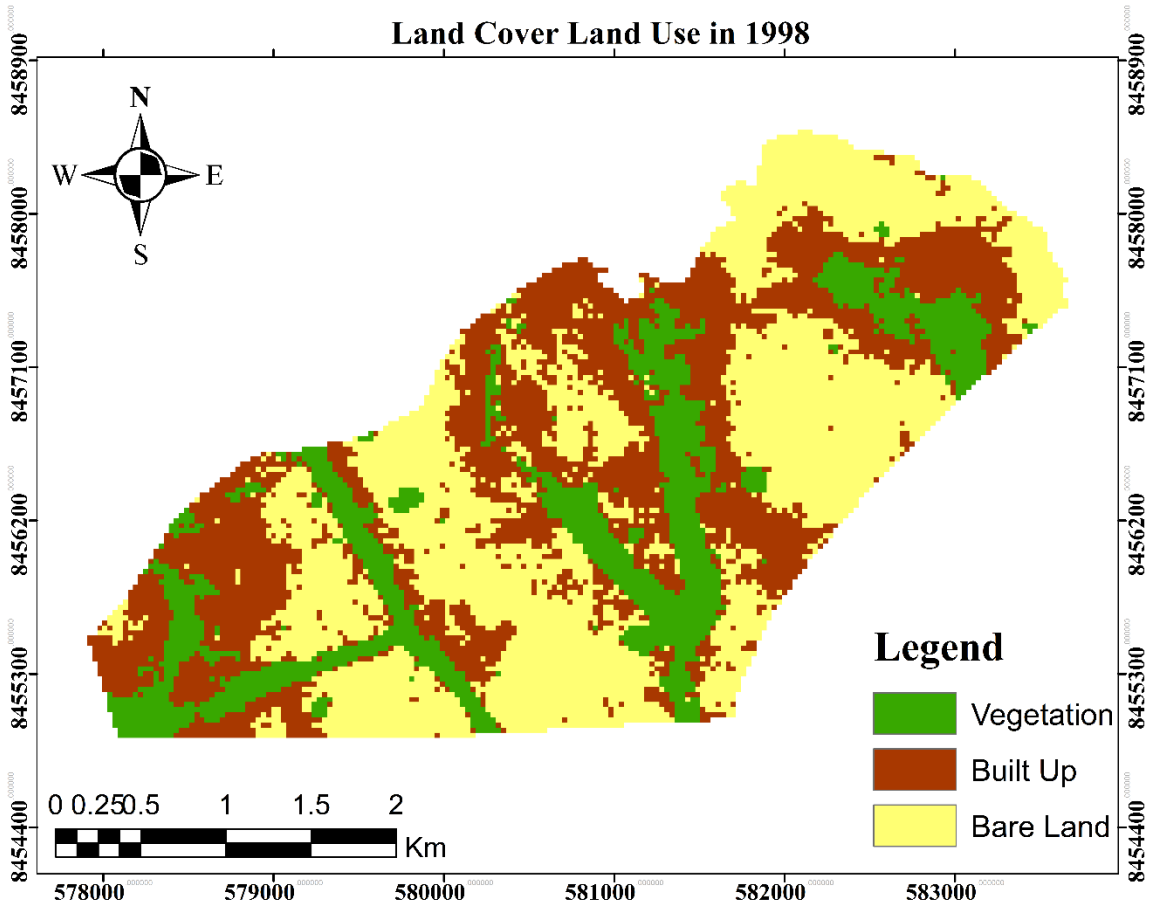


Figure 5: Land cover land use for 1998 Mtandire satellite image

Figure 6 and 7 display the results generated from classification of 2008 satellite image. There is a presents of artificialwater category in this image and of 2018.The built-up area now is dominating with a maximum of 64.47%, bare land 34.42%, water 0.07% and vegetation 3.02%. 0n this image, there was an observation at the bottom part. The number of settlements or built up have largely disappeared. This might arise by an error where some of the pixels of built-up were classified as bare land. Water's bar does not appear because is very low.

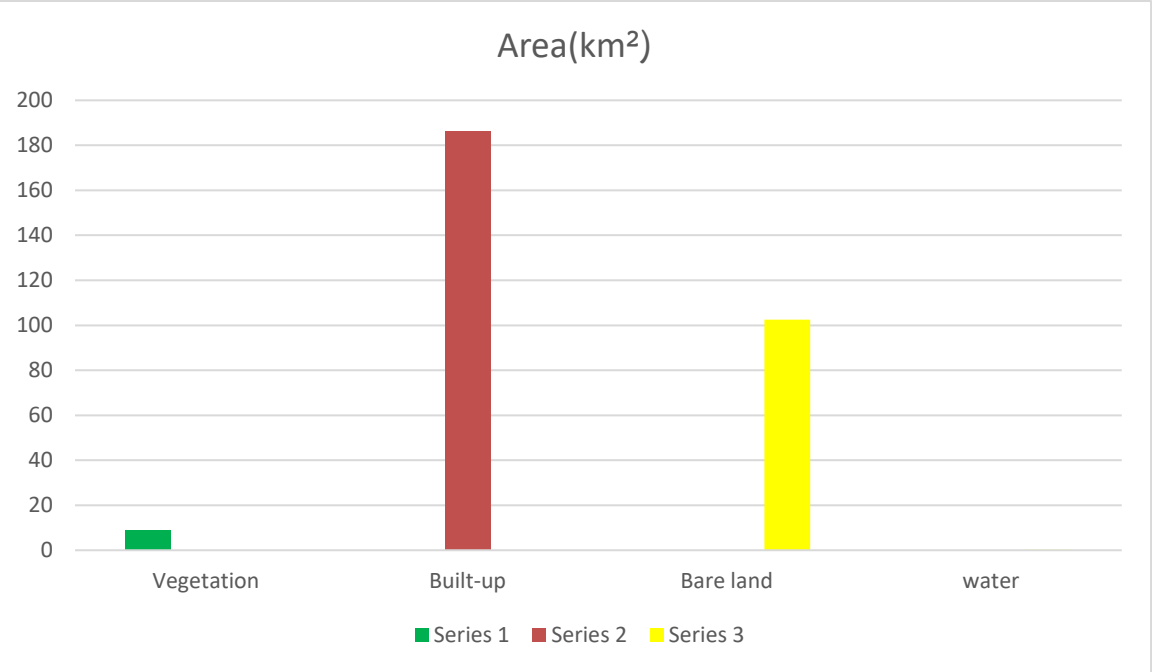


Figure 6 Area coverage by each category in 2008 LULC map

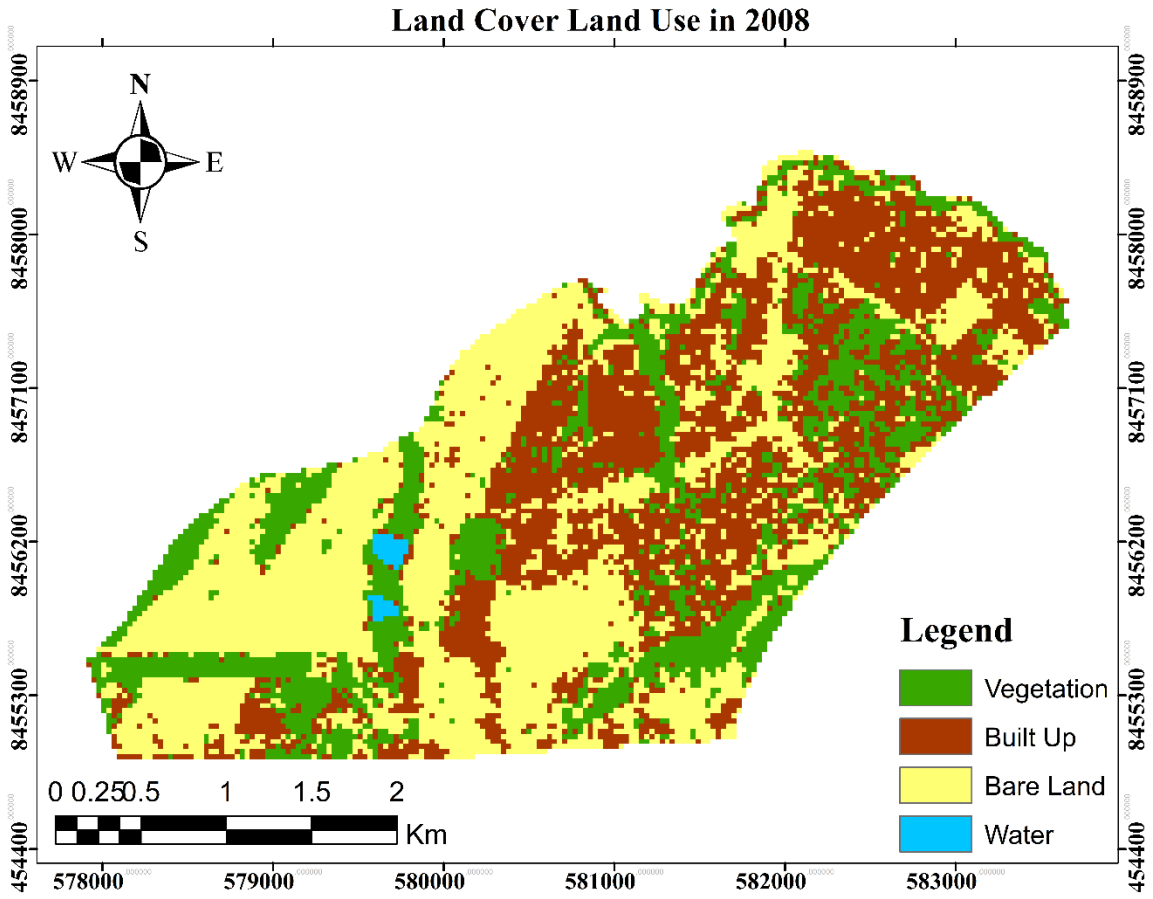


Figure 7: Land cover land use for 2008 Mtandire satellite image

Then analysis of 2018 Landsat image is displayed in figure 8 and 9 where the built-up is still dominating with maximum of 72.16% while other categories are decreasing despite of water with bare land 25.18%, vegetation 2.53% and water 0.07%.

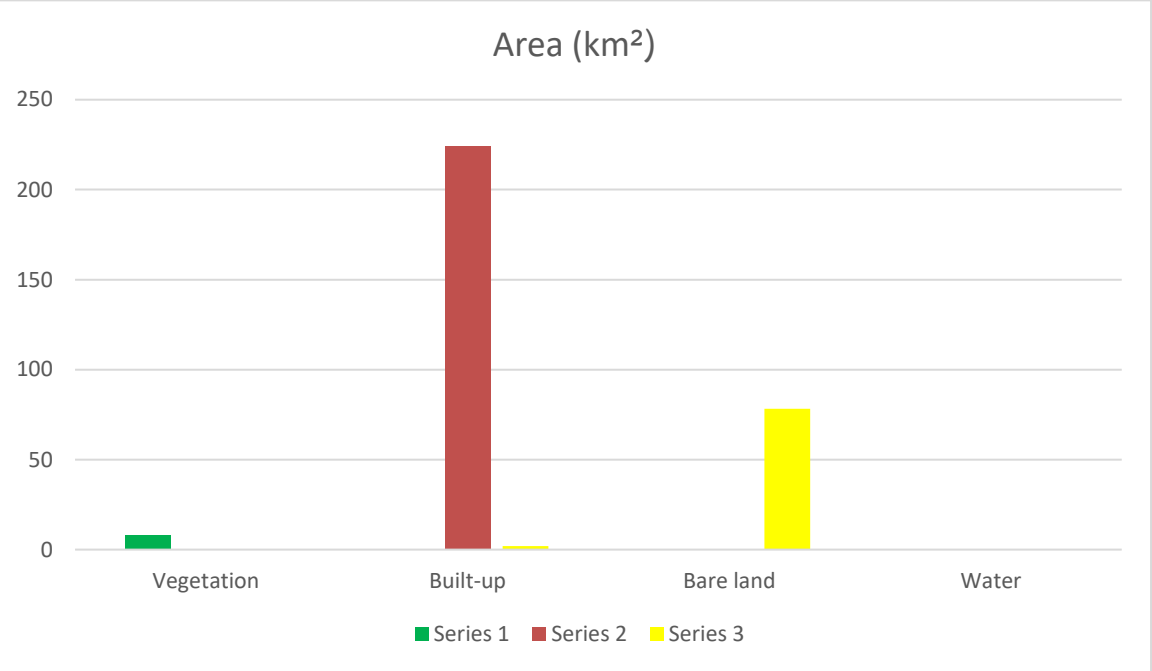


Figure 8 Area coverage by each category in 2018 LULC map

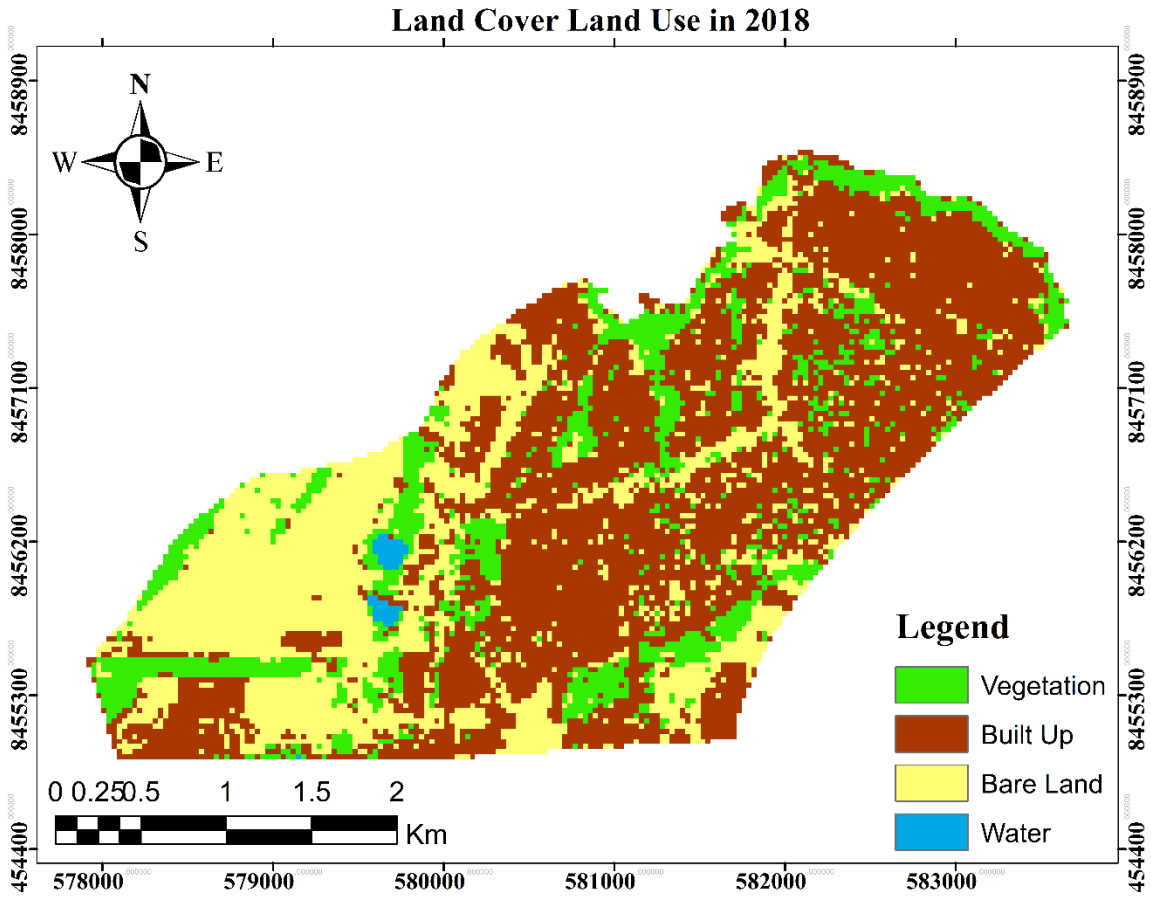


Figure 9: Land cover land use for 2018 Mtandire satellite image

4.2. Accuracy assessment

The accuracy assessment of 1998, 2008 and 2018 was done based on reference data using the following accuracy error matrices. The randomly generated samples in all images were tested with ground truth data.

Table 3: The error matrix for test samples classification in 1998 image

	Vegetation	Built up	Bare land	User
Vegetation	6	0	0	6
Built up	0	5	2	7
Bare land	0	3	4	7
Producer(Total)	6	8	6	75%

Table 4: The error matrix for test samples classification in 1998 image

	Vegetation	Built up	Bare land	Water	User
Vegetation	9	1	0	0	10
Built up	0	8	4	0	12
Bare land	0	2	6	0	8
Water	2	0	0	0	2
Producer(Total)	11	11	10	0	72%

Table 5: The error matrix for test samples classification in 1998 image

	Vegetation	Built up	Bare land	Water	User
Vegetation	7	3	4	0	14
Built up	4	11	2	0	17
Bare land	3	6	8	0	17
Water	2	0	0	0	2
Producer(Total)	16	20	14	0	52%

However,based on above information from the tables, the overall accuracy, user's accuracy, producer's accuracy and Kappa coefficients were calculated using formula stated in chapter 3. Therefore, tables below are for the results.

Table 6: Accuracy Assessment results for 1998 LULC map

LULC category	User's accuracy(%)	Producer's accuracy(%)	OCA (%) =75 KC (%) =62
Vegetation	100	100	
Built-Up	71.43	63	
Bare land	51.14	67	

The Overall accuracy and kappa coefficient for 1998 image classification were 75% and 62% respectively.While the producer's and user's accuracy are higher than overall accuracy for only built-up and vegetation. The lower accuracy values arise because medium spatial resolution for Landsat data as small size of category areas. This applies to all values in below tables of 2008 and 2018. However, the Kappa value obtained in above calculations, was lower than the overall classification. The difference arise because each of them includes different type of data from the matrix. The overall accuracy included major diagonal data and excludes omission and commission errors. Kappa included nondiagonal elements of matrix as product of marginal row and column.

Table 7: Accuracy Assessment results for 2008 LULC map

LULC category	User's accuracy(%)	Producer's accuracy(%)	OCA (%) =72 KC (%) =54
Vegetation	90	82	
Built-Up	67	73	
Bare land	75	60	
Water	100	18.2	

Table 8: Accuracy Assessment results for 2018 LULC map

LULC category	User's accuracy(%)	Producer's accuracy(%)	OCA (%) =52 KC (%) =29
Vegetation	50	44	
Built-Up	65	55	
Bare land	48	57	
Water	100	13	

In general, Mtandire area was covered by large amount of vegetation and bare land but with population growth of households, there is dynamic of LULC on which dominant human interaction through settlement establishment has been demonstrated in present 2008 and 2018 land use land cover analysis.

4.3. The household population growth in Mtandire analysis

The figure below, shows the rapid population growth of households in Mtandire area from 1998, 2008 to 2018. The increase in number means that large number of people are moving to Mtandire for the search suitable land in order to establish settlements. This exerts pressure on natural resources such land, water and vegetation. In 1998, there were 6,200 households with 38% owned and 62% rented. This number increased in 2008 to 14,700 with 34% owned and 66% rented. Then in 2018 it increased to 17,645 households with 41% owned and 59% rented.

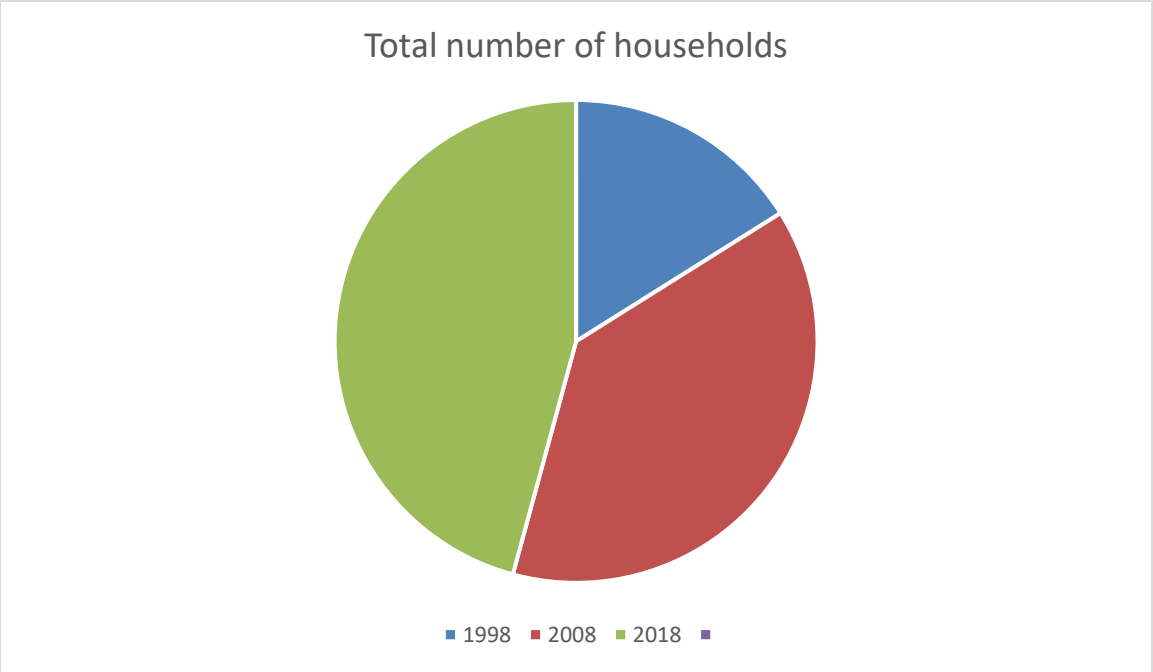


Figure 10: household population growth in Mtandire area

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Landsat satellite images were used to generate LULC information for Mtandire area. 1998, 2008 and 2018 were the selected satellite images. Upon classification, bare land was dominant with maximum 64.4% in 1998 but in 2008 and 2018 built-up was dominant with maximum of 64.47% and 72.16% respectively. In this case, between 1998 and 2008 there is a depletion of vegetation area about 2.983 km² and 2008 and 2018 is 1.212 km² while bare land is 73.68 km² and 24.252 km² respectively.

From this research study, there is a decrease in vegetation, water and bare land while built up increases because there is an increase of people moving to Mtandire area based on the increase in number of households as 6,200 for 1998, 14, 700 in 2008 and 17,645 in 2018. This is correlated to LULC change where the increase in built-up houses, decreases vegetation which actually increases run off and discharge. Thus the movement of people to Mtandire area triggers LULC changes which influences flooding of Lingadzi River.

5.2. Recommendation

Further studies are required on the contribution of urbanization and land use or land cover changes in Mtandire area. These studies should be conducted every year in order to see how it is impacting thereby enabling to come up with significant methods of reducing run off such afforestation and reforestation.

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