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DEPARTMENT OF GEO-SPATIAL SCIENCES AND TECHNOLOGY

BACHELOR OF GEO-INFORMATION AND TECHNOLOGY

INVESTIGATION AND MAPPING OF POPULATION GROWTH, CHANGE AND ACCESS TO SERVICES IN THE OTJOMUISE TOWNSHIP OF WINDHOEK.

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Table of Contents

Table of figures

List of tables

List of maps

List of Acronyms

1.	Dr	Doctor
2.	LDCs	Less Developed Countries
3.	MDCs	Mid Developed Countries
4.	Namwater	Namibia Water Corporation
5.	NSA	Namibia Statistics Agency
6.	PolySDI	Polytechnic Spatial Data Infrastructure
7.	PSDI	Polytechnic Spatial data Infrastructure

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I would like to acknowledge Miss Asteria Ndeshuuva of the City of Windhoek for allowing me to interview her on the issue topics of population change within the city of Windhoek after independence.

I would also like to thank and acknowledge the people from Otjomuise who I spoke to and were friendly enough to respond with answers to the questions I asked them regarding the township they live in.

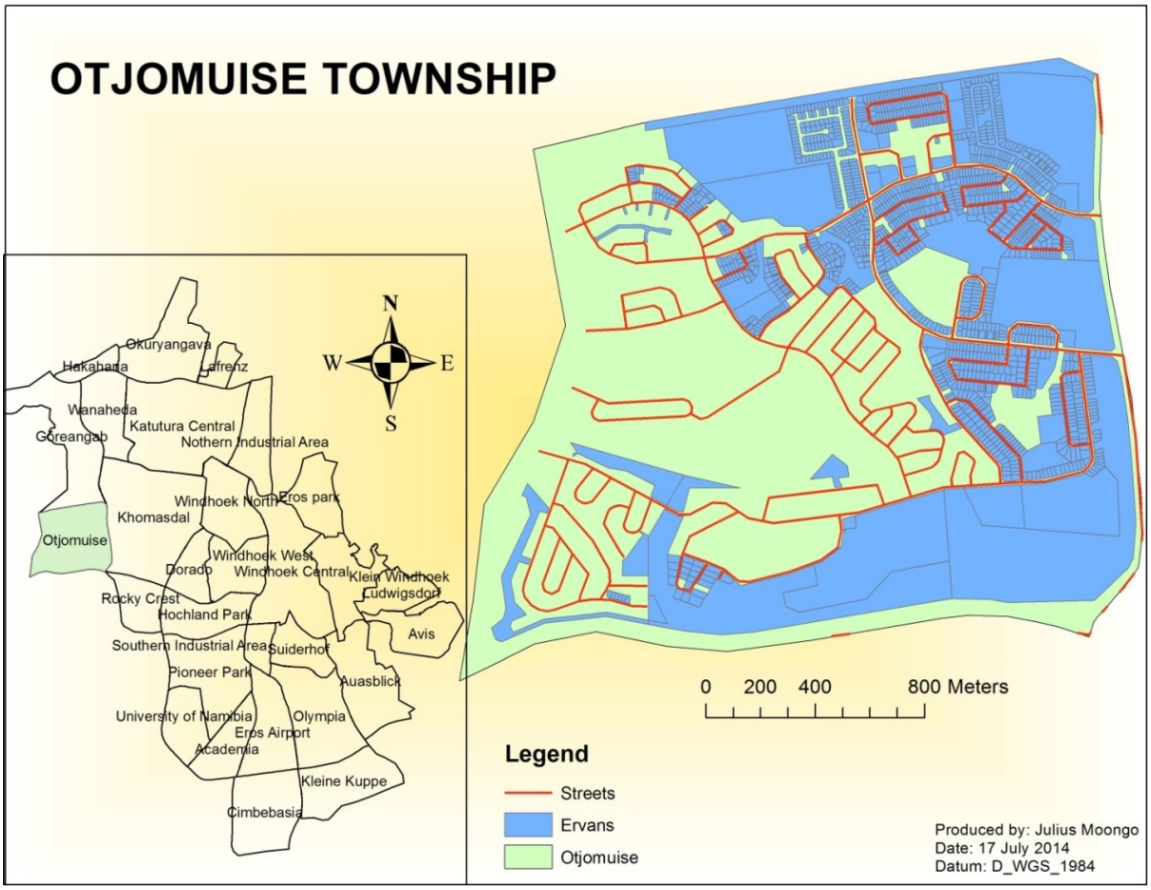
And finally I would like to thank my parents, Barkias Moongo and Saarti Moongo for encouraging me to do my level best in my study. I would like to thank them for their motivational words throughout my study.

1. Introduction and Background of the Study

Population increase brings a lot of opportunities, however these opportunities also comes with challenges; among others increase in informal settlements and crime. This research is conducted as a result from the high increase of the population in the city of Windhoek. It will illustrate, model and map the patterns of population increase in the Otjomuise Township, based on population data obtained from remote sensing data taken from satellite and airplane platforms of different time intervals.

1.1. Study area and its background

Otjomuise Township is one of the 31 townships that make up the CoW. Otjomuise was a formal settlement that resulted from the constant expansion of locations such as Katutura and Khomasdal in the City of Windhoek (Gray. M, 2008). The township comprises of many people of different mixed indigenous groups that can be found in every part of the country. These groups are for example Wamboes, Damaras, Coloureds, kavangos etc. The township was conceived as a new settlement area in 1989 due to pressure of immigrants from rural areas and other towns into the city; it was eventually regarded for middle-income housing (Mundia, 2007). The study area is made up of business area and residential area, where the residential area is divided into formal residential areas and informal residential areas.



Map 1: Locality map

1.2. Aims and Objectives of the project

This research is aimed to investigate, model and map the increase in population of the Otjomuise Township. This will be done by digitizing and mapping out the increase in population using remotely sensed data from satellite platforms and that from an airplane platform, and the investigation of how different services are distributed within the township and if everyone benefits from such services. Services mainly being the access to health facilities, schools, transportation services etc.

The main research objectives of this study are as follows:

- To map out the increase in population based on the increase of dwelling units on satellite images and aerial photographs through digitizing.
- To show the different land uses that where taking place in the township in 2001.
- To show which enumeration areas are more highly dense in population then others.
- To map the different population sizes within the township.
- To show the available services such as roads, transportation services and health facilities within this township.
- To map different distances from the different services available in the township to the houses or dwelling units appearing on satellite images.
- Study the distribution of people as far as service provision is concerned and whether people can access the required services.

1.3. Importance of the study

Population change has been overlooked in many cities and towns of the developing world(Weeks, 1999). This statement also applies to Namibia. People are mostly concerned with other issues such as ongoing climate change in the country. Factors such as high rural-urban migrations are the main contributor to the cities growing growth rate. As long as the population keeps increasing, the benefits will be short lived, and it will become a problem. Therefore, this research will help and assist the City of Windhoek in getting ready for future conditions that will arise due to the increase in population. Making sound investment decisions will help avoid population distribution disasters such as social foment, or even political upheavals that can occur if the city has no control and plans on how people should settle spatially (Weeks, 1999). It is mostly in townships like Otjomuise on the outskirts of Windhoek where expansion in population occur due to land being grabbed illegally by informal settlers from other parts of the country. The City of Windhoek would have difficulties evicting this large number of people from the informal settlements. Even though shelter is a basic need, the inadequate informal houses signify lack of access to proper services. This can result in too many disadvantages, a good example can be many people falling within a very low income class where unemployment and poverty play major roles, and were the level of crime will be high.

Investigation on population change has been done on a global and national level especially in developed countries of the world(Tayman, Swanson, & Smith, 2001). This will not be the first report

written of this nature, but most of the previous studies were carried out on small scales, countries and regions for example. The uniqueness of this research is that it will be done on a much larger scale, which is at a township level.

The importance of this research has the sole purpose and goal of mapping the population increase of Otjomuise Township, its growing patterns and the distance from people to different services. This would be relevant and efficient information for future planning, management and development of this specific township. Data and information that would be produced in this research in different forms are not primarily useful to the City of Windhoek only but could also be used by health service providers to track changes in the structure of the population to render their services in the geographical locations with the best demands needed. Many other businesses and government sectors also need information on how the population is settled and distributed in order to make efficient planning to benefit both them and the nation at large.

1.4. Background of the study

Population change has evolved all over the world. The most notable population change took place in the developed countries when the industrial revolution began(Garrett & Paul, 2000). During the 18th century, the population of Wales and England doubled and the number of people living in urban areas increased by a very large amount as industrial revolution and urbanization started in those two countries (Garrett & Paul, 2000).

Nowadays the level of urbanization universally varies. In developed countries, the urbanization process has reached its peak and nearing completion, while in the developing counties, urban development is an ongoing process which has just begun in most countries (Poston, Dudley, & Bouvier, 2010).

The scenario of population change in developing countries applies in Namibia, with major development projects taking place in the city. People migrate to these areas where they believe will offer better opportunities and better living conditions. Back in the days when the country was divided into different homelands, very few people had access to urban areas. This changed after independence, when the central government contrivances in Windhoek along with urban revolution and when education evolved in the country (Ndeshuuva, 2014). Apart from the urban development which results in high migration numbers in the city, the population change of the City of Windhoek also changed due to factors such as high rate of natural change and the increase in life expectancy (RAISON, 2010). This research will focus on local population change that appeared within the township of Otjomuise over a period of 10 years.

2. Literature review

It is known that urban areas are the most densely populated areas in every country, and that their populations keep increasing by a large numbers each and every year from people migrating to such areas or cities in search for better living conditions, better services, and a better social lifestyle. This in return causes informal settlements to arise and grow at a very fast rate in some townships.

2.1. What is population change and growth

The term population change refers to how the number of individuals in a population increases or decreases with time. Population change can also be described as the change in population as a result to migration, while population growth can be defined as the increase in the number of people that stay in a country, state, town or city (or in this case a township). This growth is controlled by the rate at which new individuals are added to the population; the birth rate and the rate at which individuals leave the population; which is the death rate (Ehrlich & Holdren, 2011).

The number of children a parent gives birth to is known as the birth rate. If all individuals in a population have two children then the birth rate will be 2. However, it is not necessary for the birth rate to be a whole number such as 1, 2, 3, etc. For example, if half the individuals of the population have two children and the other half have 3, then on average the birth rate will be 2.5. Likewise, if the population consists of equal numbers of males and females, and if the females give birth to 3 children each, then the average birth rate of the population will be 1.5 (Ehrlich & Holdren, 2011).

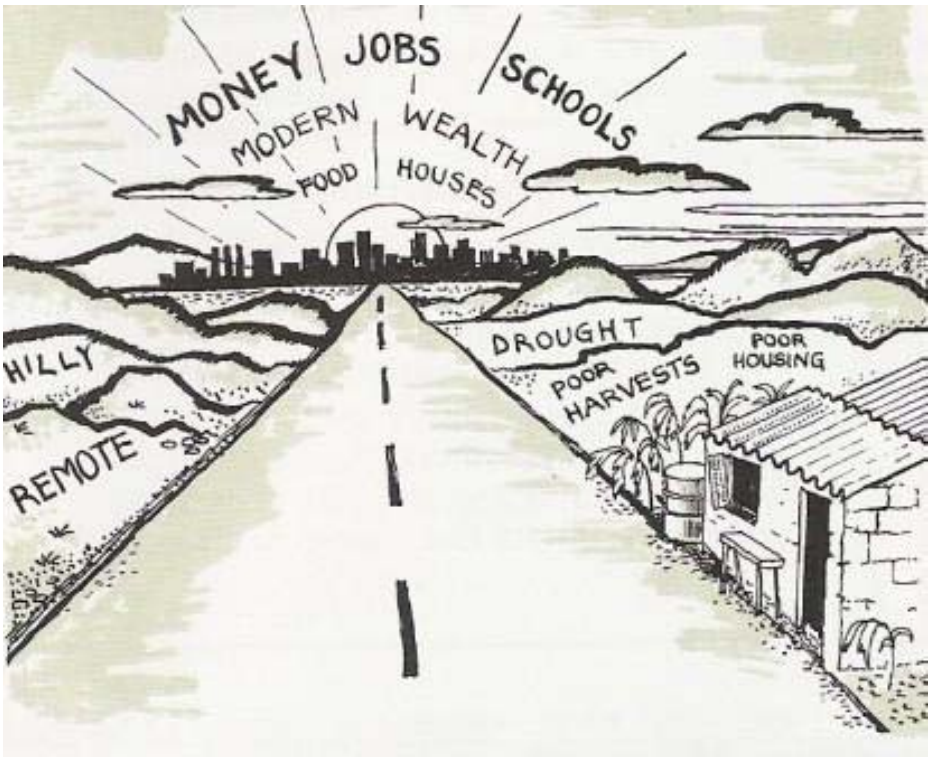
2.2. Causes of population growth in urban areas

Until recently, birth rates and death rates were about the same, keeping the population stable. People had many children, but a large number of them died before the age five (Kinder, 1998). During the Industrial Revolution, a period of history in Europe and North America where there were great advances in science and technology, the success in reducing death rates was attributable to several factors(Kinder, 1998). Firstly, increases in the production of food and distribution; secondary, the improvement in public health (water and sanitation), and thirdly; medical technology (vaccines and antibiotics), along with gains in education and standards of living within many developing nations (Kinder, 1998). Without these attributes present in many children's lives, they could not have survived common diseases like measles or the flu. People were able to fight and cure deadly germs that once killed them (Kinder, 1998). Because of this technology in urban areas, people migrate there and could produce more and different kinds of food. Gradually, over a period of time, these discoveries and inventions spread throughout the world, lowering death rates and improving the quality of life for most people.

(Hays, 2013) Described the causes of population growth in cities as one of the following:

- Ultimately its businesses. Cities are grown from big business interest and their need for skyscrapers, factories and

- Migration of people to cities from rural area in search for better employment in those factories and to live a better life.
- Population growth caused by natural births, more births than deaths.



Source: *http://www.geographylwc.org.uk/GCSE/igcse/Settlement/urbanisation.html*

Figure 1: Push and pull factors of urbanization

2.3. Advantages of population growth

The growth in population can have some advantages. Population growth is a good thing for the world because it adds diversity to society, creates more responsible and moral citizens in the world, and it contributes to the maintenance of order in society (English, 2012). Population growth is also important because we need a new generation of people who can think big and create ways to keep society strong. When new babies are born, some may grow up to invent new technologies that can ensure safe food production methods for humans (English, 2012).

Economist professor Mulligan (2009) stated that the more people on earth, the greater the chance that one of them has an idea of how to improve alternative energies, or to mitigate the climate effects of carbon emissions. It takes only one person to have an idea that can benefit many. Plus, the more people on earth, the larger are the markets for new innovations.

2.4. Disadvantages and consequences of population growth in urban areas

Rapid human population growth has a variety of consequences. Population grows fastest in the world's poorest countries. High fertility rates have historically been strongly correlated with poverty, and high childhood mortality rates. Falling fertility rates are generally associated with improved standards of living, increased life expectancy, and lowered infant mortality. Overpopulation and poverty have long been associated with increased death, and disease. People tightly packed into unsanitary housing are most likely to be vulnerable to natural disasters and health problems (Kinder, 1998).

However, most of the world's 1.2 billion desperately poor people live in LDCs. Poverty exists even in MDCs. One in five Soviet citizens reportedly lives below the country's official poverty line. In the United States, 33 million people, one in eight Americans is below the official poverty line. The rapid expansion of population size observed since the end of World War II in the world's poorest nations has been a cause of their poverty (Kinder, 1998).
Poverty is a condition of chronic deprivation and need at the family level. Poverty, is a major concern of humankind, because poverty everywhere reduces human beings to a low level of existence. Poor people lack access to enough land and income to meet basic needs. A lack of basic needs results in physical weakness and poor health. Poor health decreases the ability of the poor to work and put them deeper into poverty (Kinder, 1998).

Kinder (1998) stated that iinstead of allowing poverty to persist, it is important to limit the number because in dense populations too many lack adequate food, water, shelter, education and employment. High fertility, which has been traditionally associated with prosperity, prestige, and security for the future, now jeopardizes chances for many to achieve health and security.

Both rich and poor countries alike are affected by population growth, though the population of industrial countries are growing more slowly than those of developing countries. At the present growth rates, the population of economically developed countries would double in 120 years (Kinder, 1998). The Third World, with over three quarters of the world's people, would double its numbers in about 33 years. This rapid doubling time reflects the fact that 37 percent of the developing world's population is under the age of 15 and entering their most productive childbearing years (Kinder, 1998).

Apart from poverty which is the main disadvantage of population growth, there are many other disadvantages associated with the rapid population growth in urban areas (Shukla, 2009). These can be for example result in:

- Sickness and spreading of diseases and problems of starvation and malnourished population,
- Insufficient natural resources to provide adequate goods and services,
- Inadequate facilities like housing and medical,
- Education facilities may not meet the requirements of the entire population,
- Unemployment,
- Higher crime rate due to unequal distribution of wealth and insufficient financial resources,
- Environmental pollution,
- Agricultural production is insufficient to meet the requirements of the entire population, money is diverted to ensure that the population is fed, rather than carrying out fundamental research,

- Lower life expectancy,
- Large number of people living in unhygienic conditions,
- High birth rate, due to lack of proper medical facilities death is also very high,
- People succumb to various diseases, and child labor will be common, to sustain themselves and families force their children to work, rather than send them to school (Shukla, 2009).

2.5. Namibian population and the environment

Compared to other nations, Namibia's population is very small, although this is the case; the population is very crowded in some locations and towns, like in the informal settlements of Windhoek. It's mostly within the poorest groups of people that live mostly on the edges of towns and cities that the land is degraded as a result from pollution of land and the overuse of land and this can be seen within the Otjomuise township of Windhoek. There are actions taken and policies made to protect the environment, but squatters and informal settlers don't put them into consideration.

3. Methodology

This project is aimed to cover the following: the collection of the relevant data, visualizing the collected data into a GIS software, the processing of the data in the way it is needed, the analysis of the resultant data after geo-processing and the outputs as the final steps of all the geo-processes, and the compilation of the final report.

3.1. Specific methods

The methods going to be used are based on extrapolating past trends based on characteristics such as formal and informal residential areas. This could be identified using a high resolution aerial photograph and satellite images of Windhoek. The raster data's are for years 2001, 2005 and 2011.

3.1.1. Digitizing

Digitizing in GIS is the process of converting geographic data either from a hardcopy or a scanned image into vector data by tracing the features. During the digitizing process, features from the traced map or image are captured as coordinates in either point, line, or polygon format (Morais, 2012). Digitizing will be used in this research to digitize all dwelling unit polygons within the Otjomuise Township. Every house and shack in both formal and informal residential areas and business areas will be digitized from satellite images of 2001, 2005 and 2011. This digitized data will help identify the number of dwelling units or households the township increased with from the different years (2001, 2005, and 2011)

The structures coverage change for 2001 to 2005 and 2005 to 2011 for the Otjomuise Township will be computed or digitizing with reference to the aerial raster data presented earlier. To digitize with reference to this images, they will have to be projected in the same way as the overlaid polygon covers layers.

Digitizing these covers will be done as per observed structure on the aerial photos. This will give the approximate areas that will then be considered in this report as structures cover layers

Overall, the structures change detection implemented by digitizing 2001 to 2005 and 2005 to 2011 structures cover, focuses mostly on the outer spill of structures. The target area (study area) was computed by digitizing with reference to the townships extension layer available from PSDB and the 2011 aerial photo of Windhoek. The digitizing method is being done at the moment, and the results from it will be shown in the final derivable of this project.

3.2. Project Workflow

The following workflow shows the timeline and different processes that were undertaken for the successful completion of this study.

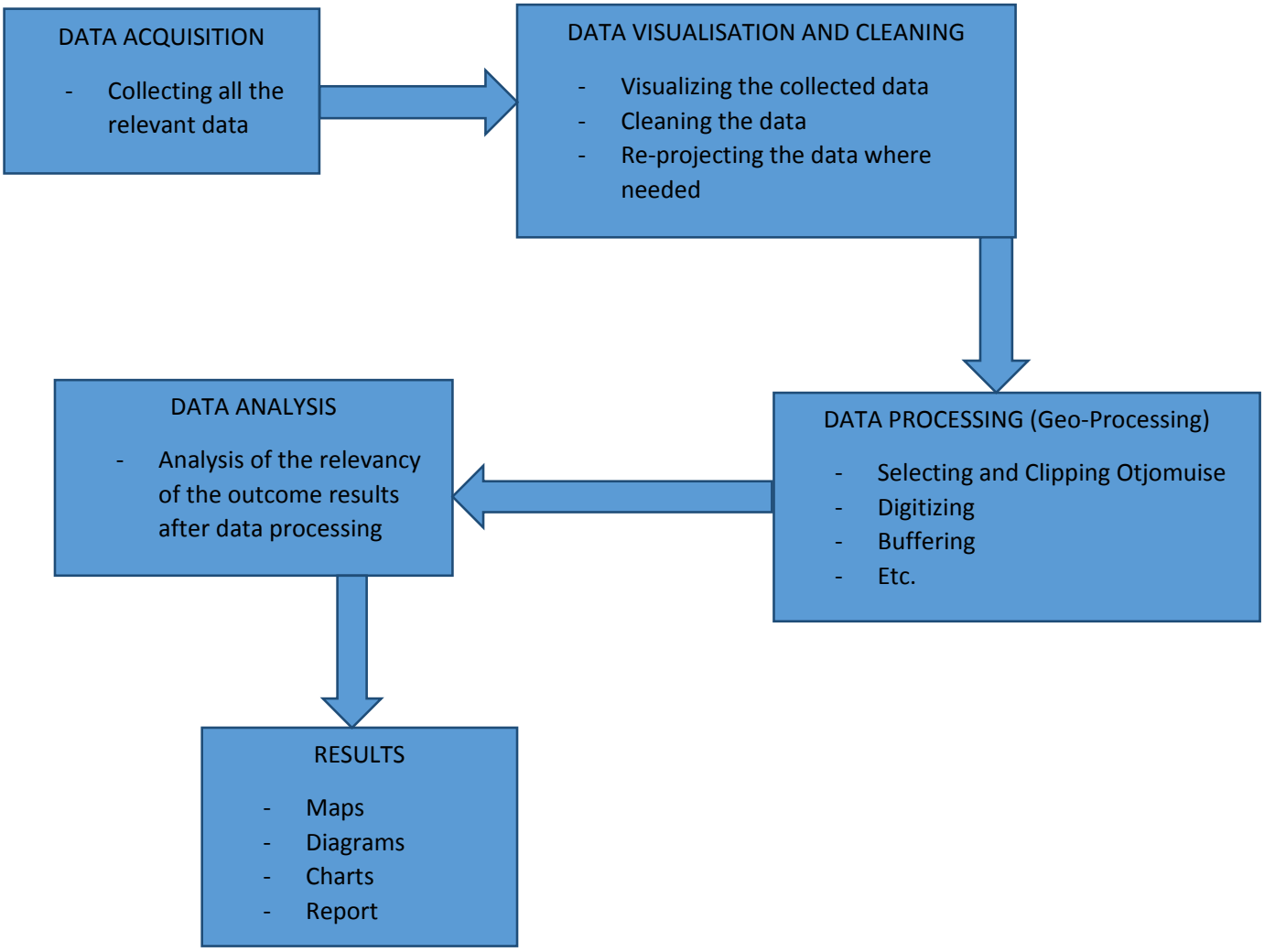


Figure 2: Project workflow

3.3. Source of data

All the data used during this research was acquired from the Polytechnic Spatial Data Infrastructure (PSDI) or the PolyDB for short. There was no other data use acquired from elsewhere not on the PSDI. The data on and that makes up the PolyDB was collected from many different institutions by Dr Alex Verlinden. These institutions are for instance the City of Windhoek, Namibia water corporation (Namwater), Namibia Statistics Agency (NSA) etc.

3.4. Data Acquisition and Characteristics

All the data that is used in this project comprises of both raster and vector datasets. All of the required data is found on the Polytechnic Spatial Data Infrastructure, which is a spatial database for academic use at the Polytechnic of Namibia. Data sets acquired from the PolyDB are free of charge and no payment is required to acquiring them. Below is a table of the different shape files data that is being used in this project.

Table 1: Data to be used in study

NAME OF SHAPE FILE	*SOURCE*	*DATATYPE*	*METADATA*
WINDHOEK_2001	PolyDB	Raster, taken from satellite platform	Present
Windhoek 2005_infrared_false color	PolyDB	Raster, taken from airplane platform	Present
WINDHOEK_2011_0.15m_RGB_GEOGRAPHIC	PolyDB	Raster, taken from satellite platform	Present
WHK_townships	PolyDB	Vector, polygon	Present
WHK_township_extensions	PolyDB	Vector, polygon	Present but not complete
TRAN_WHK_Road centrelines-5	PolyDB	Vector, lines	Present
POP_2011_building_SurveyPoints	PolyDB	Vector, point	Present
POP_2001_ea_hh_all_attributes	PolyDB	Vector, polygon	Present
POP_2001_constit_Persent_Distribution_of_households_by_main_materials_used_for the_walls	PolyDB	Vector, polygon	Present
	PolyDB	Vector, polygon	Present

HLTH_medical_facilities_base	PolyDB	Vector, points	Absent
HLTH_hospitals	PolyDB	Vector, points	Absent
Windhoek_Shopping areas_2012_ll	PolyDB	Vector, points	Present
TRAN_Approved_taxi_stops	PolyDB	Vector, points	Absent
TRAN_Bus_Stop_in_Windhoek	PolyDB	Vector, points	Absent

3.5. Data Quality

The quality of the vector data varies. Some of the vector data quality is good, but for others, example the TRAN_WHK_Road centrelines-5, have street lines running over, or on top of evens, this is wrong and needs to be corrected.

The quality of the raster images differs between the 3 different years. The images taken in 2001 have a resolution of 0.15 cm, the ones taken in 2005 have a resolution of 0.5m while those taken in 2011 also had the resolution of 0.15cm. All this resolutions are good for the purposes of this project as this will render the individual dwelling units on the images as visible, and this will allow them to be digitized, which is the major required process of this project. In order to allow correctness during digitizing, different topology rules will be done during the digitizing process. This will for example be i.e the avoid polygons from overlapping rule.

Below is a table showing the raster data resolutions.

Table 2: Raster data technical specifications

YEAR	***RESOLUTIONS***	***BANDS***	***SPATIAL REFERANCE***
2001	0.15cm	132	WGS_1984
2005	0.5m	132	WGS_1984
2011	0.15cm	132	WGS_1984

3.6. Methodology execution aid programs

There was only one main software used throughout the project and other supporting software's, this are:

- **ArcGIS**
- Quantum GIS

- MS office package

ArcMap and Quantum GIS are both GIS software's that were used for all the GIS purposes of this project, they were mainly used for visualization and digitizing purposes, and other geo processing required for an effective completion of this project. These geo processes can be for example clipping, buffering, defining projections, erasing polygons from other polygons using the erase tool etc.

The methods applied are based on extrapolating past trends. Based upon characteristics such as informal and formal residential areas, a number of socioeconomic groups can be identified using high resolution aerial photography and satellite images of which a series exists (2001, 2005, and 2011) for Windhoek.

Below is a table showing the platforms on which the different images where obtained from.

Table 3: Platform used to obtain raster data

YEAR	***Taken from:***	***RESOLUTIONS***	***BANDS***	***SPATIAL REFERANCE***
2001	Satellite Platform	0.15cm	132	WGS_1984
2005	Airplane platform	0.5m	132	WGS_1984
2011	Satellite Platform	0.15cm	132	WGS_1984

3.6.1. Selecting study area

Firstly, after loading the Windhoek Township layer into Arcmap. The study area had to be selected, and a layer had to be created from it, this layer being that of the Otjomuise Township.

The township extension layer that shows the extended areas that were added to Otjomuise by the CoW was also selected from the rest of its other layers. And a layer was created from this Townships extension layer.

The selection of the study area process is illustrated in the figure below.

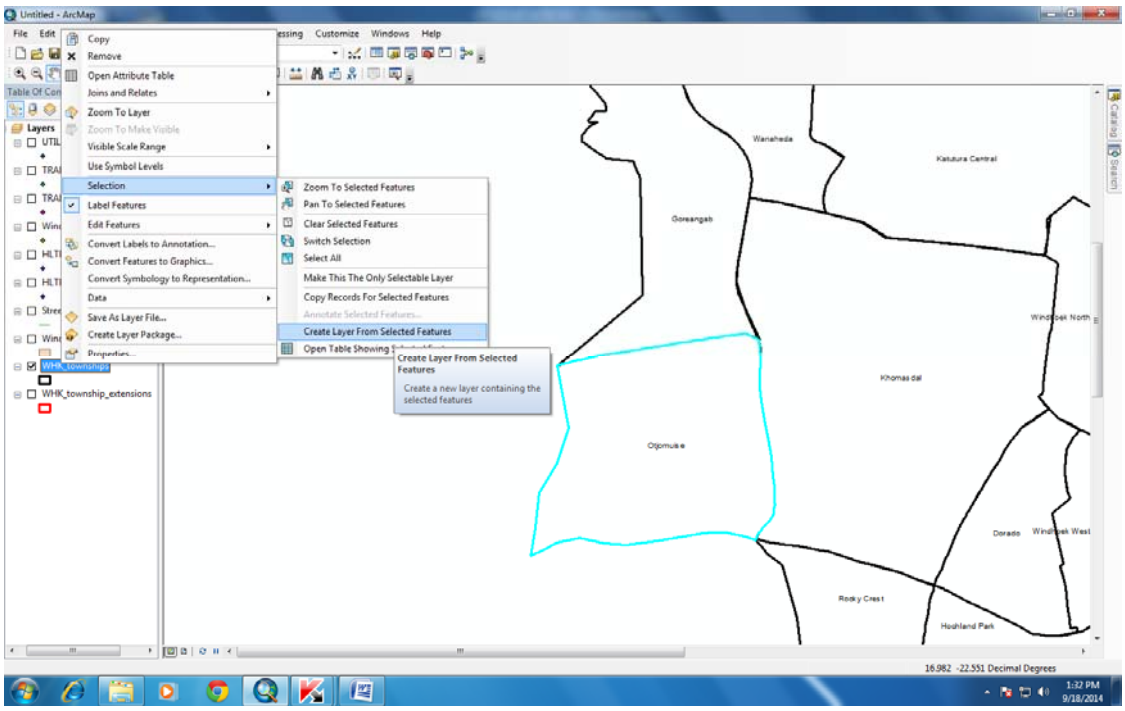


Figure 3: Creating layer from selected study area

The newly created layer needs to be exported as a shape file. This will allow the layer to be saved as a shape file or as a dataset standing on its own. This shape file was named Otjomuise. The shape file layer is shown in the following figure as how it appeared in Arcmap.

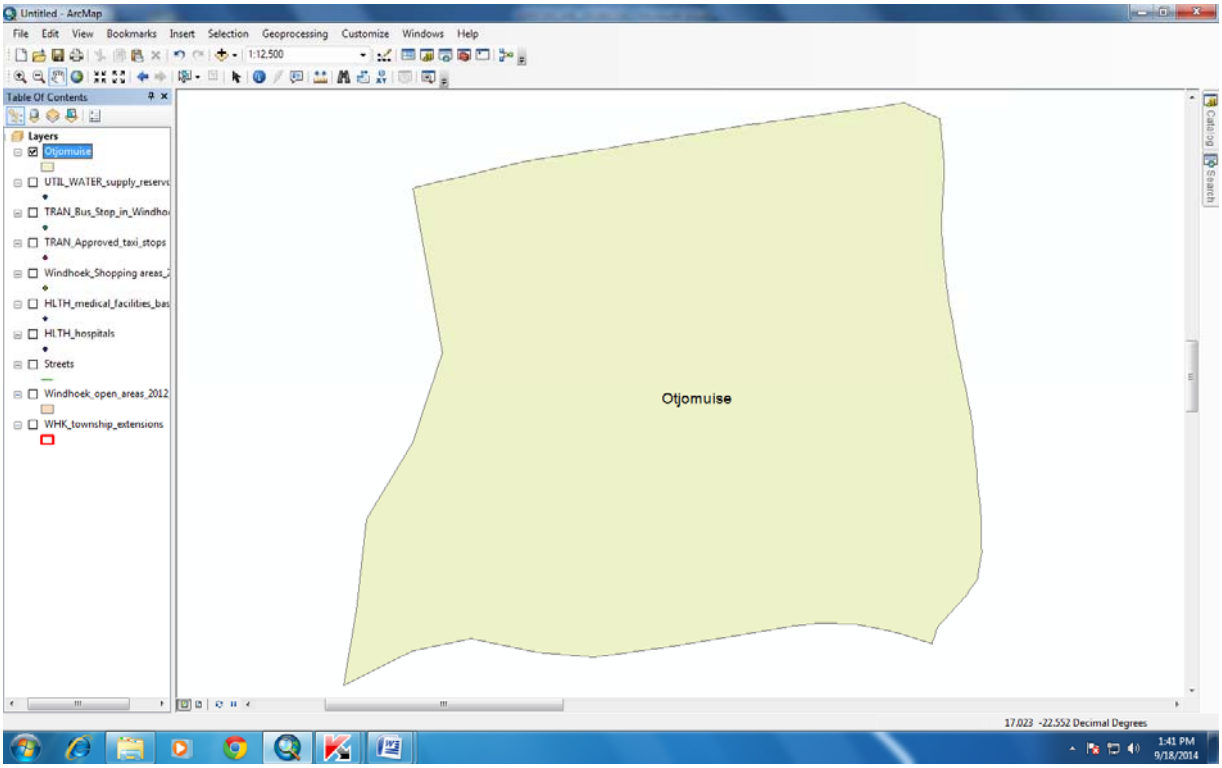


Figure 4: Study area

3.6.2. Merging

Merging as the name states is the combination of input features from multiple input sources (of the same data type) into a single and new, output feature class. The input data sources may be a point, line, or polygon feature class or even tables.

The two newly created shape files, the Otjomuise layer and that of the Otjomuise extension had to be merged into a single layer, this is done with a geo-processing tool called merge. Below are images showing the two layers before they were merged during the merging method and the single layer after it has been merged, the layer has then been renamed to Otjomuise1.

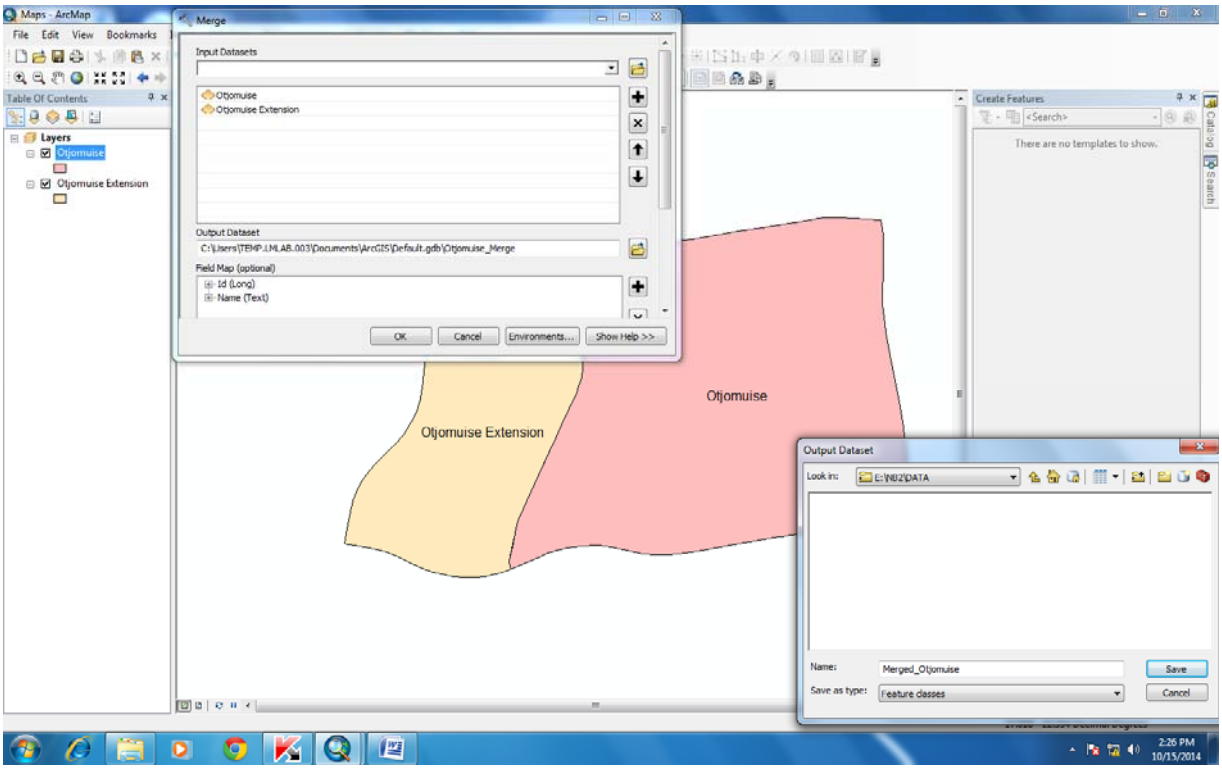


Figure 5: The merging process

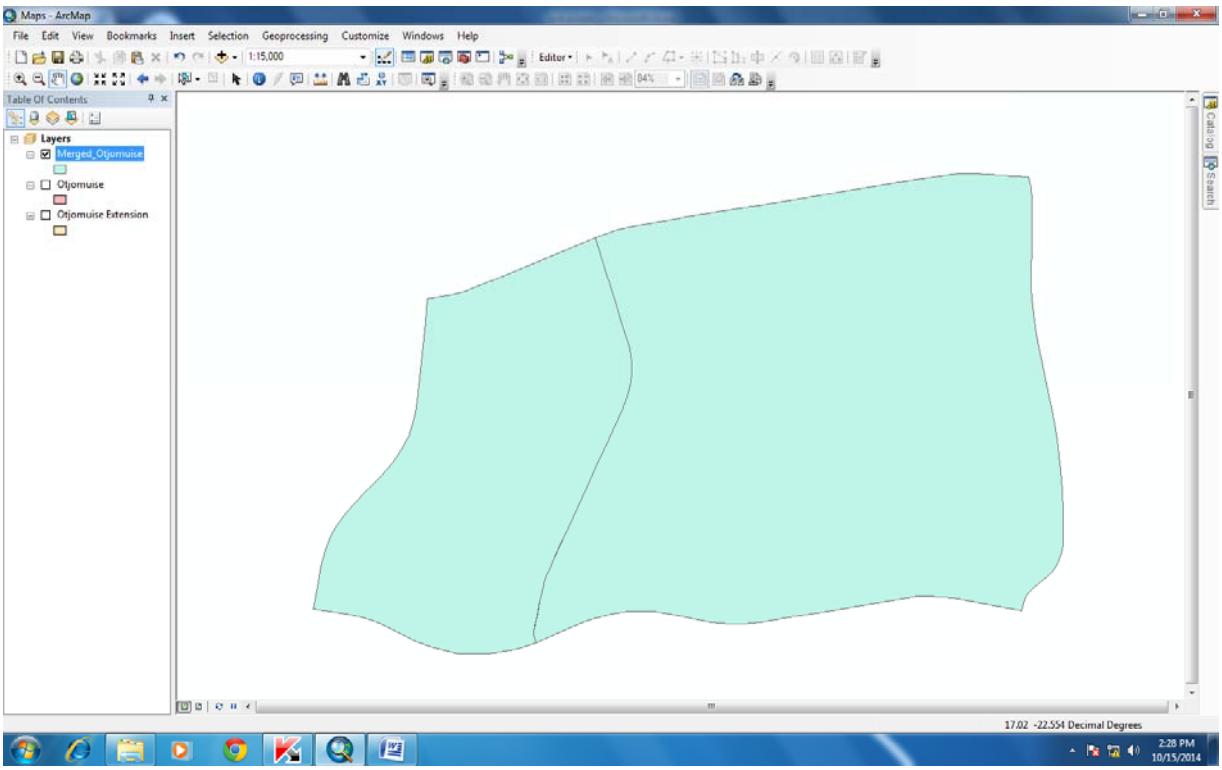


Figure 6: The layer after it has been merged

3.6.3. Clipping

Clip analysis can be defined as the function of using the extent of one geographic layer to clip or curve out the extent of another geographic layer (Morais, 2008).

After obtaining the study area, all the other data layers relevant for this study were also loaded into Arcmap and clipped within the boundaries of the main study area layer. This layer being that of the Otjomuise layer that was previously created in the first steps of this study.

Below is an example of how the clipping was done on the POP_2011_EA_12June12_peopleonly layer of the whole country, and the results after it has been processed and clipped only within the Otjomuise shape file.

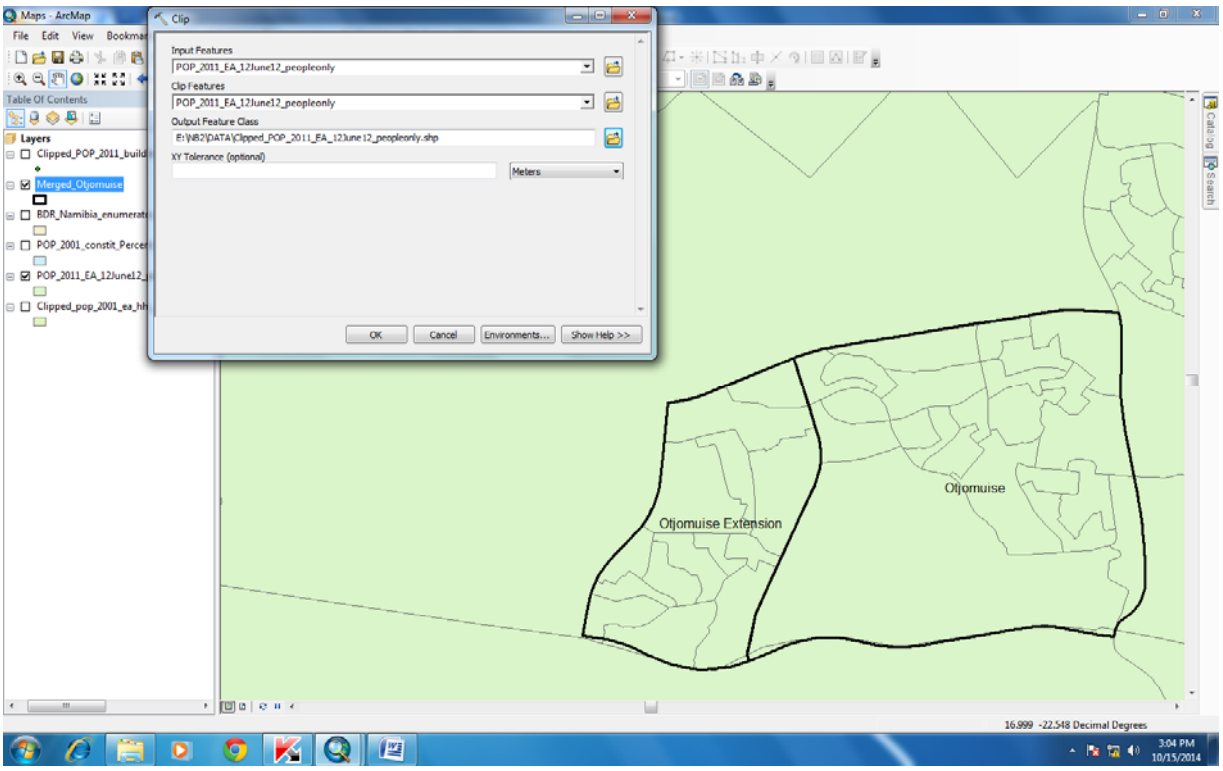


Figure 7: The clipping process

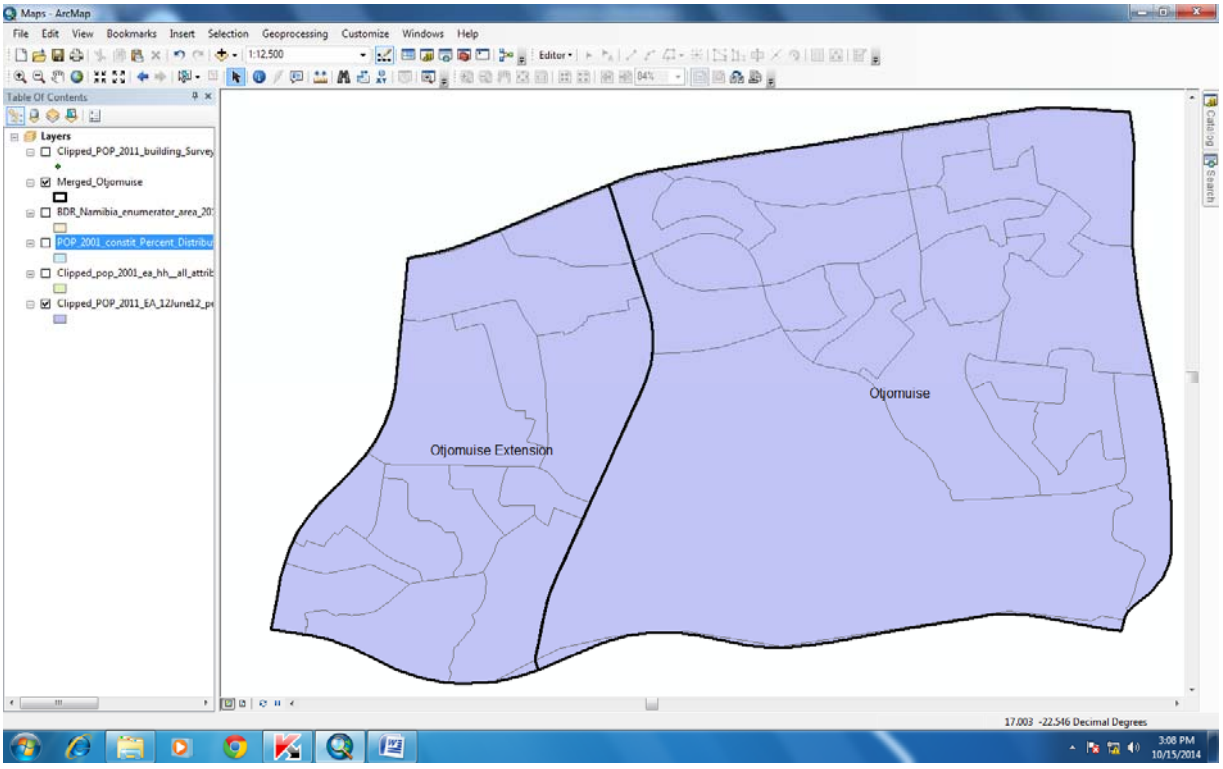


Figure 8: Clipped layers overlaying the study area

3.6.4. Digitizing

The next step that followed was to load the satellite images into Arcmap and digitize the households or dwelling units that appear on them. These images are those taken in 2001, 2005, and 2011 respectively.

After digitizing all the three images, different colors were assigned to the households or dwelling unit covers depending on the year of the image they were digitized from. The 2001 image dwelling units were assigned a blue color, the 2005 dwelling units cover where assigned a green color and the 2011 a red color.

The digitizing process is illustrated in the following figure below. By the time the following print screen was taken, the 2011 population cover was busy being digitized.

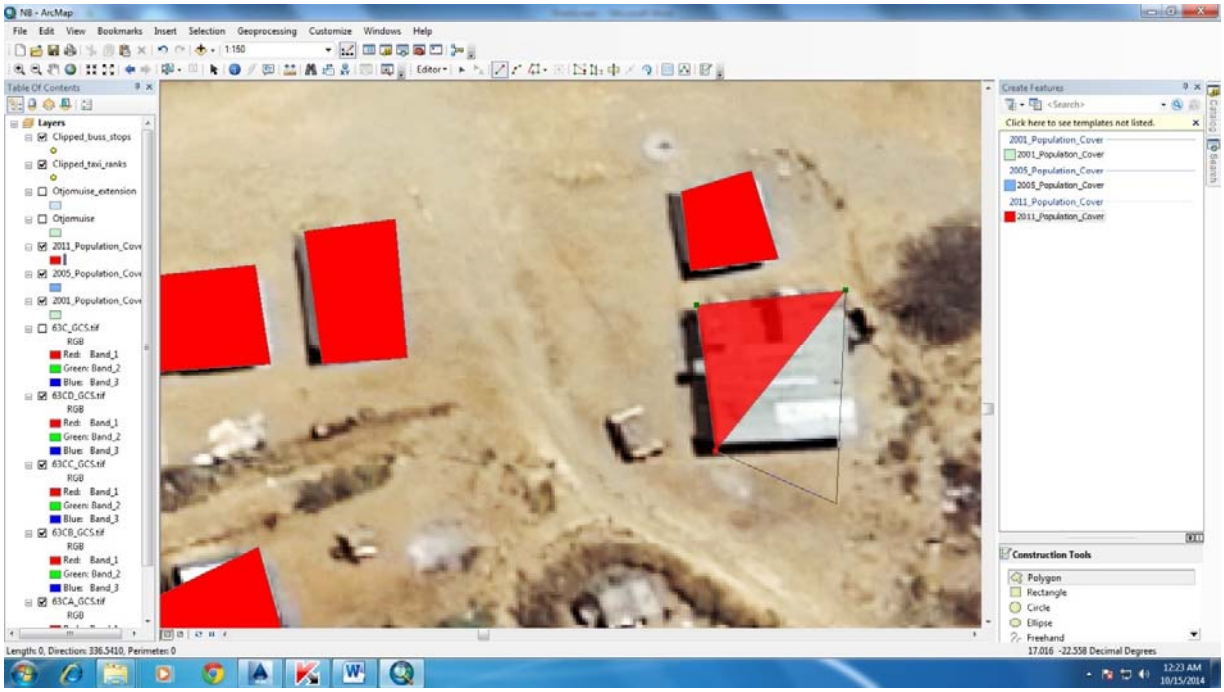


Figure 9: Digitizing

3.6.5. Overlaying and buffering

After overlaying the raster data and vector data relevant for this study, different buffer distances were made. This buffers were done on the different service available in the study area. Different buffer distances where chosen. This was done as illustrated by the following figures.

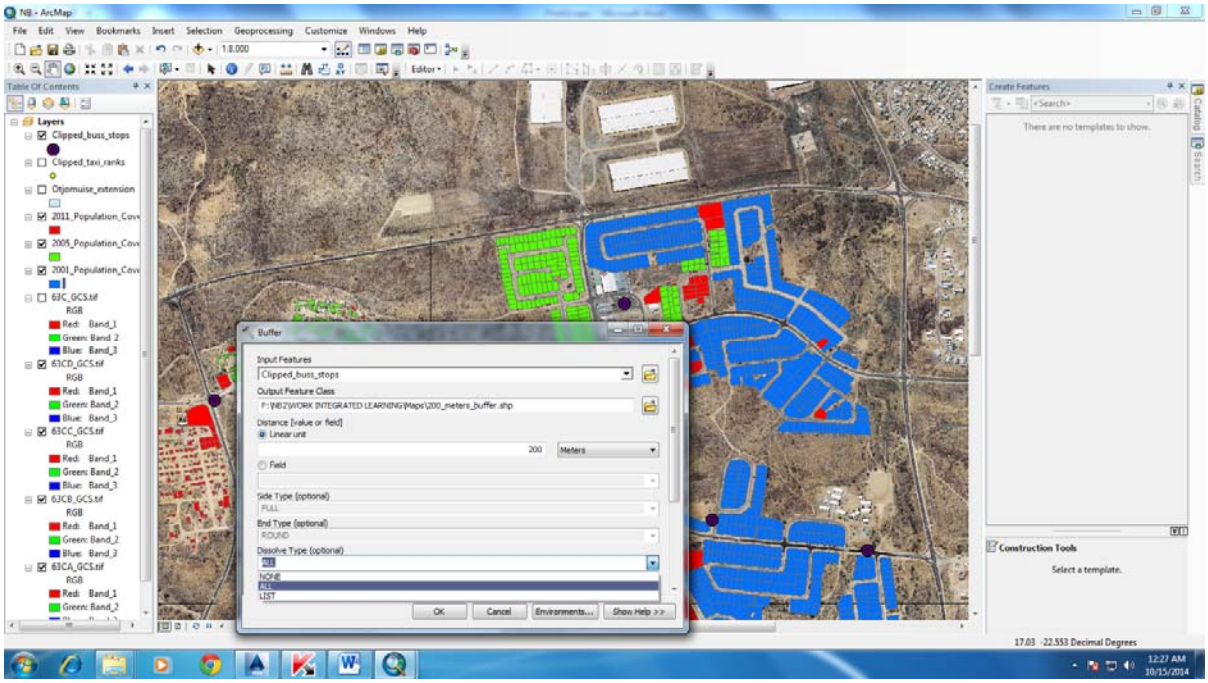


Figure 10: Buffering

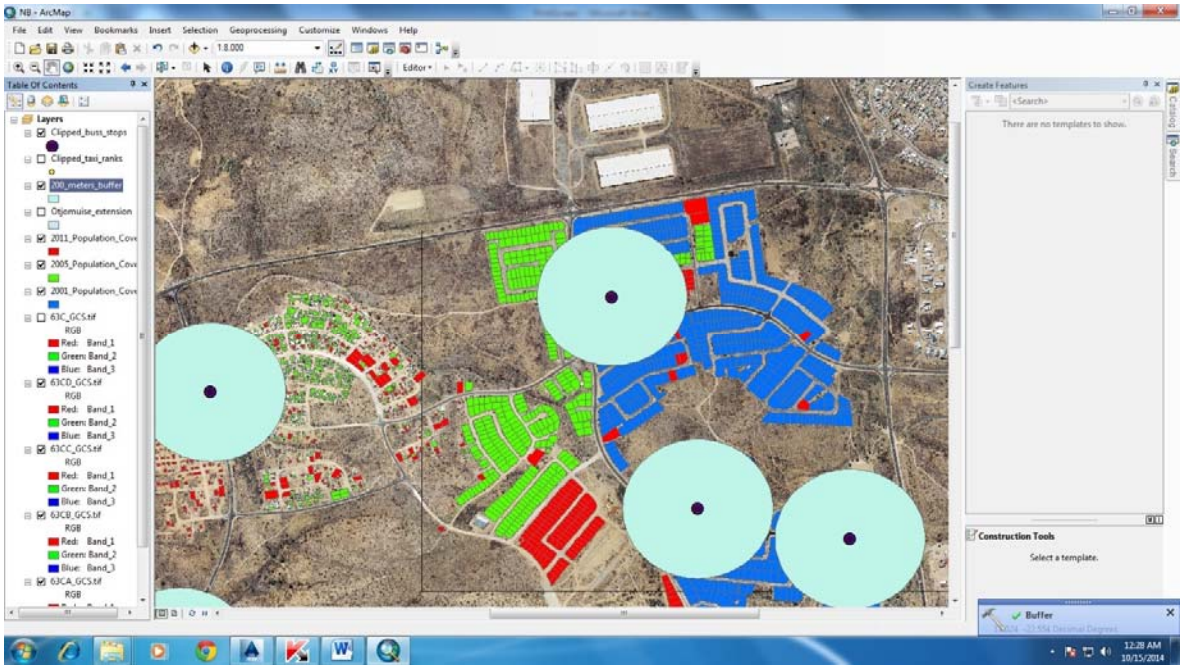


Figure 11: Buffer results

4. Project Results

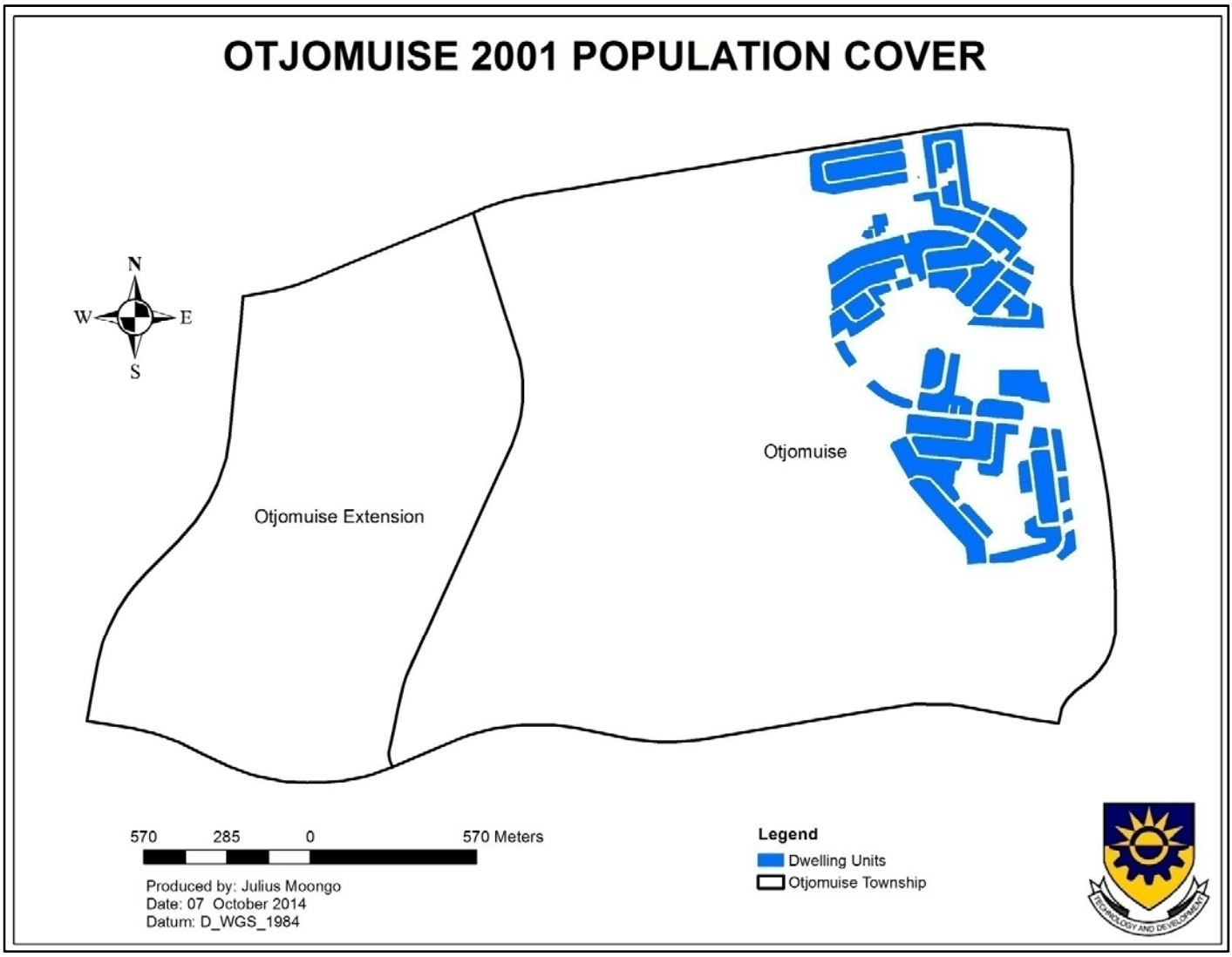
The expected results will be the illustration on how the township of Otjomuise increased from 2001 to 2011 based on the increasing of dwelling units as digitized on the different raster data. Different maps illustrating the growth of the informal settlement in Otjomuise in every five years from 2001, 2005 to 2011. There are also maps that show the population size and density within the Otjomuise township and the different distances of which people are located from health facilities and other relevant services.

4.1. Specific project outcome

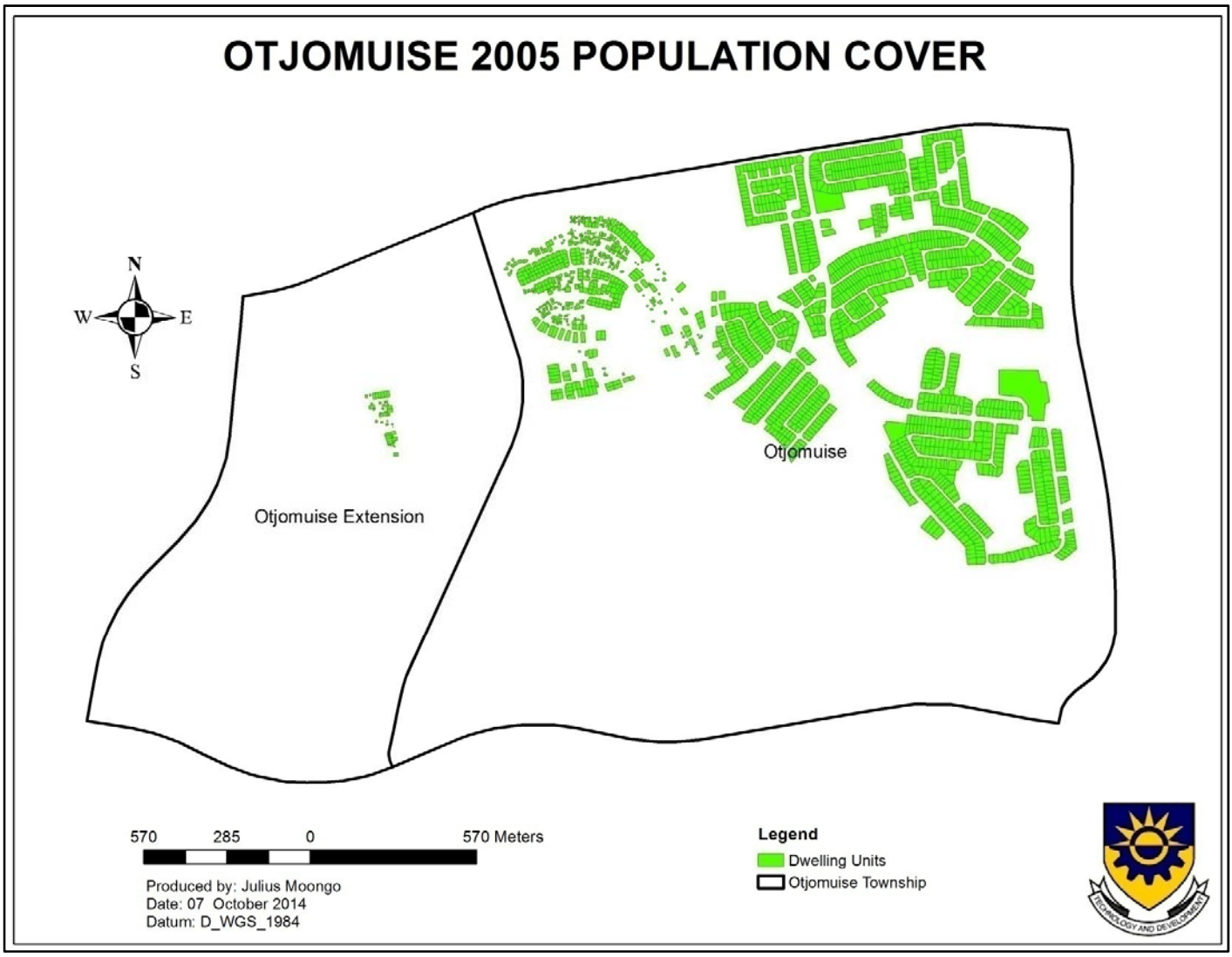
Different Maps showing the expansion of the population or dwelling units in the Otjomuise Township. This is an output from digitizing the satellite images and Aerial photographs, and a final Report that documents all the procedures done in this research.

4.1.1. 2001, 2005 and 2011 population covers

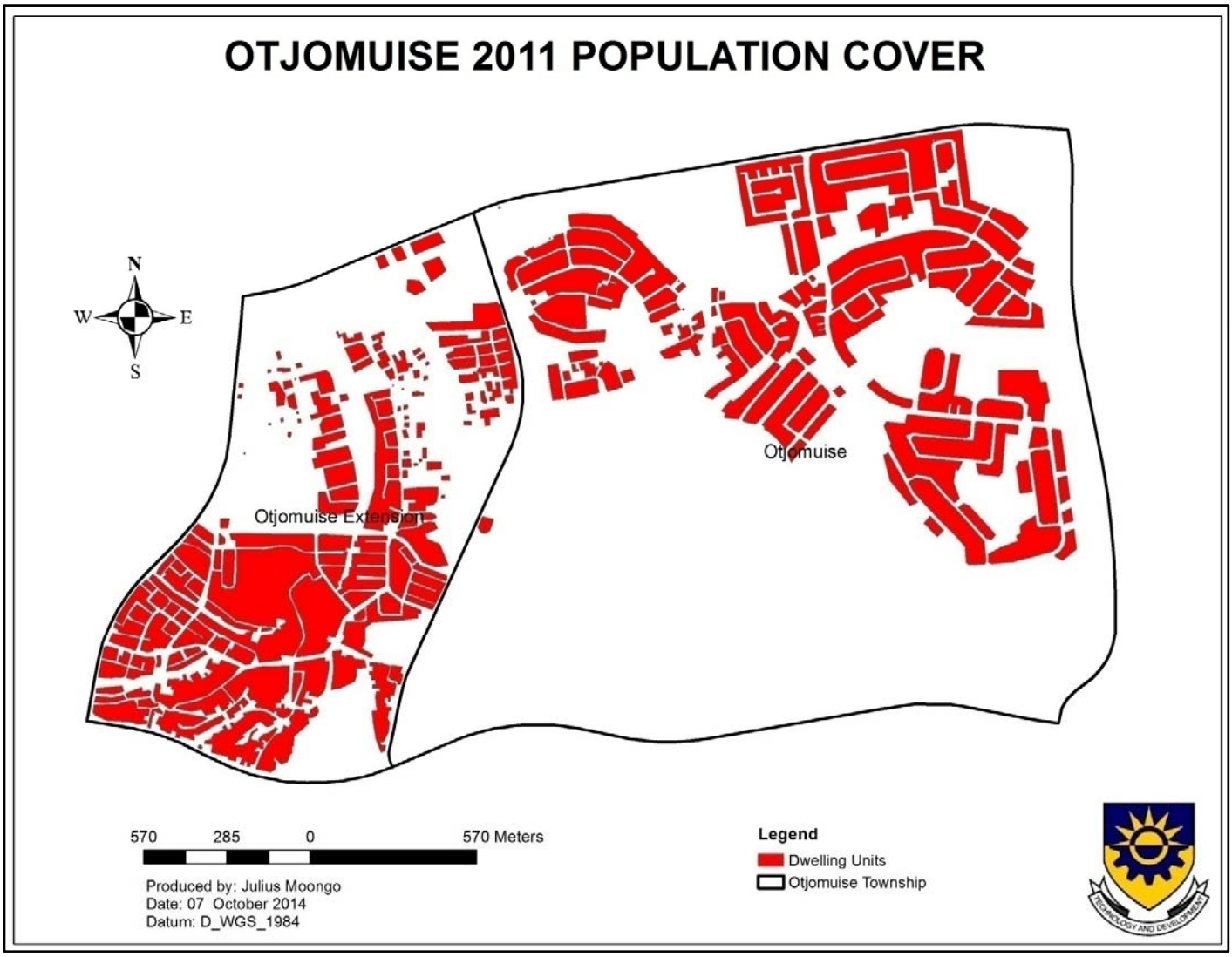
The following maps shows the population cover based on the dwelling units that were digitized from the 2001 satellite images, the 2005 aerial photographs and the 2011 satellite images.



Map 2: 2001 Population cover



Map 3: 2005 Population cover



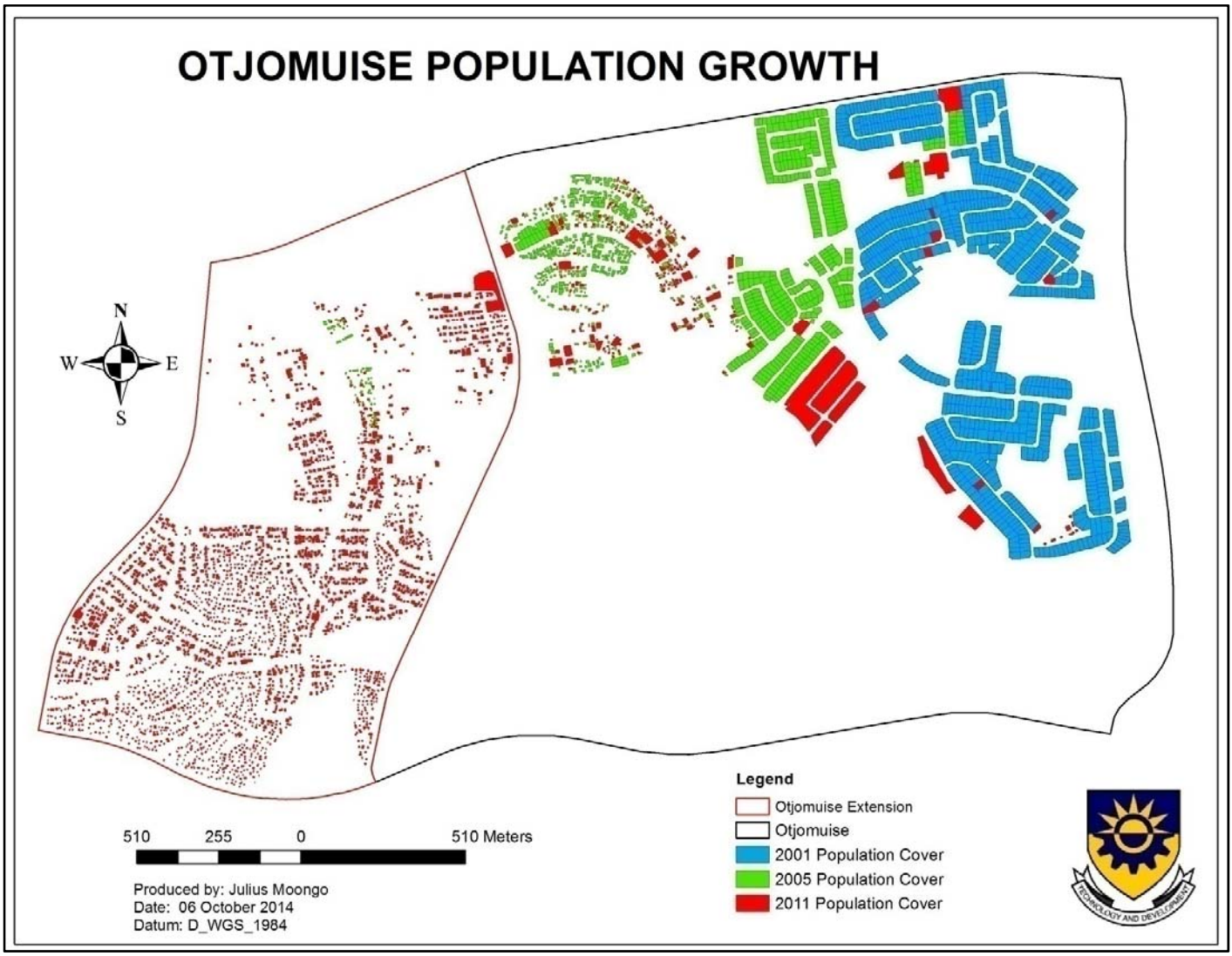
Map 4: 2011 Population cover

4.1.2. Increase of dwelling units and population as seen on satellite images

Below is a map illustrating the patterns of the increasing population in the Otjomuise Township. The information on the map is made up of digitized data that represents different dwelling units that existed on the surface of the Otjomuise Township. The dwelling units keep increasing and thus three years were chosen to show the growth in dwelling units and population. The dwelling units, as to be seen on the map, are represented in different colors. Each color represent the year on which the image was taken and these were the images used in the digitizing process. The blue color presents the dwelling units that were visible on the 2001 satellite image. The green color represents the dwelling units that were later added to the township, and adding to the previous dwellings that were already there in 2001. The green color represents the dwellings that were

visible on the 2005 image. The red color represents dwelling units that were digitized from the 2011 image. This are dwelling units that were added to those that were visible in the 2005 image.

The following map shows the patterns of the population growth pattern.

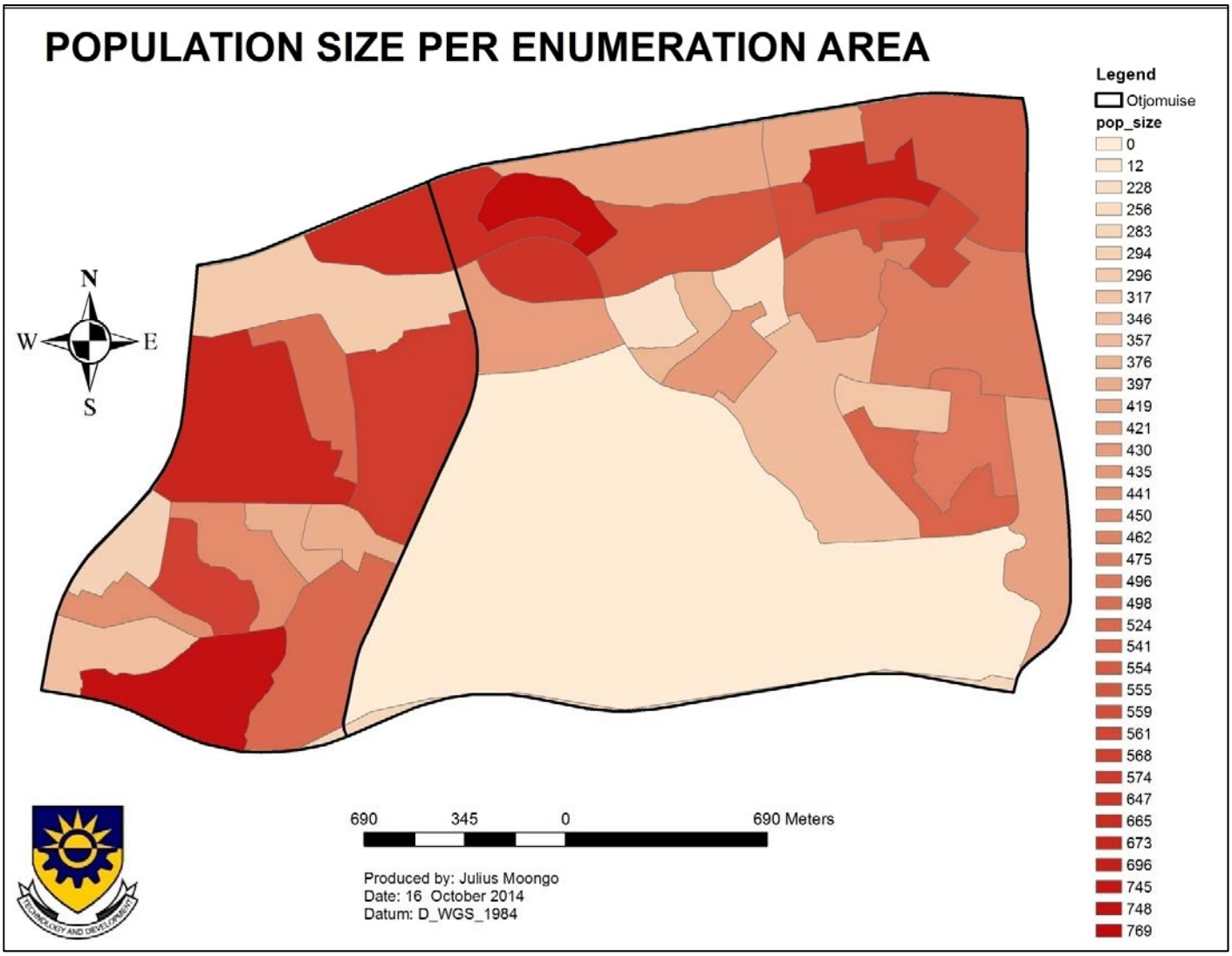


Map 5: Population growth

4.1.3. Population size per enumeration area

The map below is a choropleth map. A choropleth map is a map that uses choropleth symbols which tabulate enumeration areas or built areas within the study area as symbols themselves. The different shades of colors represents the different population sizes of the enumeration areas. The darker the color, the higher the population in size in that specific area, and the lighter the color, the lower the population in size in that specified area.

The following choropleth map shows the population size of Otjomuise per enumeration area from the 2011 Namibian census.



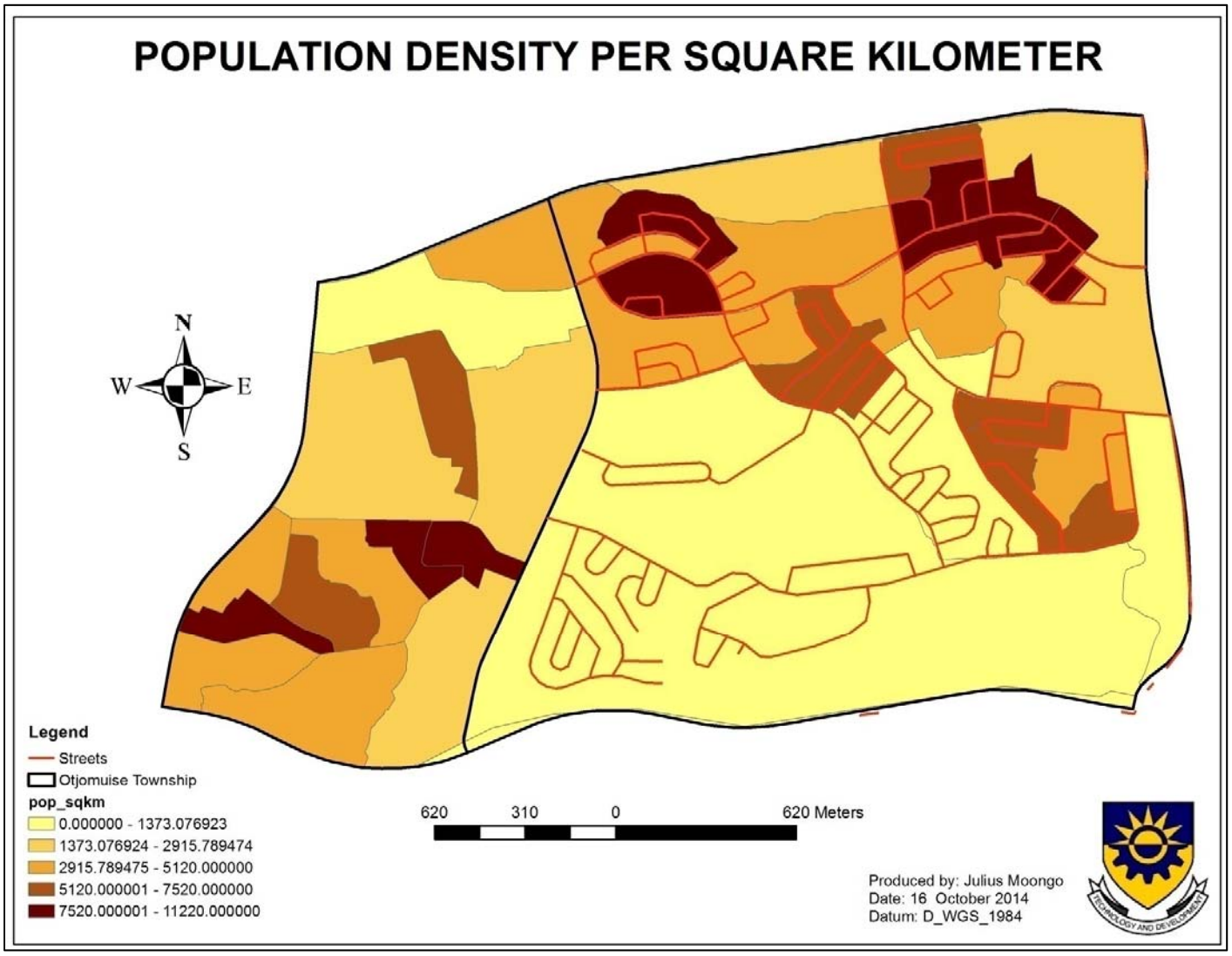
Map 6: Different population sizes of Otjomuise

4.1.4. Population density per square kilometer

Population density shows the number of people recorded to be living in a certain area or the number of dwelling units that were observed in that particular area in relation to the size of the area. The following map is a choropleth map showing population density using different shades of colors to tabulate the enumeration areas. The different shades of colors represents the different population densities of the enumeration areas. The darker the color, the higher the population

density in that specific area, and the light colors means the population density in that area is less. The high, mid, and low population densities areas of Otjomuise are all mixed together.

The map below shows the population density per square kilometer in the study area during the 2011 Namibia census year.



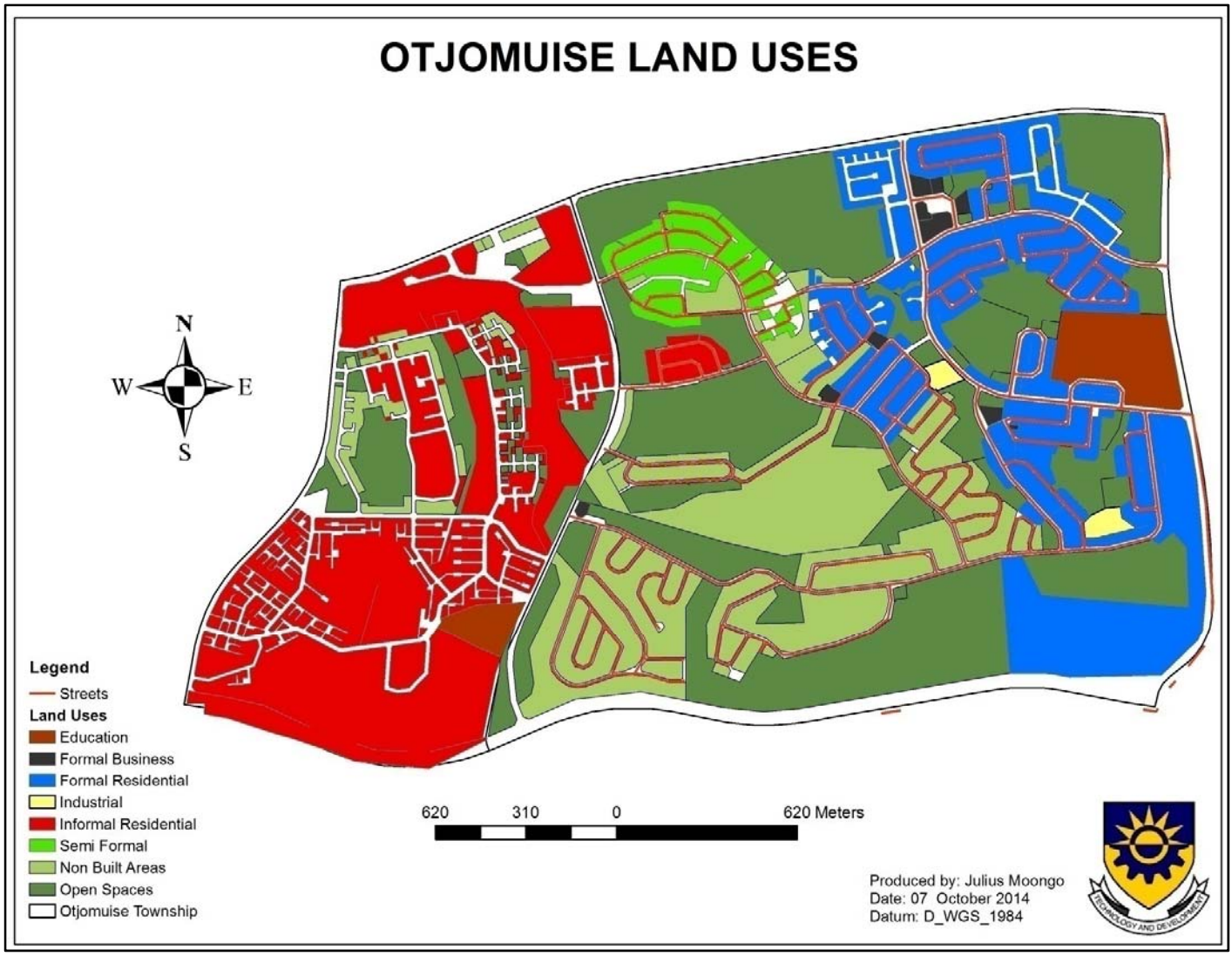
Map 7: 2011 Population density of Otjomuise

4.1.5. Different land uses in Otjomuise

The study on the area of interest showed that there are many different land uses taking part in the township of Otjomuise. An example of the land uses taking place in the study is: Education- which is shown with a brown color on the map. Other land uses includes: Formal businesses- shown with a black color, Formal residential- shown with a blue color, Industrial shown with a yellow color, Informal residential shown with a red color, Open spaces shown with a lotus pond

green color, Non built areas shown with a medium olivenite color, and Semi formal residential areas shown with a light green color.

The non built areas represent areas to be developed in future but are currently still not developed and are empty. The semi formal residential represents residential areas that were previously belonging to the informal residential category but have lately grown and are becoming formal residence.



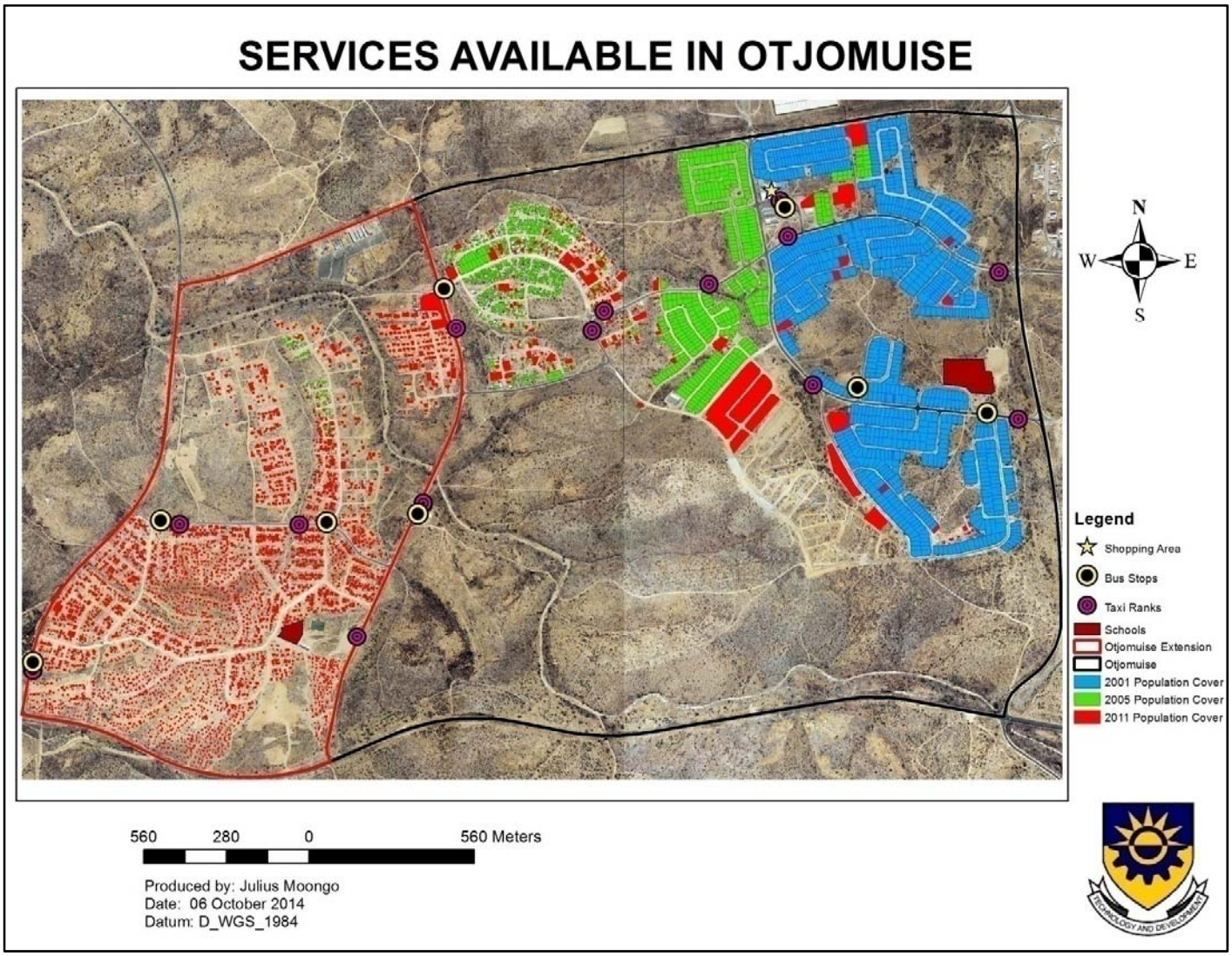
Map 8: Different land uses

4.1.6. Availability of services

The study conducted on the area of interest shows that there are not much services available that are needed by the population within Otjomuise. The study shows that there no health facilities within the study area, health facilities being either hospitals or clinics. The only services available in the study area are those of public transportation purposes, this being taxi ranks and bus stops where municipal busses stop to transport people. Another type of service available

within the study area is a shopping area, the only place where the people of Otjomuise can go buy their daily needs because this is a retail shop. The study area also has two schools available.

The following map shows the different types of services available within the township.



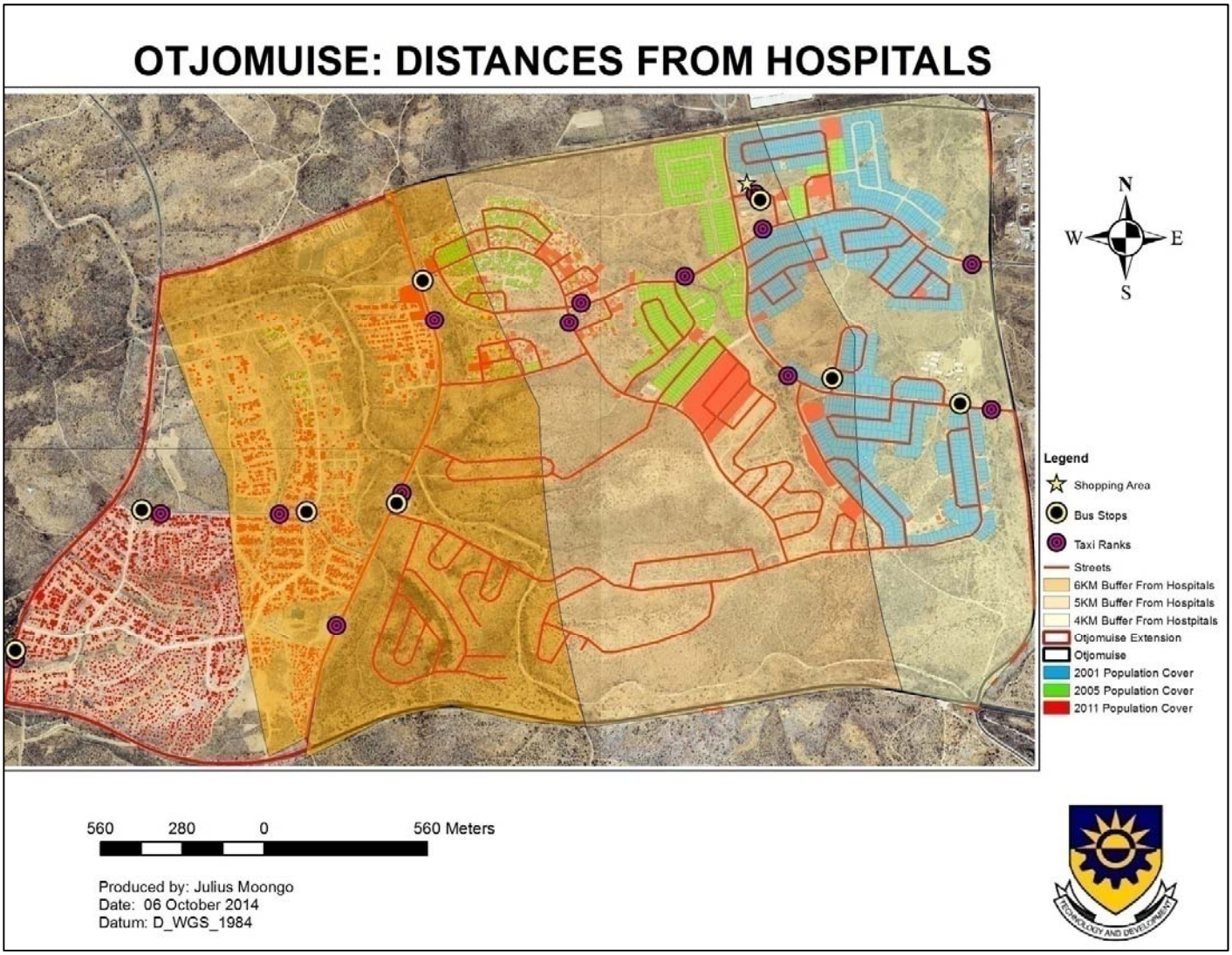
Map 9: Different services in Otjomuise

4.1.7. Buffer distances from available services

4.1.7.1. From health facilities

The study shows that there are no health facilities of any kind within the study area. The population of Otjomuise have to travel long distances in search of health related services. The closest population of Otjomuise to a hospital have to travel a distance between 3 and 4 Kilometers. Different populations are in areas that fall within a certain distance from hospitals.

This distances are for example within 5 kilometers or 6 kilometers to the nearest hospitals. A portion of the population on the south western side of Otjomuise has to travel a distance greater than 6 kilometer to get to the nearest health facility.

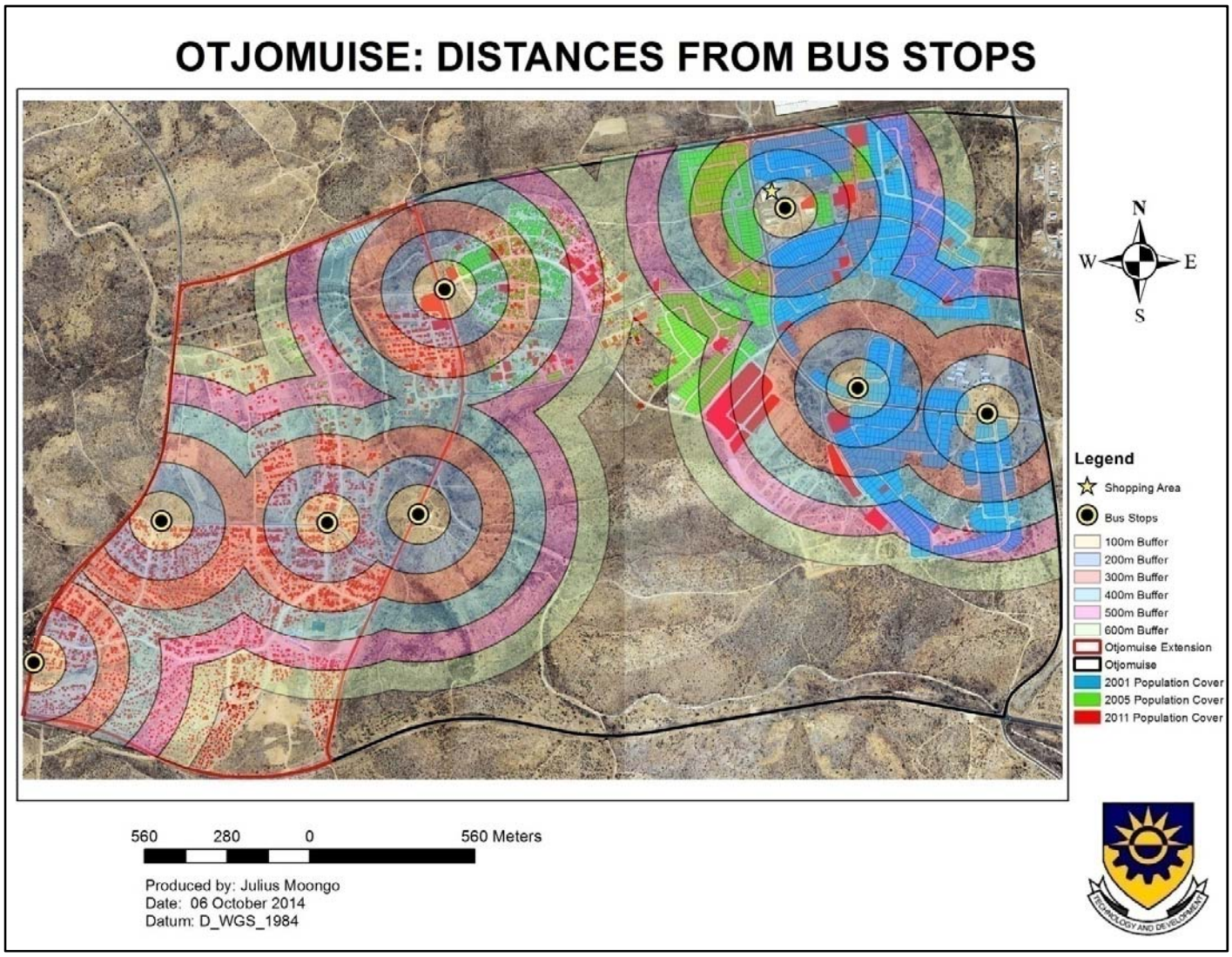


Map 10: Distances from hospitals

4.1.7.2. From transportation services

The study shows that's there are 8 bus stop and 14 taxi ranks that are registered within the study area. Different people who reside within the study area and those who use municipal public transportation buses have to travel different distances to get to the closest bus stop. This distances can be from as less than 100 meters to 600 meters from the bus stops. 600 meters is a perfectly walk able distance to any destination. But for the population that lives more than 600 meter from bus stops find it hard to walk there and are therefore requesting the municipality to add another bus stop on the south western side of the township preferably on the road leading to Daan Viljoen from Windhoek.

Below is a map that shows the different distances people have to travel in order to get to the closest bus stops to them.

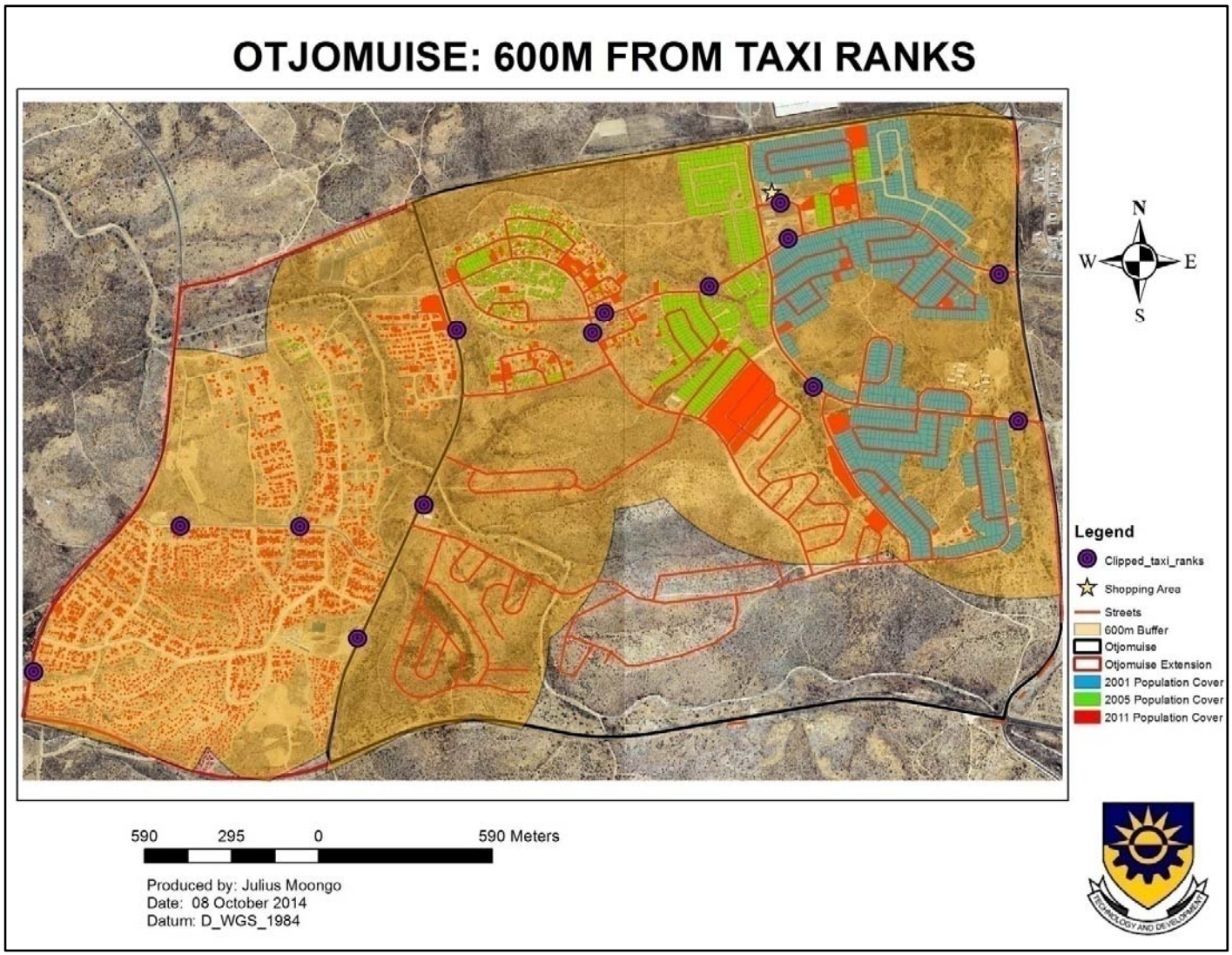


Map 11: Distances from bus stops

The study conducted on the study area shows that taxi ranks are almost accessible to every part of the population. The 14 taxi ranks are almost perfectly distributed within the study area so as to be available to everyone. A buffer distance on 600 meters was made from the 14 taxi ranks all around the study area and this buffer distance covers almost every dwelling unit visible on the 2011 image of Otjomuise. Only a tiny bit of the dwelling units lie outside the 600 meter buffer distance from the taxi ranks. This is not a big issue because, unlike buses, taxis move around almost anywhere. Taxis move in and out of different streets, and do not stick to stopping strictly at taxi ranks like busses do. The other factor that makes addition of taxi ranks less important than the addition on bus stops is, taxis in Windhoek are a lot compared to the busses that operate as public transportation services. Taxis can also operate 24/7, any day and any time, whilst municipal busses only operate on specific hours of the day that they are required or authorized

to. If one misses that hour, they will have to wait for the next available bus that operates on the same route. Bus stops are usually full to capacity for people waiting for transportation to their destinations and some travel while standing. That is why other people use taxis thought it is a more expensive type of transportation service compared to municipal busses.

The map below shows the 14 taxi ranks and the 600 meters buffer distance from them.



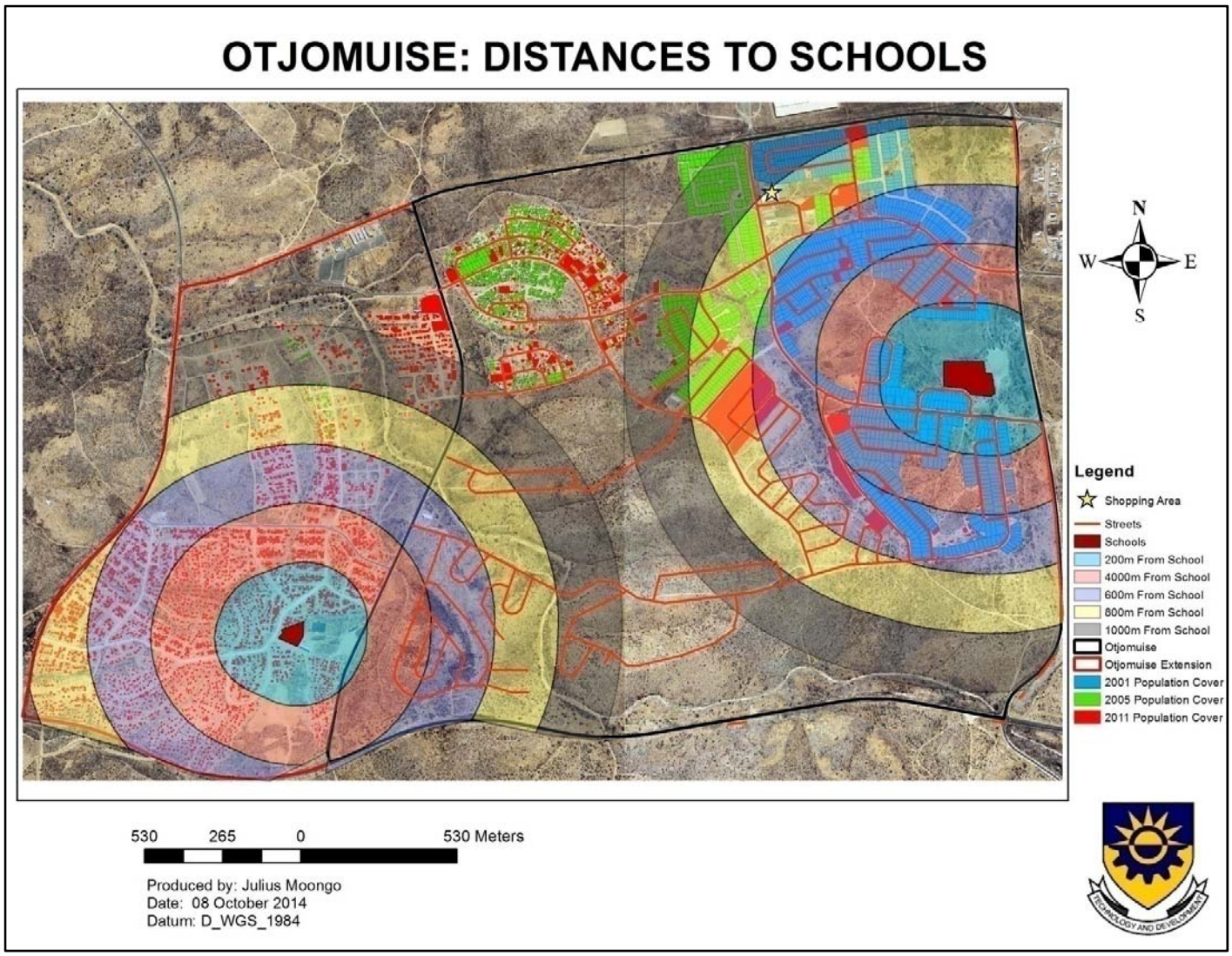
Map 12: 600 meters from taxi ranks

4.1.7.3. From schools

The study conducted on the area of interest showed that there are two primary schools in Otjomuise. This two schools are clearly visible on the 2011 image but on the 2005 image only one of the two schools was visible, the Michelle Mclean primary school. Although there are two schools in the study area, some children from the township have to travel long distances to go to school depending where they are situated in the township. There is a section of the population

that lies outside the buffer distance on 1 kilometer from the two schools. This means, if there are children that resides in this areas they have to travel distances of more than 1 kilometer just to go to school. Most of this children walk to school and do not use taxis as a means of transportation due to the circumstances they live in. And then there are those children that stay close or within a certain buffer distance from one of the schools, but due to some reasons they don't attend classes at that school but instead attends school at the furthest school from them.

The map below shows the different distances from the schools to the nation.



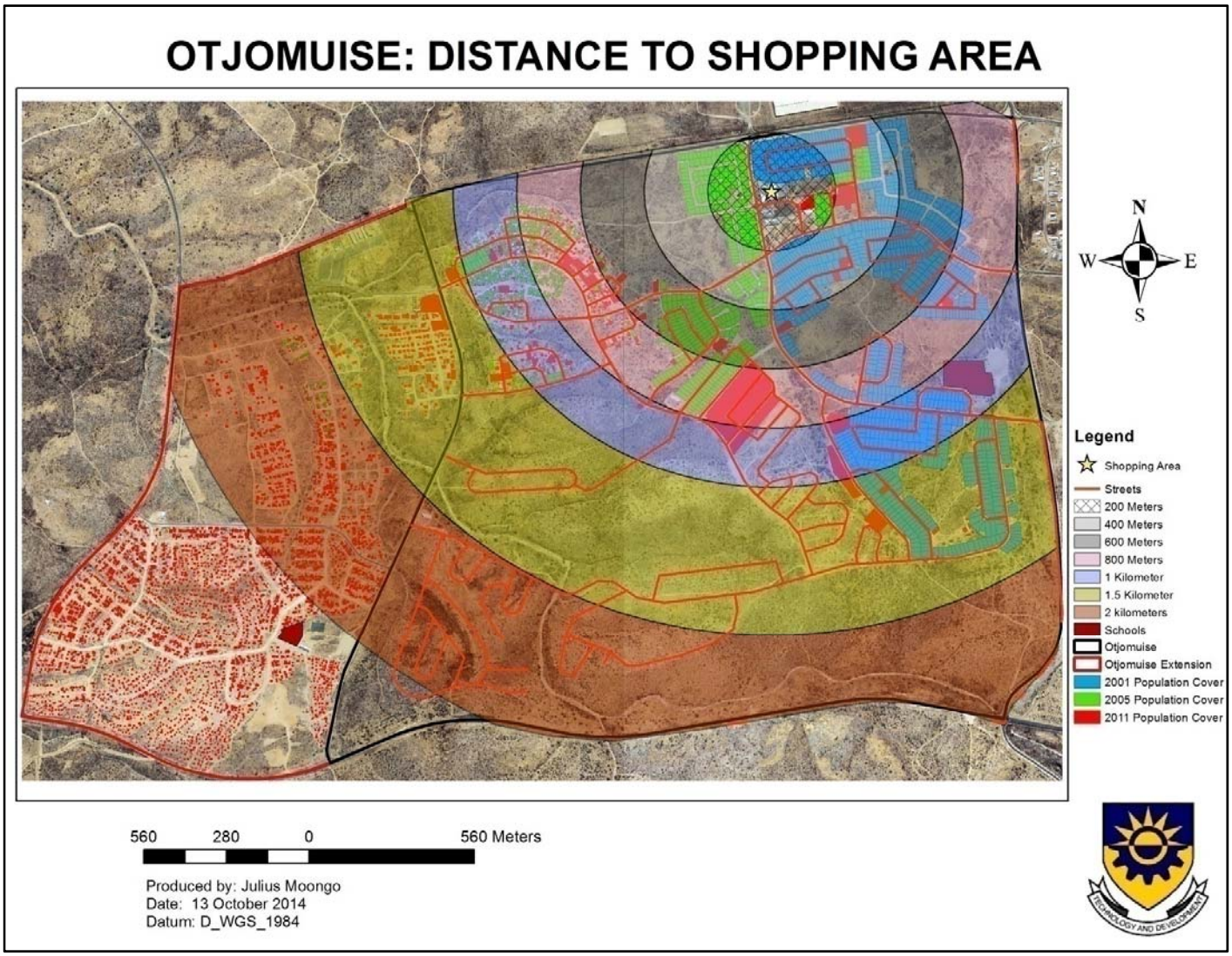
Map 13: Distances to schools

4.1.7.4. From the shopping area

The study shows that there is only one area within the whole township of Otjomuise where people can go and do their shopping. The main retail store there is the deli super market and

bottle store. This being the only shopping area of the township forces people to travel lengthy distances for that. The population of the informal settlers is the most affected by the long distance. People who stay in the south western parts of the township which is part of the informal settlement have to travel a distance of more than 2 kilometers just to get to the shopping area.

This is illustrated in the map below.



Map 14: Distances to shopping area

4.1.8. Statistic results

The statistics from the 2001 census results shows that 96.1% of the houses in Otjomuise were built with cement bricks. 0.5% were built with burnt bricks, 0.1% from mud clay bricks, and 1.7% from corrugated irons. 0.9% of the houses there were built from other materials not mentioned earlier, 0.7% of the houses were not stated as to which materials used to build them.

The figure below show the attribute table of the 'Clipped POP 2001 constituency Percent Distribution of households by main material used for the walls' layer, that shows what was already explained in the paragraph above.

Table

Clipped_POP_2001_constit_Percent_Distribution_of_households_by_main_material_used_for_the_walls

FID	Shape *	REGION	CONST	Cnt_CONST	Cement_Bri	Burnt_Bric	Mud_Clay_B	Corr_Iron	Prefab	Wood_Poles	Sticks_mud	Other	Not_Stated	Num_House
1	Polygon	Khomas	Khomasdal North	46	96.1	0.5	0.1	1.7	0.2	0.3	0.3	0.1	0.7	5770

1 (1 out of 2 Selected)

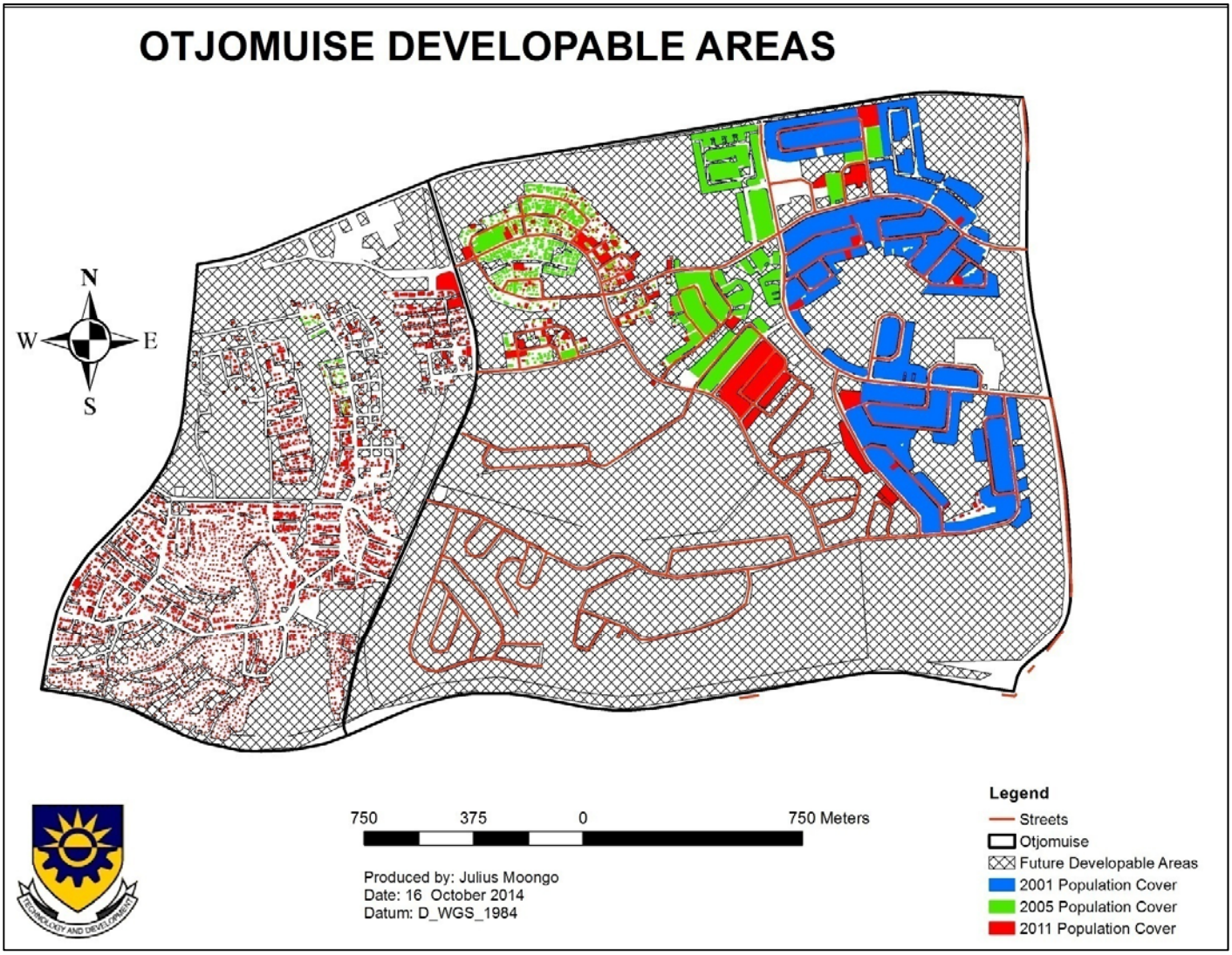
Clipped_POP_2001_constit_Percent_Distribution_of_households_by_main_material_used_for_the_walls

Figure 12: Attribute table of materials used to build houses

4.1.9. Projected future population growth and development

Future population projection is done to predict future population change, to make planning for future effects easier and to help make informed decisions. It also helps to set awareness based on future likelihoods and as a base ground for other future projection.

The map below illustrates the already built areas within the township in 2011 and areas that are most likely to be developed in the future. This are the areas where people are predicted to be living in adding to the existing areas where people were living in 2011.



Map 15: Developable land

4.1.10. Distribution of people with service provision

The population in Otjomuise seems not to be clustered in one area due to a service being available in that area, but it is more distributed unevenly almost in every part of the township except in the southern parts of the township where there is not population available.

5. Recommendations

Studies of population change helps establish the needs for future developments in an area. It is there for recommended that the city of Windhoek to consider more study's in population growth to make sure that all areas within the city are taken care of.

In the case of Otjomuise more formal houses need to be built in the non-built open area of Otjomuise, and on the open spaces of Otjomuise, in order to tackle the issue of the fast growing informal settlement. The informal settlement is very big in size compared to the formal residential area as seen on the 2001 image.

The world's current population growth calls for an increase in efforts to meet the needs for food, water, health care, technology and education. In both developed, developing and less developed countries, massive efforts are needed to keep social and economic conditions from downgrading further, any real advances in well-being and the quality of life are negated by further population growth. Many countries lack adequate supplies of basic materials needed to support their current population. Rapid population growth can affect both the overall quality of life and the degree of human suffering on Earth. So an effort needs to be taken to keep the growing population on a stable mode. The population data also needs to be made available for researchers to help in quality and accurate decisions about the population.

6. Conclusion

This study was aimed to be done in a period of six months, from July until the end of October. This research covered the topic of population growth within the township of Otjomuise, The study of the population was analyzed through the GIS perspective. The main research objective was to study the increase of the population within the township of interest, using different data collected, and the access of the population to services.

Otjomuises population has been increasing and the townships size has also been increasing over the years. The people of this township are mostly of medium and poor societies. They reside in this place because they can't afford life in town and high class suburbs. Otjomuise was a well off township of formal residential areas only as seen on the 2001 images and of few habitants. But from the 2005 image, informal houses, being shacks started to show up on the township. By 2011, as the image shows, the informal settlements of the township increased extremely, they covered more than half the area covered by formal residential areas of the township.

Proximity analysis to different available services was done. The results shows that the area lacks a lot of other services and those that are available within the study area are not really close to everyone within the population. Services are few although the areas occupied but the population keeps increasing by large percentages year by year.

Proximity analysis was done to the available services to determine the different distances the population have to travel to the different available services in the township. The results of the study can help developers in selecting suitable areas on which they can decide to set up new developments which can be made to cater for the growing population. Although the area might have shown growth and expansion of its boundary, the township is mostly covered by informal settlements based on the analysis of the results from the 2011 image.

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