

Analyzing impacts of road network on vegetation using GIS and Remote sensing techniques

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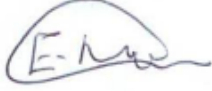
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DECLARATION

I declare that the above-mentioned dissertation titled “Analyzing impacts of road network on vegetation using GIS and remote sensing techniques” is my own work generated from data acquired by myself, and that it has not previously been submitted for assessment to another University or for another qualification. All sources from which part of the information in this dissertation was obtained were acknowledged.

Candidate's Signature:  Date: 17/11/2018

Supervisor Signature:  Date: 20/11/2018

Dedication

I wish to dedicate this to my late mother, Jacqueline Mosepele. I would also like to dedicate it to my grandmother; she taught me to persevere and prepared me to face the challenges with faith and humility.

Acknowledgements

Foremost, I would like to convey my sincere appreciation to my supervisor Dr N. N. Ndou for the continuous support through each stage of this research, for his guidance, his patience, motivation, and immense knowledge. Many thanks also go to Prof Ruhiiga, his assistance and direction has been invaluable. Thanks to the National Research Fund (NRF) and the North West University Postgraduate Bursary for providing funding for the research. I would also like to thank the United States Geological Survey (USGS) provided the Landsat satellite data, which was extremely valuable for my dissertation, through their website.

I also thank my friends in the Department of Geography and Environmental Science for the stimulating discussions, for the sleepless nights we were working together. Finally to my family I appreciate your moral support and special thanks to my grandmother and my aunt for their encouragement, support and love.

ABSTRACT

Reducing connectivity, road networks threaten the effectiveness of natural reserves, thus, representing a critical conservation matter. This work aims to: (1) map and classify the road network, (2) characterize road-side natural vegetation condition, and (3) assess the impact of road networks on vegetation cover and condition.

First, NDVI image was generated from a multi-temporal image and used as a base from which land cover classes were extracted, comprising four categories viz. healthy vegetation, degraded vegetation, bare surface and water. This study applied supervised classification-maximum likelihood algorithm in ArcGIS 10 to detect vegetation cover observed in the study area, using multispectral satellite data obtained from Landsat 8 OLI for the year 2017. The classification results show that total overall accuracy achieved was 0.88.5, and the Kappa coefficient was 0.7992 for the classification of the 2017 image; which is acceptable in both accuracy total and kappa accuracy.

Vegetation sampling transect, based quadrats 30m² measurements, were surveyed during field work within the predetermined distances of 50m, 100m and 150m from the road. Road networks were digitized from a high-resolution imagery Google Earth. Vegetation condition was then related to road network, with the multinomial logistic regression confirming a significant relationship between vegetation condition and road network. The null hypothesis formulated was that “there is no variation in vegetation condition as we move away from the road”. Analysis of vegetation condition revealed degraded vegetation within close proximity of a road segment and healthy vegetation as the distance increase away from the road. The Chi Squared value was compared with the critical value of 3.84, at the significance level of 0.05 to determine the significance of relationship. Given that the Chi squared value was 395, 5004, the null hypothesis was therefore rejected; there is significant variation in vegetation as the distance increases away from the road.

The results reveal that road network has an obvious impact on roadside natural vegetation, especially vegetation within the road vicinity. The study provides a baseline knowledge regarding roadside vegetation and would be helpful in future for conservation of biodiversity along the road verges and improvements of road verges. It is therefore recommended that improvements on unmanaged recreation for instance off-road vehicle use, that result on degradation of roadside vegetation and soils. The conclusion is that the road network plays an important role in the condition of vegetation.

Key Words: Chi squared, Geographic Information System, Multinomial Logistic Regression, Remote Sensing, Road Side Vegetation.

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LIST OF ACRONYMS

ASL.	Above Sea Level
ASTER	Advanced Spaceborne Thermal Emission and Reflection Spectrometer
AVHRR CIR	Advanced Very High-Resolution Radiometer False Colour Infrared
CaMg (CO ₃) ₂	Calcium Magnesium Carbonate
CCA	Canonical Correspondence Analysis
CNES	Centre National d'Etudes Spatiales
CO ₂	Carbon dioxide
CRISP	Centre for Remote Imaging, Sensing and Processing
CIAT	International Center for Tropical Agriculture
DBSA	Development Bank of Southern Africa
DCA	Detrended Correspondence Analysis
DEM	Digital Elevation Model
DN _s	Digital Numbers
DRS	Dynamic Road Segmentation
EIA	Environmental Impact Assessment
EMR	Electromagnetic Radiation
ERRMAT	Error Matrix
ETM+	Enhanced Thematic Mapper Plus
GCP	Ground Control Point
GDS	Geomagnetic Direction Sensor
GIS	Geographical Information System
GEOTIFF	Geographic Tagged image file format
INS	Inertial Sensor
IVCM	Integrated Vegetation-Complex Map
KIA	Kappa Index of Agreement
KML	Keyhole Markup Language
LAI	Leaf Area Index
MRF	Markov Random Field
MODIS	Moderate Resolution Imaging Spectrometer
MSS	Multispectral Sensor

NDVI	Normalized Difference Vegetation Index
NIR	Near-Infrared
OLI	Operational Land Imager
R	Red
RMSE	Root Mean Square Error
RTK-GPS	Real-Time Kinematic Global Positioning System
SAR	Synthetic Aperture Radar
SAVI	Soil Adjusted Vegetation Index
SANBI	South African National Biodiversity Institute
SPOT	Système Pour l'Observation de la Terre
SAVI	Soil Adjusted Vegetation Index
SVI	Simple Vegetation Index
SWIR	Short Wave Infrared
GEOTIFF	Geographic Tagged image file format
TRMM	Tropical Rainfall Measuring Mission
TIR	Thermal Infrared Bands
TM	Thematic Mapper
ToA	Top of Atmosphere
UAV	Unmanned Aerial Vehicles
UTM	Universal Transverse Mercator
USGS	United States Geological Survey
VI	Vegetation Index
VIS	Visible
VNIR	Visible to near-infrared bands
WSDOT	Washington State Department of Transportation
WGS84	World Geodetic System of 1984

CHAPTER 1

INTRODUCTION

1.1 Background to the Study

The negative impact of roads on natural vegetation is recognized as a major contributor to the global biodiversity for many plant lives (Ahmed *et al.*, 2009; Signal *et al.*, 2007; Forman & Alexander, 1998; Pickering and Hill, 2007). Road transport is the most common way of transportation in almost all parts of the world, and many nations have given about one to two percent of their land area to roads and roadsides (Forman, 1998). These linear roads are interconnected, forming complex networks, which vary in shape and purpose (Freitas *et al.*, 2013). However, because of its permeating nature, the existence of roads results in a wide range of environmental impacts, making it very challenging to achieve ecosystem sustainability (Caliskan, 2013). According to Van der Ree *et al.* (2015), nature within the strip of road and roadside is degraded. The physical presence of roads may result in a disturbed sequence of surrounding landscape and can cause displacement of vegetation (Fu *et al.*, 2010; Jones *et al.*, 2000). The impact of road network can be highly observed in areas where there is existence of biodiversity, availability of indigenous vegetation that needs to be protected and conserved (Ahmed *et al.*, 2009; Karani, 2007).

Road planners tend to focus on the narrow strip adjacent to a roadway, yet the effects can extend beyond roads (Roedenbeck *et al.*, 2007). Effects of road on vegetation must be investigated within a corridor known as the road-effect zone (Roedenbeck *et al.*, 2007), which is an area over which significant ecological effects of road extend outward from a road (Forman & Deblinger, 2000). The zone is created to integrate the various land use types, habitat, and resources on each side of the road that may prospectively be affected by road (Eigenbrod *et al.*, 2009). There are reviews and reports on road impacts on vegetation (Spellerberg, 1998; Forman & Alexander, 1998; Seiler *et al.*, 2004; Forman, 1995; Ahmed *et al.*, 2009). Despite this available literature, it becomes increasingly apparent that an improved understanding of the road impacts on vegetation for improved assessment and prediction is required.

Although there are existing methods, the present study aimed at improving methods to provide better insight on the extent to which these road networks affect vegetation using Geographic Information System GIS and Remote Sensing. The study was designed to assess the impact of road networks on vegetation cover and condition. As a result of road transport being the most common transportation, impact emanating from road network was investigated in relation to roadside vegetation along roads in the study area. The results from this study were intended to assist in informing decision makers, policy makers and conservationists, about the extent of the impacts

brought about by road network to natural vegetation. GIS and Remote Sensing techniques were utilized in this study because they have capabilities to map and assess the road-effect zone of the roads to determine the areas and resources that are impacted on by the road effects. The advantage of using these methods is that the systems are also able to acquire information from inaccessible areas.

The use of GIS and Remote Sensing techniques have become a popular approach in assessing and quantifying vegetation condition (Diouf & Lambin, 2001; Manyashi, 2015; Nauwanga, 2009; Kakembo & Ndou, 2017). The health of vegetation is dependent on the leaf nitrogen concentrations, plant nutrient, leaf water content and leaf pigments such as chlorophyll concentration (Nauwanga, 2009). These factors like leaf properties can be used as indicators to determine the stress of vegetation. Stress conditions of vegetation result in a change of the plant's reflectance spectrum, therefore stressed vegetation can be identified on the basis of specific spectral responses (Manyashi, 2015). Several vegetation indices have been proposed for vegetation condition detection. A vegetation index is an indicator that describes the greenness, the relative density and health of vegetation for each picture element, or pixel, in a satellite image (Huete *et al.*, 2002). Scientists transform raw satellite data into vegetation indices using mathematical formulas (algorithms), based on the sharp rise in reflectance of green vegetation between 670 and 780 nm (Baret & Guyot, 1991). This gives researchers an advantage to create images and other products that give a rough measure of vegetation type, amount, and condition on land surfaces around the world (Gitelson *et al.*, 1996).

1.2 Problem statement

Several roads exist in the Zeerust town of South Africa and its surroundings that connect different villages. Some of the roads in this area are unofficial and not registered in the South African roads database, while others exist in the database. This poses a challenge for policy makers and conservationists, who may be interested in spatial information on current and future roads, in order to evaluate their prospective impacts and make informed decisions. Understanding this road-ecology interaction will help to develop appropriate mechanisms for preserving local ecology along road networks. Against this background, the current study was set to investigate the impacts of road networks on vegetation condition in this area. The results of this study were thus meant to provide better insight on the extent to which these unregistered roads affect natural vegetation, and the information is important to policy makers and conservationists. Human development influences an increase in the number of roads to achieve transportation needs. Whereas road network plays a significant role in socio-economic development, a closer look at this reveals its effects on local ecology. Road network cover a substantial area of land directly, thus causing disturbances and changes to the natural environment, altering the surrounding habitats by influencing the quality and

sustainability for plant growth. Impact of roads on plant communities include changes in species composition eg transforming native vegetation into non-native vegetation. Roads pose a particularly challenging problem to those interested in biodiversity conservation in developing countries. Studying the ecological impacts of roads is an important area of research because the impacts often extend far beyond the surface of the road itself.

1.3 General hypothesis

The amount and condition of roadside vegetation could be explained by road network conditions.

1.4 Main aim of the study

The main aim of this study was to analyze the impact of road networks on roadside vegetation cover density.

1.5 Specific Objectives

The following objectives were formulated in order to achieve the main purpose of the study:

- To map and classify the road network in the town of Zeerust, South Africa
- To characterize road-side natural vegetation condition of this town
- To assess the impact of road networks on vegetation cover and condition of the selected area

1.6 Significance of the study

Roads exist in different shapes and sizes, each with its own different potential impact. Roads cause destruction or alteration of habitats due to construction disturbance of the habitats along the road. This study was designed to provide a significant background in understanding the impact brought about by road network to the natural environment. This study aimed at filling the gap in understanding ecological impacts of road networks using GIS and remote sensing applications; to help reduce the environmental impact of roads. This study would also be beneficial to the road authorities of South Africa in their strategic plans for road maintenance and construction; and to the environmental conservationists, as they require the environment to be used in a way that is sustainable. The study was also anticipated to provide baseline knowledge regarding roadside vegetation and would be helpful in future for conservation of biodiversity along the road verges and improvements of road verges.

1.7 Chapter Outline

1.7.1 Chapter 1: Introduction

In this chapter, research background is provided, highlighting the impact of road networks on vegetation. A general perspective of roads impacts on natural vegetation is provided. The research problem, aim of the study, specific objectives, general hypothesis and significance of the study are

provided.

1.7.2 Chapter 2: Description of the study area

This chapter provides background to the study area's physical environment. The aspects pertaining to the location of the area, including vegetation types, climate and topography, geology soil, elevation, slope, aspect and land use.

1.7.3 Chapter 3: Literature review

This chapter reviews previous work done in relation to the impact of road networks on vegetation. Literature on effects of road network on vegetation cover condition is also reviewed in this chapter. GIS and remote sensing methods for road network and vegetation cover condition mapping are also discussed. Statistical methods applicable in determining the relationship between road network and vegetation condition are also discussed.

1.7.4 Chapter 4: Research methodology

This chapter outlines the description of the methods used to achieve the aim and set of objectives. Image pre-processing, NDVI, image classification, accuracy assessment and the image buffer technique used are explained. Statistical techniques used to analyze vegetation conditions are also described.

1.7.5 Chapter 5: Results

This chapter provides the results obtained in this study. An analysis of vegetation condition is presented in the form of maps. The relationship between road network and vegetation is presented in the form of statistical numbers.

1.7.6 Chapter 6: Discussion and Conclusion

In this chapter, an interpretation of the results for the study is provided. The effectiveness and shortfalls of the techniques and methods employed to determine the impact of road network on vegetation as revealed by multinomial logistic regression are also provided in this chapter. Recommendations, directions for future research and an overall conclusion are presented.

The subsequent chapter (Chapter 2) provides the background of the study area.

CHAPTER 2

DESCRIPTION OF THE STUDY AREA

2.1 Introduction

This chapter describes the study area and highlights characteristics of the study area, which are important to the study. In further understanding the study area, a description of vegetation types underlying the geology of the area and the major soil types of the study area are highlighted. Other aspects pertaining to the location of the area include climate, slope, aspect and elevation.

2.2 Background information and location

The study area is situated in the Ngaka Modiri Molema district of the North West Province, South Africa. The study area lies in the Marico valley, a low area between hills, with Marico River running through it (Malan & Van Niekerk, 2005). The Zeerust town and its neighbouring villages which are the focus of this study lie in the geographical coordinates of 25° 32' 0" South, 26° 5' 0" East. The neighbouring villages include Ntsweletsoku, Gopane, Mantsie and Dinokana, and the whole study area covers a geographical area of approximately 908 square kilometers.

Zeerust town is a commercial hub for most of the villages situated around the area. Available road network facilitates for the movement of people, despite the fact that road travel has a broad variety of effects on vegetation cover (Donaldson & Bennett, 2004). The study area is dominated by Bankenveld, Mixed Bushveld and Sourish Mixed Bushveld vegetation types. The town provides two exit road routes to Botswana, with N4 being the main road link between South Africa and Botswana (Adata, 2011). The types of road networks found in the study area include minor roads, collector roads and local roads. Figure 2. 1 shows the road network and vegetation cover in the area of study.

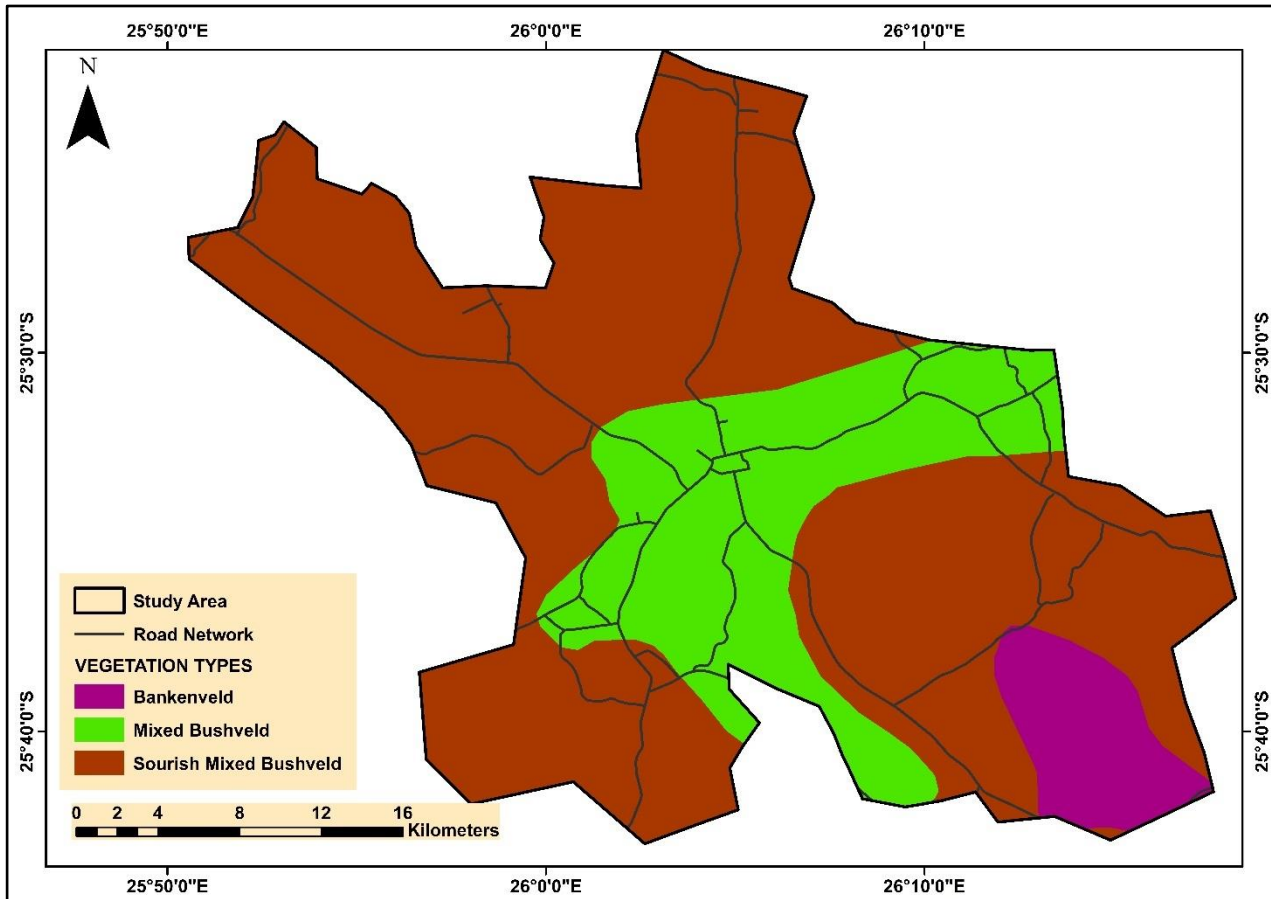


Figure 2. 1: Road network and vegetation cover in the area of study.

2.3 Vegetation type

The study presents a variety of vegetation types shown in Figure 2. 2. The study area is characterised by three vegetation types namely, the Bankenveld, Mixed Bushveld and Sourish Mixed Bushveld (Figure 2. 2). The Bankenveld vegetation is found in the south-eastern part of the area. It consists of a great variety of grassland and bushveld communities, distributed in a mosaic pattern (Bredenkamp *et al.*, 2003). The Mixed bushveld is found in the central part of the study area. Bushveld vegetation consists of a mixture of trees and shrubs of varying height, together with grasses and forbs (Coetzee *et al.*, 1977). It includes a mixture of Bushveld and open Savanna Bankenveld, from dense, short bushveld to open tree Savannah. The Mixed Bushveld occurs at the northern side of the study area (Acocks, 1988). According to Schmidt *et al.*, (2002), the Mixed Bushveld occurs on undulating to rugged terrain, soils are mostly coarse, sandy and shallow, overlying quartzite, granite, sandstone or shale. The different vegetation types in the study area are due to variation in topography, geology, soil composition and climate (Mkhosi, 2003).

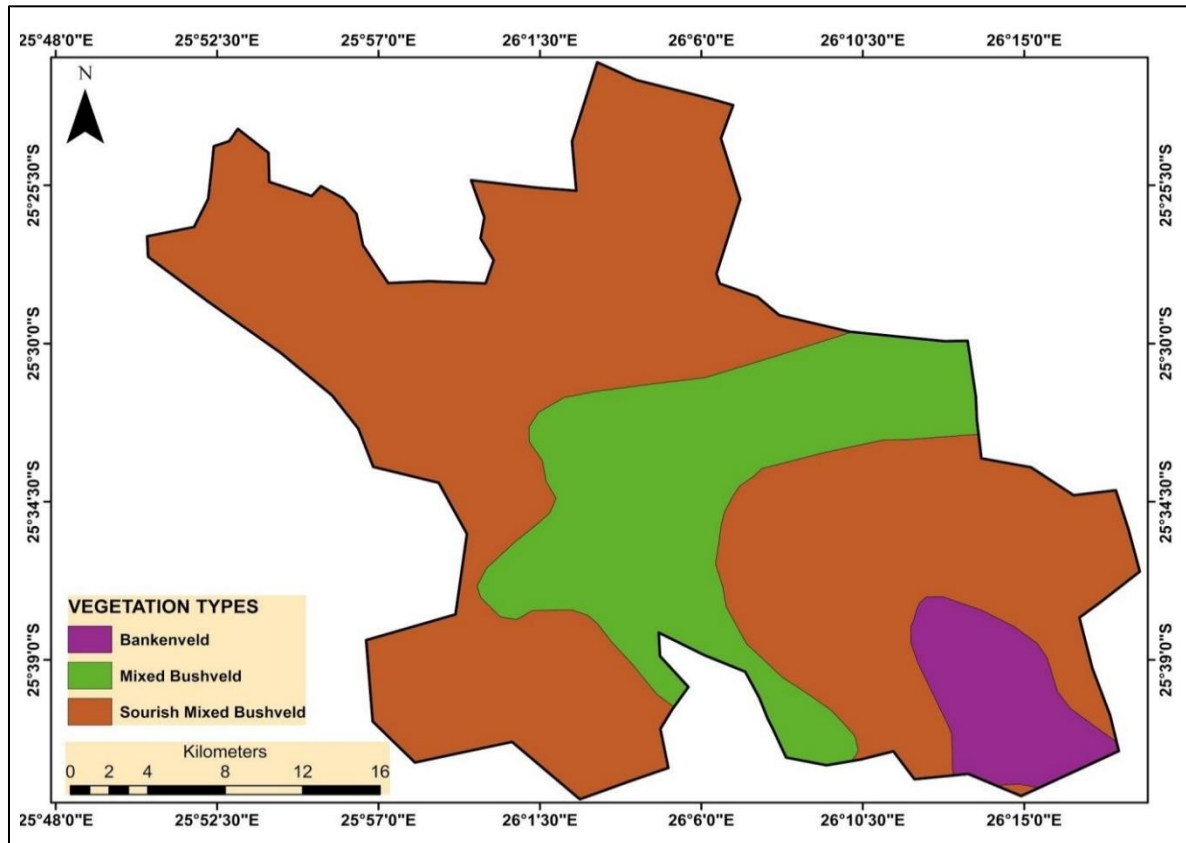


Figure 2. 2: Vegetation types found in the study area (Data source: Acocks, 1988)

2.4 Climate and topography

Climate plays an important role in determining the availability of water resources, the nature of the natural landscape and vegetation types (Walmsley & Walmsley, 2002). The climate of the study area is characterised by well-defined seasons: hot summers and cool sunny winters (Spickett *et al.*, 2011). According to Malan and Van Niekerk (2005), temperatures in the area vary from 9°C in winter to 40°C in summer. The study area consists of only two ecological regions namely, the Highveld and Western Bankenveld. The Western Bankenveld has a complex topography that varies from lowlands, hills and mountains, with the relief varying from moderate to high (Kleynhans *et al.*, 2005). The Mixed Bushveld is the most definitive vegetation type of the region. Highveld, the high lying region is characterized by plains with a moderate to low relief (Kleynhans *et al.*, 2005). These ecological regions can have implications on vegetation conditions, thereby redirecting soil water availability, influencing the distribution of other edaphic properties such as base saturation, soil temperature, and particle size distribution (Franzmeier *et al.*, 1969). Figure 2. 3 shows the ecological regions of the study area.

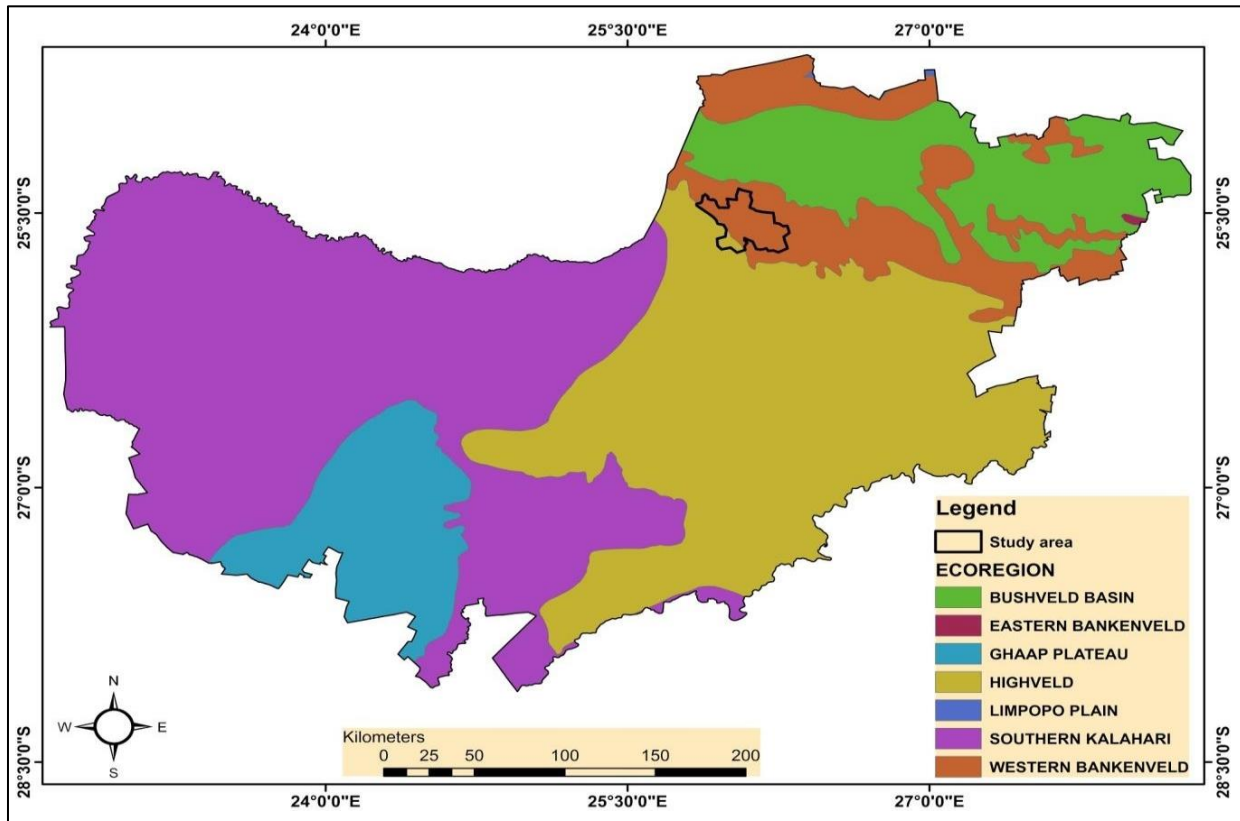


Figure 2. 3: Ecoregion of the study area

2.4.1 Elevation

The elevation surface of the study area was generated from the Aster DEM and was found to range from < 97.4 to > 584.4 meters above sea level (asl.). Elevation plays a role in the health and growth of vegetation. According to Jin *et al.* (2008), elevation is a topographic factor that controls the distribution and patterns of vegetation in mountainous areas. Elevation may affect the type and amount of sunlight that plants receive, the amount of water that plants can absorb and the nutrients that are available in the soil (Mata-González *et al.*, 2002). High elevated areas have unique vegetation patterns different from those on surrounding lowlands (Mata-González *et al.*, 2002). Munger (2007) investigated the influence of elevation on vegetation and found that areas with the highest elevation were found to have relatively low NDVI values while areas with low elevations were ascertained to have high mean NDVI values and the greenest vegetation. Soil moisture content varies with elevation; higher elevations generally have lower soil moisture, while lower elevations generally have higher soil moisture (Jin *et al.*, 2008). This is because water flows downhill due to gravity. The DEM was manually classified to emphasize a particular range of values. The resulted elevation map was a standard classification of elevation values. A manual assignment of classes was useful for isolating and highlighting ranges of data. Figure 2. 4 shows the elevation distribution in the study area.

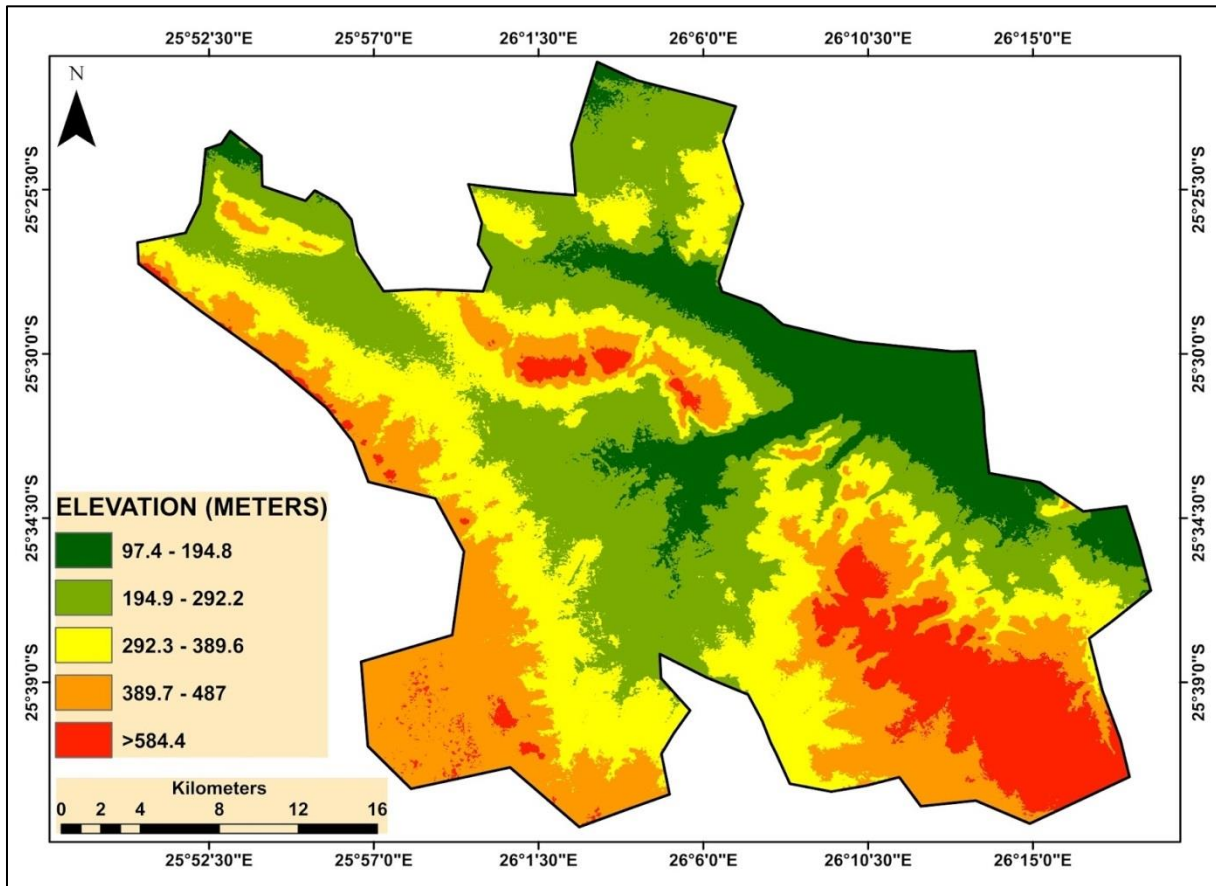


Figure 2. 4: Elevation map of the study area

2.4.2 Slope

A large part of the study area lies on the gentle slope. The steepness of a slope affects vegetation growth through differential incidence of solar radiation, wind velocity and soil type (Bliss, 1956). A steep slope is prone to surface runoff and soil erosion, which causes soil degradation that in turn, affects vegetation growth (Lal, 2001). The slope surface of the study area was calculated from DEM and was classified into five categories in ArcGIS. Slope tool was run on an elevation database. It was found that the slope surface ranges from <9.88 (gentle slope) to >49.4 (steep slope). Planar method was used for slope computation; here the slope is measured as the maximum rate of change in value from a cell to its immediate neighbours. The computation of slope requires at least seven cells neighbouring the processing cell and should have valid values. Figure 2. 5 illustrates the slope characteristics of the study area.

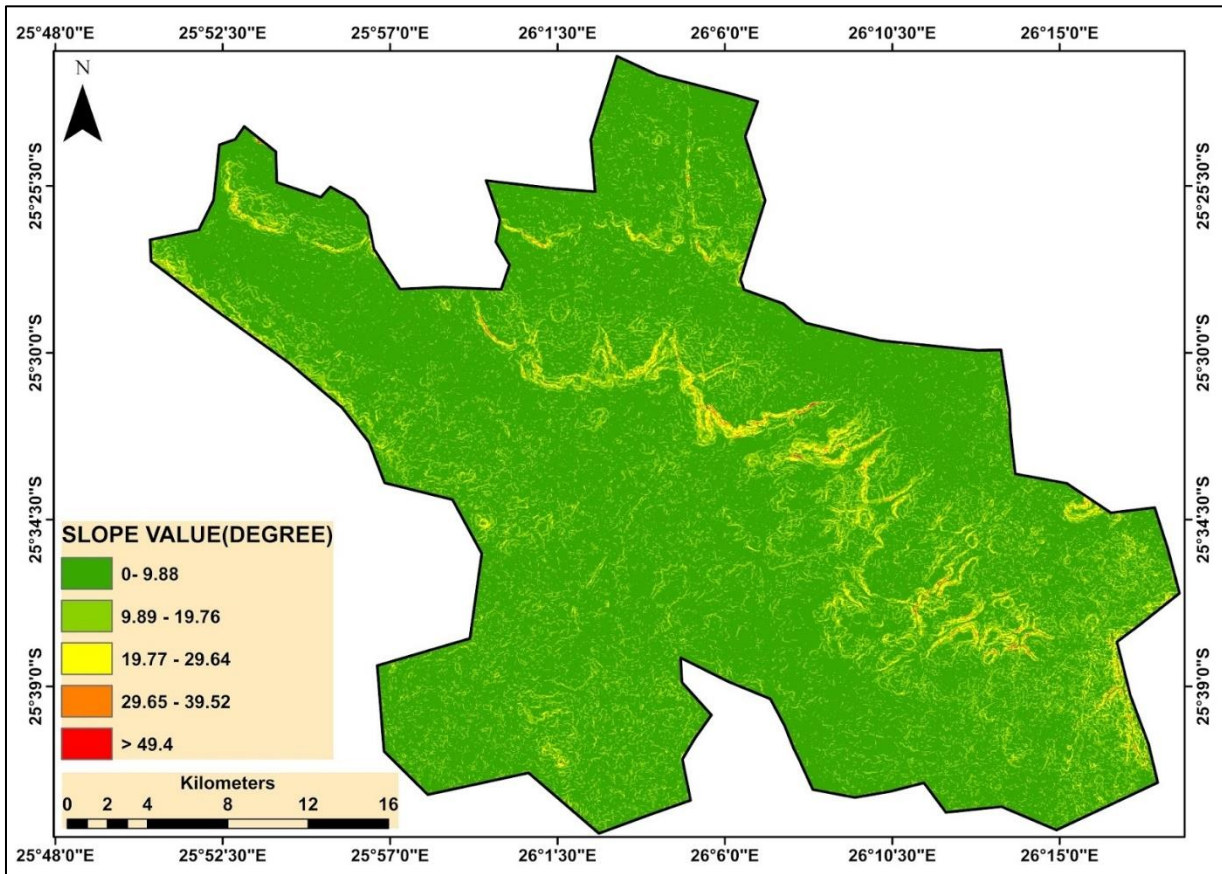


Figure 2. 5: Slope of the study area

2.4.3 Aspect

The slope aspect of the study area was another topographic attribute of the study area calculated from DEM. It was found that the study location is dominated by the north east facing slope. According to Holland & Steyn (1975), in the northern hemisphere, the south-facing slopes get more solar energy than the north-facing slopes and are consequently defined by lower water availability; that is why the south-facing slopes in the northern hemisphere have the highest proportion of vegetation than north-facing slopes in the same hemisphere. The reverse is true for the southern hemisphere. Jin *et al.* (2008) ascertained that vegetation growth in the Qilian mountain areas is principally affected by aspect. The impact of aspect on vegetation growth was found to be significant in the altitudinal zone of 3200 m and 3600 m (Jin *et al.*, 2008). Figure 2. 6 illustrates the aspect characteristics of the study area.

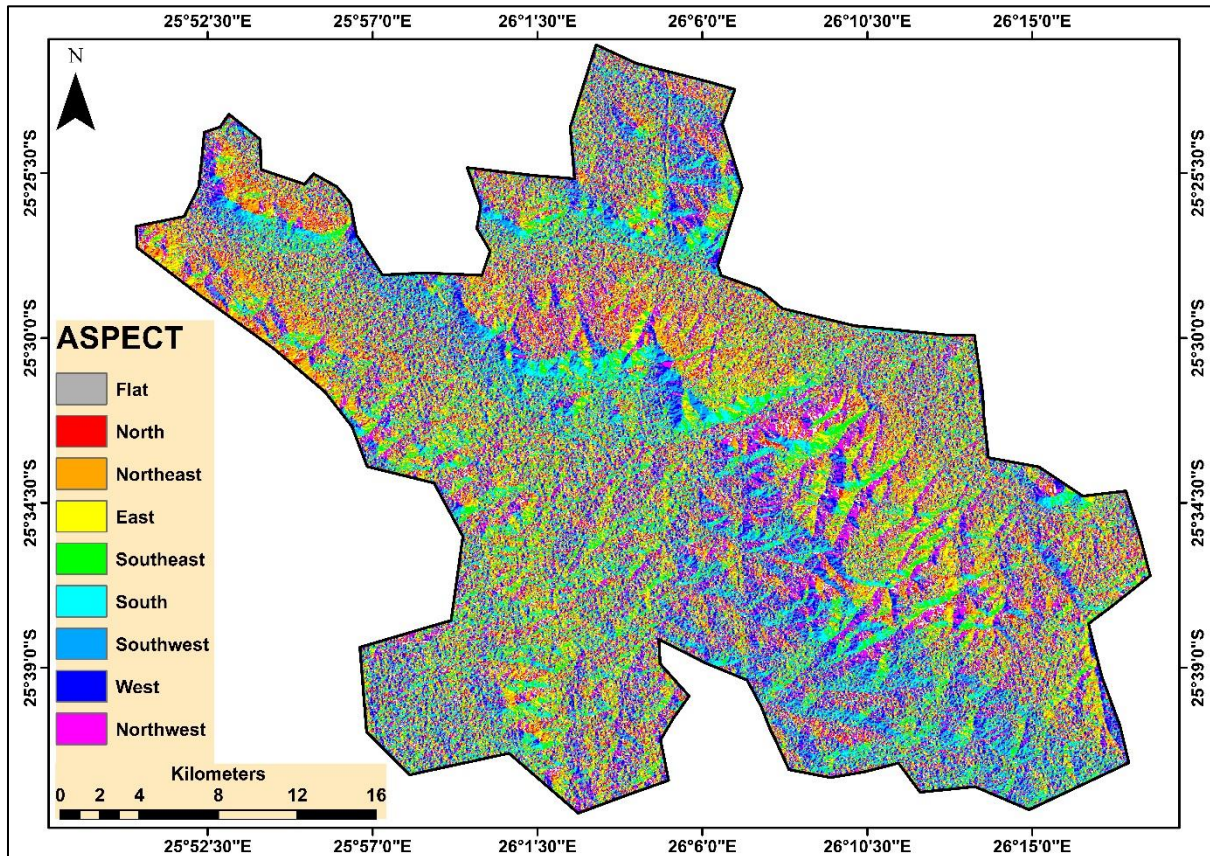


Figure 2. 6: Aspect map of the study area

2.5 Geology

Most of the geological formations of the North West province are of the Archaean and Proterozoic origin (Cornerlius & Hurlburt, 1976). The various geology types encountered in the study site area are the: Pretoria group, Malmani subgroup, Penge and Yaalian, with minor Daspoort and Silverton. The Penge and Malamani subgroups constitute the Chuniespoort group (Walraven, 1995). The bedrock underlying the study area consists of the Dolomite, Subordinate Chert, Minor Carbonaceous Shale, Limestone and Quartzite of the Malmani subgroup, and the Penge consists of iron formation. The Pretoria group with the formations of Daspoort and Silverton, consists of Shale, Quartzite, Conglomerate, Breccia, Diamictite (Walraven, 1995). The minor formations Daspoort and Silverton consist of Quartzite with minor shale and siltstone, while the Vaalian formation consists of Diabase.

The Pretoria group underlies the large part of the study area, the bedrock consisting of quartzite, which implies not only a high degree of hardness, but also a high level of quartz content. Quartzite generally comprises greater than 90% quartz (Hirth *et al.*, 2001). As the quartz content increases, the potential fertility and water holding capacity of the soil generally decline (Jones & Graham, 1993). The part of the study area, belonging to the Malmani subgroup, has little running water and the area contains large dry flats, with low water-holding capacity. For instance, the Dolomite is a

common hard rock-forming mineral. It is a calcium-magnesium carbonate with a chemical composition of $\text{CaMg}(\text{CO}_3)_2$. Figure 2. 7 is a map showing the geology of the study area.

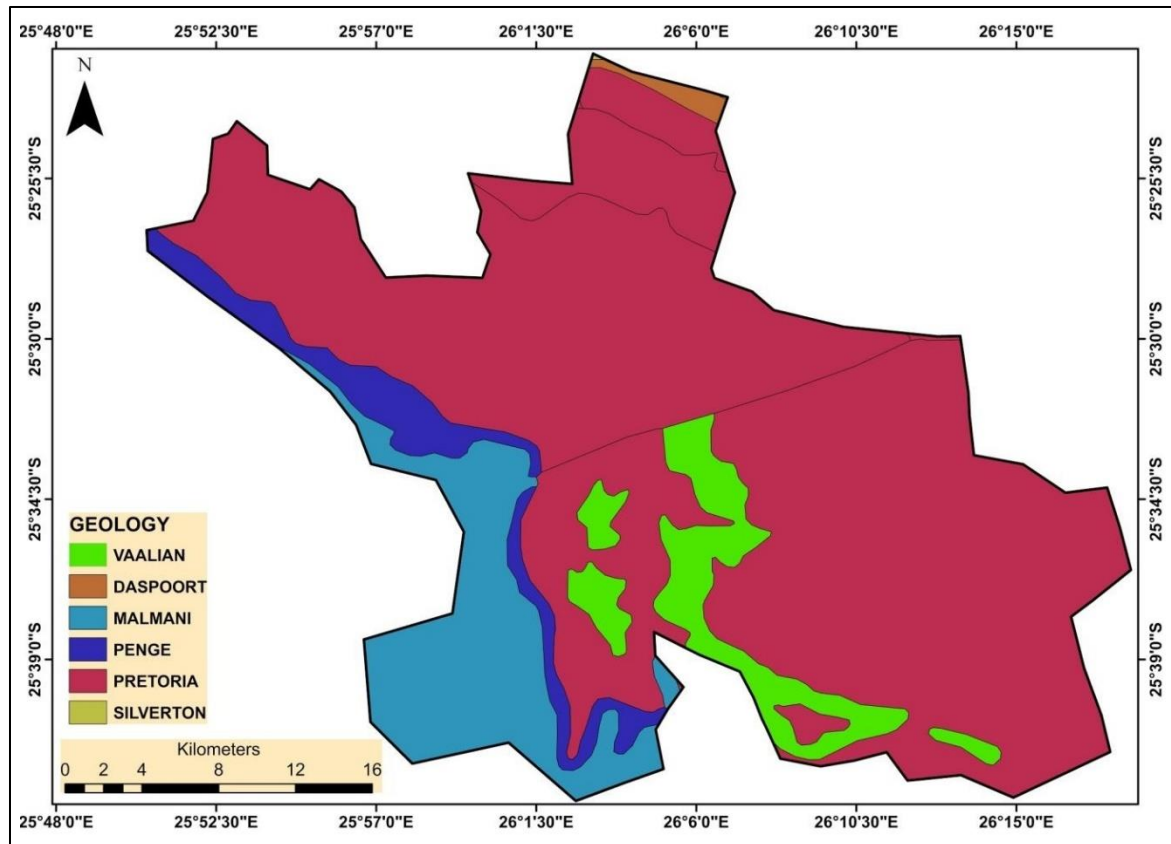


Figure 2. 7: Geology map of the study area

2.6 Soils

Soils are dynamic in nature and are constantly evolving and degrading by means of natural and man induced processes (Islam & Weil, 2000). According to Tromp-van Meerveld and McDonnell (2006), soil types are closely linked to the prevalent topography, geology and climate of the area. The nutrients and moisture in the soil are affected by both elevation and location. The study area is characterised by the Haplic Acrisol, Plinthic Acrisol, Petric Calcisol, Lithic Leptosol, Ferric Luvisol, Haplic Lixisol and Rhodic Nitisol soil types, signifying variations in the nutrient amounts available in the soils. Figure 2. 8 shows the soils of the study area. According to Munyati and Moeng (2015), Haplic Lixisols are strongly weathered soils with poor to very poor plant nutrient status. Luvisols and the nitisols on the other hand, are moderately to strongly weathered soils (Láng *et al.*, 2016). Luvisols have high nutrient content and good drainage; this makes them suitable for a wide range of agriculture (Saggar *et al.*, 2001). Nitisol are well-drained soils with a clayey subsurface horizon, they have a good soil structure, good porosity and good water holding capacity (Creutzberg, 1986). This soil type is among the most productive soils.

Acrisol is a type of soil classified by the Food and Agriculture Organization, and in the study area, there is Haplic and Plinthic Acrisol. They have poor chemical property levels of plant nutrients and have little weatherable minerals left (Láng *et al.*, 2016). The Acrisols are associated with nitisols; and they tend to be deep red or dark red in colour and are well-drained soils with a clayey subsurface horizon (Klamt & Van Reeuwijk, 2000). Lixisols develop on old landscapes in a tropical climate with a pronounced dry season (Oorts *et al.*, 2000). Their age and mineralogy have led to low levels of plant nutrients and a high erodibility (Oorts *et al.*, 2000). The natural vegetation of most Lixisols in the tropical and subtropical regions is savannah and open woodland (Driessen *et al.*, 2000). The Calcisols is that of soils in which accumulation of calcium carbonate is or has been the most dominant soil forming process (Driessen *et al.*, 2000).

According to Driessen *et al.* (2000), Calcisols soils are mostly related to arid and semi-arid environments, they usually carry sparse vegetation. Calcisols soils are well-drained soils with fine to medium texture, and they are relatively fertile because of their high calcium content. Leptosols are soils, which either are limited in depth by continuous hard rock within 30 cm of the soil surface, or contain or overlie within the same depth material with very high calcium carbonate content, or are very gravely throughout (Oehl *et al.*, 2010). Most Leptosols are under natural vegetation, being susceptible to erosion, desiccation, or waterlogging, depending on climate and topography (Casermeiro, 2004).

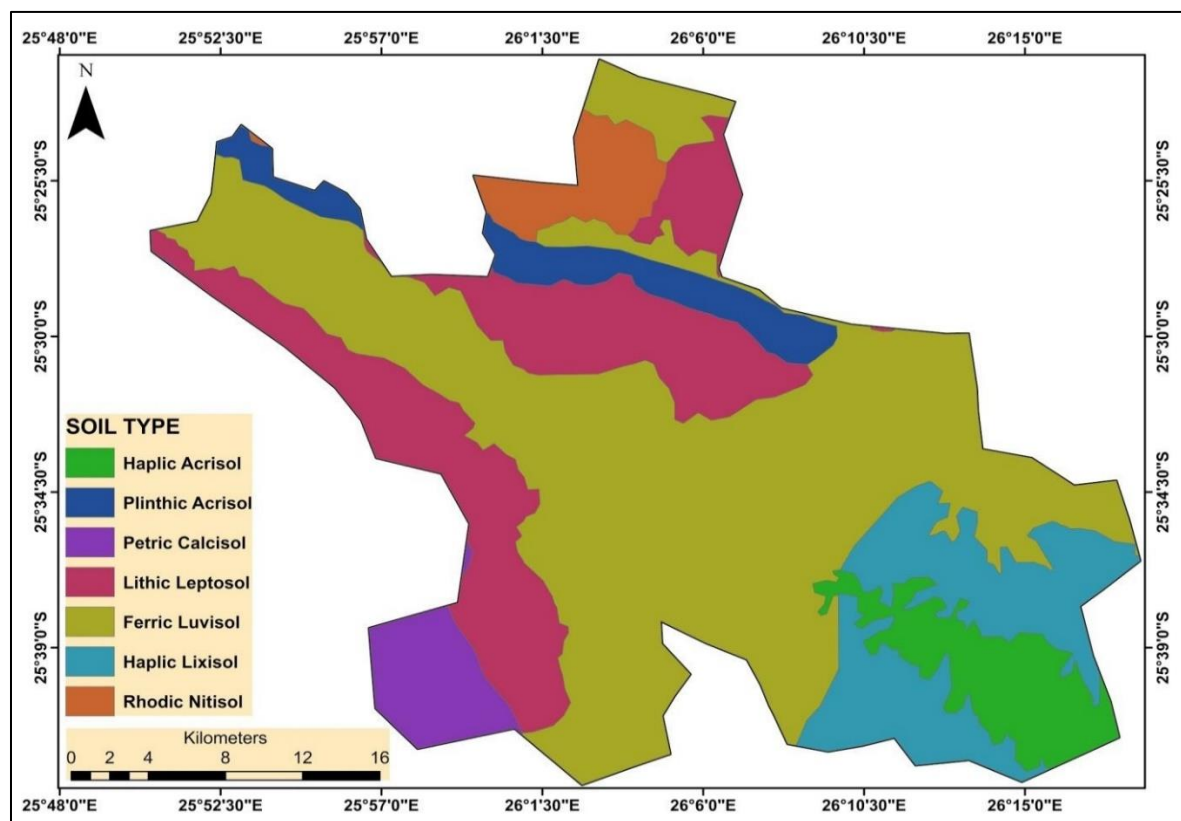


Figure 2. 8: Soils of the study area

2.7 Land use

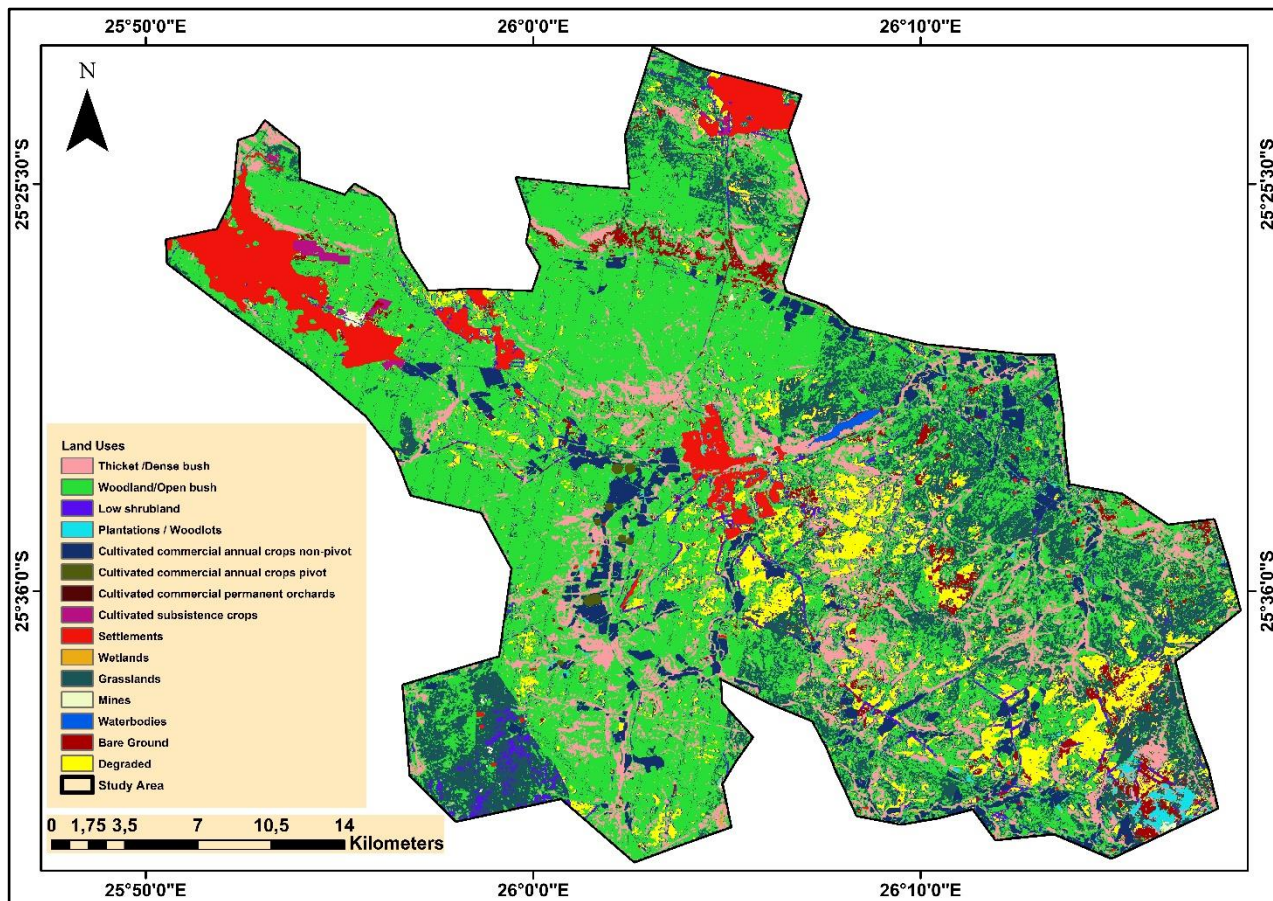


Figure 2.7: Land use cover in the study area

The largest land use practices in the study area include cattle rearing, cultivation of crops, game farming and ecotourism etc (Malan & Van Niekerk, 2005). The 2013-2014 South African National land use cover shapefiles were downloaded from the South African National Biodiversity Institute (SANBI) and used to generate the land use cover map in the study area. Farming activities are mostly dominated by white commercial farmers. In some case, mixed farming system practice is carried out whereby farmers would rear cattle alongside the cultivation of perishable vegetables (Nde, 2015). The surrounding area is bordered by human settlements around town.

The subsequent chapter provides a review of literature pertaining to the current study.

CHAPTER 3

LITERATURE REVIEW

3.1 Introduction

This chapter reviews previous work done in relation to the impact of road networks on vegetation by recognized researchers from global to local scale. The significance of road networks and vegetation are also discussed in this chapter. Literature on effects of road networks on vegetation cover condition is also reviewed in this chapter. GIS and remote sensing methods for road network and vegetation cover condition mapping are also discussed. Statistical methods applicable in determining the relationship between road network and vegetation condition are also discussed.

3.2 Significance of vegetation

Natural vegetation provides habitat for many threatened and endangered species, and it is for the most part helpful, in the environment (Al-Ahmadi & Hames, 2009). The presence and beauty aspects of vegetation are regularly utilized as an argument for preservation; reason behind why biodiversity is continuing to decrease internationally (Pearson, 2016). Vegetation is a key segment of a biological system and, all things considered, is associated with the control of different biogeochemical cycles, e.g., water, carbon, nitrogen (Foley *et al.*, 2000). Cowling *et al.*, (2004) describes vegetation as a group of plants forming the plant cover of a geographic area. Vegetation is of extraordinary scientific significance as it gives verifiable historical records of the combined effects of natural processes and land use (Davis, 1982).

It is also important for controlling erosion by protecting soils and river banks, this provides habitat for a wealth of unique biodiversity (including threatened species), reduces land degradation and salinity, and also improves water quality and availability (Al-Ahmadi & Hames, 2009). Vegetation provides a base for all living organisms and plays an important role in storing significant amount of carbon, mitigating the effects of climate change through evapotranspiration and albedo (Al-Ahmadi & Hames, 2009). Foley *et al.* (2000) has noticed the significance of vegetation cover as an intelligent piece of the atmosphere framework. Vegetation can be effortlessly depicted and mapped, and accordingly, can be utilized to: screen changes in cover, composition, and structure because of characteristic or human-impacted instances (Hermy *et al.*, 2007). As indicated by Hermy *et al.* (2007), for protection of vegetation to be effective, these four imperative advances are expected to keep up plant populaces in the long term and also to achieve habitat management goals.

3.3 Significance of road networks

Road networks comprise of huge number of interlinked streets displaying many patterns ranging from star-like to grid-like, with irregular patterns being recognized (Zhang & GIS Center Lund

College, 2004). The development of road networks plays an essential part in the economic development of a nation and, along these lines, the kilometre-age of paved roads existing in a country is often utilized as an index to evaluate the degree of its development (Jenelius, 2010). The expansion of road networks not only reduces the cost of transportation, both in terms of money and time, but also assists in the integration of various regions within the country and the better understanding of neighbouring countries at the international level (Nakanyala *et al.*, 2015). Road networking and transportation contribute to the development of a country by bringing in direct benefits from its role in the development of some sectors, such as agriculture, industry and commerce (Aldagheiri, 2009). Road infrastructure, as one of the economic sectors, contributes to poverty reduction of a country, because it involves massive aid-financed projects in roads within the country (Karani, 2007.). In addition, road networking plays an important role in increasing production, increasing employment and by enhancing mobility, taking people out of isolation and therefore, poverty (Aldagheiri, 2009). Roads are transport corridors imposed on landscapes by humans for the movement of people, livestock and materials.

Road networks facilitate movement of goods and services in all sectors of the economy including: tourism, education, health and agriculture among others; now it can be concluded as a fact that roads play a key role in the socioeconomic development of every country (Prideaux, 2000). Joutsensaari (1996) studied the effects of road improvements on transport costs by assigning the current product volumes of a Finnish brewing industry (about 650 million litres) onto the road network of the years 1970 and 1995. According to Joutsensaari (1996), the transport costs of brewing industry have decreased by approximately 50% due to the improvements of main road network. On the other hand, a study by Derekenaris *et al.* (2001), found out that road networks are important as they offer solutions to the problem of ambulance management and emergency incident handling. Road networks together with GIS, accomplish an effective routing and distribution system of ambulances, this aspect has helped so much by minimizing their response times and thus improving the way in which emergency incidents are being handled (Derekenaris *et al.*, 2001).

3.4 A review of the concept vegetation condition

In the literature there are some differences among researchers in defining the term ‘vegetation condition. In some studies, it is called biodiversity (Gillespie *et al.* 2008), ecological integrity (Carignan & Villard, 2002), or vegetation integrity (Stapanian *et al.* 2013). Vegetation condition of a region is usually defined as its deviation from a regional untouched, “original” or benchmark state for each specific vegetation type (Zhang *et al.* 2016). Harwood *et al.* (2016) stated that the concept of condition differs depending on the various interpretation. Therefore, condition is defined as an amount of the dissimilarity among two sets of dynamic states: one resultant from the natural process

and the other made by human activities, in this study human activities will be the road network. In this study the vegetation condition is defined in two states good condition which refers to a healthy green vegetation and degraded condition that refers to a poor condition of the natural vegetation observed. Naturalness of vegetation can be considered as equating to vegetation condition (Dillion *et al.* 2011). Vegetation changes over time are important indicators of condition and are particularly important as targets or triggers for management.

3.5 Monitoring vegetation condition

Monitoring is important in determining the extent and cause of changes in vegetation, such as changes in species composition and diversity, incursion of threats, change in vegetation cover, stress or overall changes in condition of vegetation communities (Newell *et al.*, 2006). Monitoring involves assessing changes in composition, structure and condition over time (vegetation dynamics), which also allows an analysis of the process that influence that change (Block *et al.*, 2001). Lawley *et al.* (2016) reviewed methods to monitor indicators of vegetation in Australia, using site-based and remote sensing approaches. They have noted that the use of integrated approach is convenient for the purpose of evidence-based decision making (Lawley *et al.*, 2016). Native vegetation can be an accurate indicator of local and regional geo-logic conditions (Solomon & Rock, 1985).

Monitoring vegetation requires repeated measurements, usually of the same sample units, to measure change or trend (Block *et al.*, 2001). According to Godinez-Alvarez *et al.* (2009), ground based measurements for both a calibration and local monitoring of vegetation are also commonly used to monitor vegetation. Godinez-Alvarez *et al.* (2009) compared three commonly used vegetation monitoring methods, which include line-point intercept, grid-point intercept, and ocular estimates. It was learned that the line- and grid-point intercepts provided similar estimates of species richness, which were lower than those based on the ocular estimates (Godinez-Alvarez *et al.*, 2009).

3.6 The role of GIS in mapping road networks

Modern techniques introduced for mapping road network include Geographic Information System (GIS). Wuboy (1995), defined GIS as a computer-based information system that enables capture, modelling manipulation, retrieval, analysis and presentation of geographically referenced data. Ajayi *et al.* (2015), used GIS to map out and analyse the road pavement condition, nature of adjacent land use, notable crime zones and accident-prone areas within the study area. Obafemi *et al.* (2011), assessed the road network system of Trans-Amadi industrial layout using a GIS. The Topographical map of scale and Google Earth, 2010 version were the sources for the acquisition of the road network data. Both the topographical map and the imagery were geo-rectified in ArcGIS 9.2 and geographic data on roads and road junction were digitized (Obafemi *et al.*, 2011).

GIS is an advantageous approach to maintaining a coherent database for roads in a scientific and efficient manner (Obafemi *et al.*, 2011). Additionally, a proper analysis and mapping of road networks cannot be underestimated because this serves as a key to economic development in terms of *per-capita* income and expenditure of the community (Gutiérrez & Urbano, 1996). A road network database of an existing spatial distribution of roads and their possible links to the roads of different places can be created, and updated, using Remote Sensing and Geographic Information Systems (Onuigbo & Orisakwe, 2013). The traditional method of road monitoring is time-consuming and costly and requires much manpower and materials (Gutiérrez & Urbano, 1996). The traditional methods cannot keep up as more and more roads are built (Onuigbo & Orisakwe, 2013). It is, therefore, necessary to utilize modern methods and technologies to monitor our roads. Hence, the choice and option of GIS and Remote Sensing in road mapping and monitoring.

3.7 Roadside vegetation assessment and management

According to Rea (2003), vegetation management practices that are used within the transportation corridors are mainly aimed at minimising encroaching shrubs and tree growth in order to increase driver visibility and road safety. In some studies, the traditional uses of herbicides, along with mechanical means such as mowing, trimming, and grading, to manage vegetation along highways, have been used (Hill *et al.*, 2005). Potential temporal variability in roadside vegetation conditions has important implications on conservation management and the restoration of activities in agricultural landscapes, both in Australia and elsewhere (Spooner & Smallbone, 2009). According to Spooner & Smallbone (2009), agricultural development has resulted in the clearing of over 85% of native vegetation, and most patches of intact native vegetation occur along roadsides.

Roadside management to conservation has been recognized in Britain, the Netherlands, and Australia, where a broad range of roadside management practices incorporate ecological goals (Forman *et al.*, 2003; Way, 1977). According to Spooner and Smallbone, (2009), roadsides may be minimally prepared for the planting of vegetation following a large disturbance that removed the existing vegetation. More so and unlike agricultural fields, roadsides are neither disturbed by heavy equipment nor plowed regularly. Native plants are also important from a conservation point of view, as they can maintain the natural plant diversity (Knops *et al.*, 1995). Some native species may have allelopathic effects on invasive plants that can then reduce the cost of roadside vegetation management (Mallik, 1987).

3.8 Impacts of road networks on vegetation

Due to the human development increase, road transport has become increasingly common in the world; people rely on road networks for transportation purpose on a daily basis. Roads cover a substantial area of land directly. However, the environmental impact of roads on surrounding

landscapes extends its potential effects even further (Donaldson & Bennett, 2004). These effects can extent to roadside areas and alter the surrounding habitats by influencing the quality and suitability for plants growth (Donaldson & Bennett, 2004). Burnett (2001), outlined some benefits of roads, which include amenity for fire management, recreation, commodity extraction, public transportation, land and resource administration (e.g., research, monitoring) and traditional uses (e.g., plant collection). Despite the socio-economic benefits that roads bring to humans, they also result in negative impacts on the natural environment (Cater, 1995). Owing to their relatively large area, road networks have a significant effect on the natural environment (Forman & Alexander, 1998). An understanding of the relationship between roads and the natural vegetation is in principle, an area of multidisciplinary research and of great applicability (Freitas *et al.*, 2009). A comprehensive knowledge of this might serve as a tool for decision making in environmental and transportation planning (Freitas *et al.*, 2009).

Therefore, it is important to understand how roads may interact with the surrounding environments, creating new landscape mosaics, which also include the human occupied areas (Eliou & Kehagia, 2007). According to Eliou and Kehagia (2007), this may assist both in transportation and environmental planning. The benefits of understanding this interaction will also assist in the implementation of rules for sustainable development, and also minimise the impact of roads on the environment (Eliou & Kehagia, 2007). From an ecological perspective, transportation infrastructure brings about changes, not only causing local habitat loss, but also disturbances and changes in natural environment ("Roads: Their Environmental Impact/Environmentalscience.Org"). Several studies have recognised the effects of human disturbances, in the form of road construction, use and maintenance activities, on adjacent roadside vegetation (Angold, 1997; Freitas *et al.*, 2013; Lane, 1976; Liu *et al.*, 2011).

Destruction and modification of vegetation further affect animals *in-situ* (Irwin *et al.*, 2010). The impact of roads on plant communities includes changes in species composition, e.g. transforming native vegetation into vegetation dominated by non-native vegetation (Forman *et al.*, 2002). The exact effects of roads also depend onto the extent and type of the road network within an area (Laurance and Balmford, 2013). Daigle (2010) also noted that vegetation disturbance due to road networks further leads to degradation of soils and modified wildlife behaviour (such as changes to animal movement). **Figure 3. 1** demonstrates the roadside vegetation, disturbed and undisturbed.

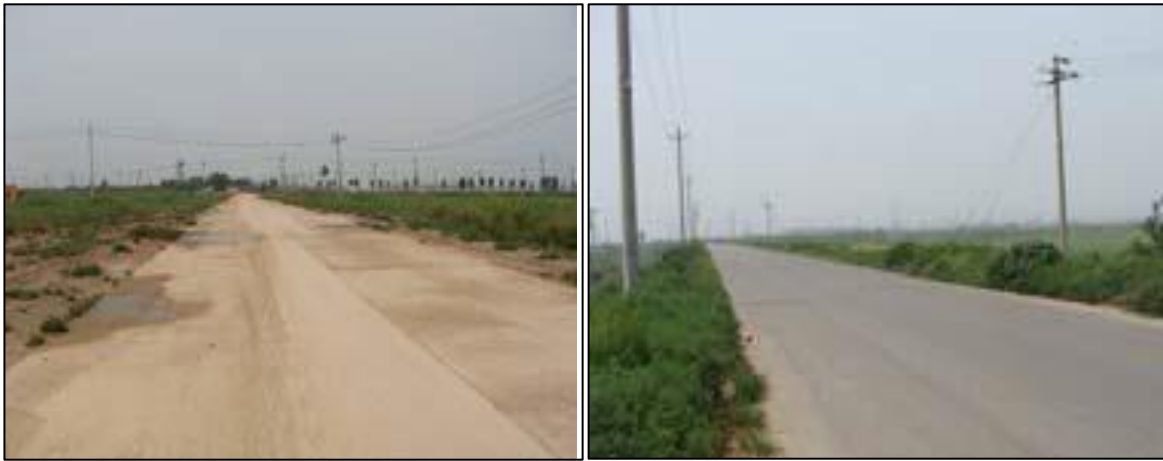


Figure 3. 1: Disturbed vs undisturbed roadside vegetation (Source: Yan *et al.*, 2012)

So far, most studies on the effects of road networks have focussed on high-traffic paved roads; most probably because their effects can be harmful and easily recognised (Angold 1997; Fakayode & Olu-Owolabi, 2003; Trombulak & Frissell, 2000). Liu *et al.*, (2011) assessed the influence of road network extension on vegetation pattern in Xishuangbanna, Yunnan Province, Southwest China. They found that the lower level roads had more effects on vegetation patches than the higher-level ones (Liu *et al.*, 2011). To examine the road network extension effect on vegetation pattern, roads were grouped into various combinations, according to road class. Similarly, Nakanyala *et al.* (2015) observed that the development and maintenance of roads have a long-term effect onto the development of the vegetation and soils. Spellerberg (1998) summarized road effects as those common during construction, along a newly completed road, and those with long-term impacts.

Angold (1997) also conducted the study to analyze the effect of a road upon a heathland vegetation in the New Forest of southern England. The study found that the extent of the edge effect in the heathland vegetation was closely correlated with the amount of traffic carried by the road, with a maximum edge effect of 200 meters adjacent to a dual road (Angold, 1997). The findings also show an increased growth of vascular, particularly grass species, and a decreased lichen abundance in the heathland vegetation within 200m of major roads (Angold, 1997). The enhanced growth of vascular plants was attributed to the increased nitrogen available in the roadside areas, and the eutrophication of these areas increased the competitive advantage of grass species (Angold, 1997). Road networks may also pose a threat on the effectiveness of natural reserves, thus, representing a critical conservation matter (Freitas *et al.*, 2013). In their study to evaluate the relationship between native vegetation cover and road distance at Neotropical landscape in the state of São Paulo, Brazil; Freitas *et al.* (2013) noted that threats related to the proximity of roads, i.e. logging, may reduce effectiveness of more than 50% of natural reserves.

According to Williams-Linera (1990), the changes in the structure and composition of vegetation communities at forest edges, reveal the altered abiotic conditions caused by the edge. This study concluded that these changes are primarily triggered by the removal of canopy vegetation, in so doing, altering the microclimatic conditions, by increasing solar radiation and decreasing relative humidity. Road networks are threatening the natural environment; the impacts being displaced species, deteriorating ecosystem, pollution, hydrological and erosion effects (Ahmed, 2014; Coffin, 2007; Forman & Alexander, 1998; Karani, 2007). According to Karani, (2007), rural areas are more vulnerable to ecological damage; Zeerust town, including its surrounding villages, is vulnerable to ecological damage, due to the lack of infrastructure and fragile ecosystems. Hence it is important to study the ecological impacts of roads in Conservation Biology and Environmental Science, as the impacts often extend far beyond the surface of the road itself (Coffin, 2007).

3.9 Validating remotely-sensed data by ground truth data

Remotely-sensed data are proxy to error, field surveys are essential to validate imagery details. Field survey is conducted, taking into consideration that vegetation is a dynamic feature. According to McCoy (2005), remote sensing personnel often select the “peak of green” period of the growing season, which is the summer season, to conduct field survey. This period may give the strongest vegetative response and provide good data. Field survey is conducted to evaluate each vegetation condition class in the imagery (Ndou, 2013). Observations are made to gather evidence regarding current condition of vegetation.

Vegetation field methods are based on two basic approaches: the line transect and the quadrat (Mcoy, 2005). For the purpose of this study, the quadrats analysis was preferred to the transect approach. Ground truthing refers to the collection and use of ground reference data about the area, object or phenomenon being studied by remote sensing (Famiglietti *et al.*, 1999). Ground truth data is necessary in order to improve the accuracy of image classification.

An accuracy assessment process is required to validate the classes. In the process of accuracy assessment, it is commonly assumed that the difference between an image classification result and the reference data is due to the classification error (Congalton & Green 1993). It is said to be “accurate” if the image classification corresponds closely with the given standard. Reymondin *et al.*, (2013) integrated field surveys and remote sensing data for monitoring Land-Use Change in Latin America.

It is important for one to know the sources of errors before implementing a classification accuracy assessment (Congalton & Green 1993). In addition to errors from the classification itself, other sources of errors, such as position errors, resulting from the registration, interpretation errors, and

poor quality of training or test samples; all affect the classification accuracy (Powell *et al.*, 2004). In order to provide a reliable report on classification accuracy, non-image classification errors should also be examined, especially when reference data are not obtained from a field survey (Lu & Weng, 2007). A classification accuracy assessment generally includes three basic components: sampling design, response design, and estimation and analysis procedures (Melgani *et al.*, 2004). Selection of a suitable sampling strategy is a critical step; and its major components include sampling unit (pixels or polygons), sampling design, and sample size (Lu & Weng, 2007).

In remote sensing, accuracy assessment is achieved by overlaying a reference image and a simulated image. The error matrix approach is the one most widely used in accuracy assessment (Foody, 2002). An error matrix measures the relationship between the image classification results and measured ground conditions. Accuracy assessment in remote sensing is achieved by using the error matrix (ERRMAT) method and the Kappa Index of Agreement (KIA). The Kappa coefficient is a measure of the overall statistical agreement of an error matrix, which takes non-diagonal elements into account. Kappa analysis is recognized as a powerful method for analysing a single error matrix and for comparing the differences between various error matrices (Lu & Weng, 2007). Modified kappa coefficient has been developed and improved as a measure of classification accuracy.

According to Congalton and Mead (1983), to properly generate an error matrix, one must consider these following factors: reference data collection, classification scheme, sampling scheme, spatial autocorrelation, and sample size and sample unit. Once the generation of an error matrix is completed, other important accuracy assessment elements, such as the overall accuracy, omission error, commission error, and kappa coefficient, can be derived. In summary, the error matrix approach is the most common accuracy assessment approach for categorical classes.

3.10 Statistical application for determining the degree of relationship among variables

Statistical methods play an important role when determining the relationship between variables. These methods define the degree of relationship between variables, significance of group differences, and prediction of group membership, structure, and questions that focus of the time course of events (Ndou, 2013). The relationship between road network and vegetation corridor is in no exception. Several scientists have used statistical applications to determine relationship between variables (e.g. Allen, 1974; Freitas *et al.*, 2009; Peng & So, 2002; Smith, 2012). Other statistical regression techniques capable of establishing the relationship between variable, include simple linear regression (Zou *et al.*, 2003) and the Pearson r correlation (Steel & Ovalle, 1984). Simple linear regression is the most commonly considered analysis method when examining the relationship between a quantitative outcome and a single quantitative explanatory variable (Chatterjee & Hadi, 2006). This simple linear regression is the process of fitting a straight line by

the method of least squares on a scatter plot to study the relationship between variables (Zou *et al.*, 2003). The intercept and the slope are referred to as the parameters and the statistical programme that finds the values of the parameters that provide the best fit of the regression line. Linear regression only looks at linear relationships between dependent and independent variables. That is, it assumes there is a straight-line relationship between them (Kamer-Ainur & Marioara, 2007), therefore, it was not suitable for use in this study.

Several statistical techniques capable of establishing the relationship between variables include simple linear regression, the *Chi*-squared test, and logistic regression analysis. The simple linear regression is the most commonly considered analysis method when examining the relationship between a quantitative outcome and a single quantitative explanatory variable (Chatterjee & Hadi, 2006). The simple linear regression is the process of fitting a straight line by the method of least squares on a scatter plot to study the relationship between variables (Findlay & Houlahan, 1997).

The *Chi*-squared (χ^2) test of independence is used to test for a statistically significant relationship between two categorical variables (Anon, 2017). This is an inferential test that uses data from a sample to make conclusions about the relationship between categorical variables in the population (Statistics Solutions, 2017). This approach involves the construction of test statistics for hypotheses involving functions of the observed proportions, which are directed at the relationships under investigation and the estimation of corresponding model parameters via the weighted least squares computations (Landis *et al.* 1976). According to Schermelleh-Engel *et al.*, (2003), this technique does not provide the most efficient estimate of the test. In cases where a relationship is to be determined between the categorical and predictor variables, the logistic regression is better suited (Ndou, 2013). The logistic regression takes into consideration the fact that the dependent variable is categorical and variables are dichotomous (Press & Wilson, 1978). The technique is most useful for understanding the influence of several independent variables on a single dichotomous outcome variable (Press & Wilson, 1978).

The Pearson *r* correlation is widely used in statistics to measure the degree of the relationship between linear related variables (Steel & Ovalle, 1984). This technique is not suitable with categorical data (Freitas *et al.*, 2009). The Pearson correlation evaluates the linear relationship between two continuous variables (Steel & Ovalle, 1984). A relationship is linear when a change in one variable is associated with a proportional change in the other variable correlation is a bivariate analysis that measures the strengths of association between +1 and -1 (Dembroski *et al.*, 1985). When the values of the correlation coefficient lies around +1, then it is said to be a perfect degree of association between the two variables, whereas if the correlation coefficient value goes towards

0, the relationship between the two variables will be weaker; and -1 indicates a perfect negative relationship.

Multinomial logistic regression (also referred to as polychotomous logistic regression) is frequently used for the analysis of categorical response data (having more than two categories) with continuous or categorical explanatory variables (Hedeker, 2003). It is known to be an extension of the logistic regression, which analyzes dichotomous (binary) variables (Starkweather & Moske, 2011). If observations are independent, the multinomial or polychotomous logistic regression model can be used to assess the influence of explanatory variables on the nominal response variable (Hsieh *et al.*, 1998). The multinomial logistic regression technique is preferred because of the overall superiority of the results (Bayaga, 2010). Additionally, the multinomial logistic regression exists to handle the case of dependents with more classes; this is referred to as the multivariate case (Bayaga, 2010).

CHAPTER 4

RESEARCH METHODOLOGY

4.1 Introduction

This chapter details the methods that were employed to achieve the purpose of the research, which was achieved by applying GIS and remote sensing methods. Satellite image taken in 2017 was utilised to analyse vegetation cover condition. The selection of the satellite image was influenced by availability and quality. GIS based data was digitized from Google Earth. Field survey, through observations and measurements of the location under study, was conducted to assess vegetation condition and assess the road network. Vegetation condition was then related to road network using the multinomial logistic regression. Figure 4. 1 provides a flowchart diagram of how the methodology was conducted.

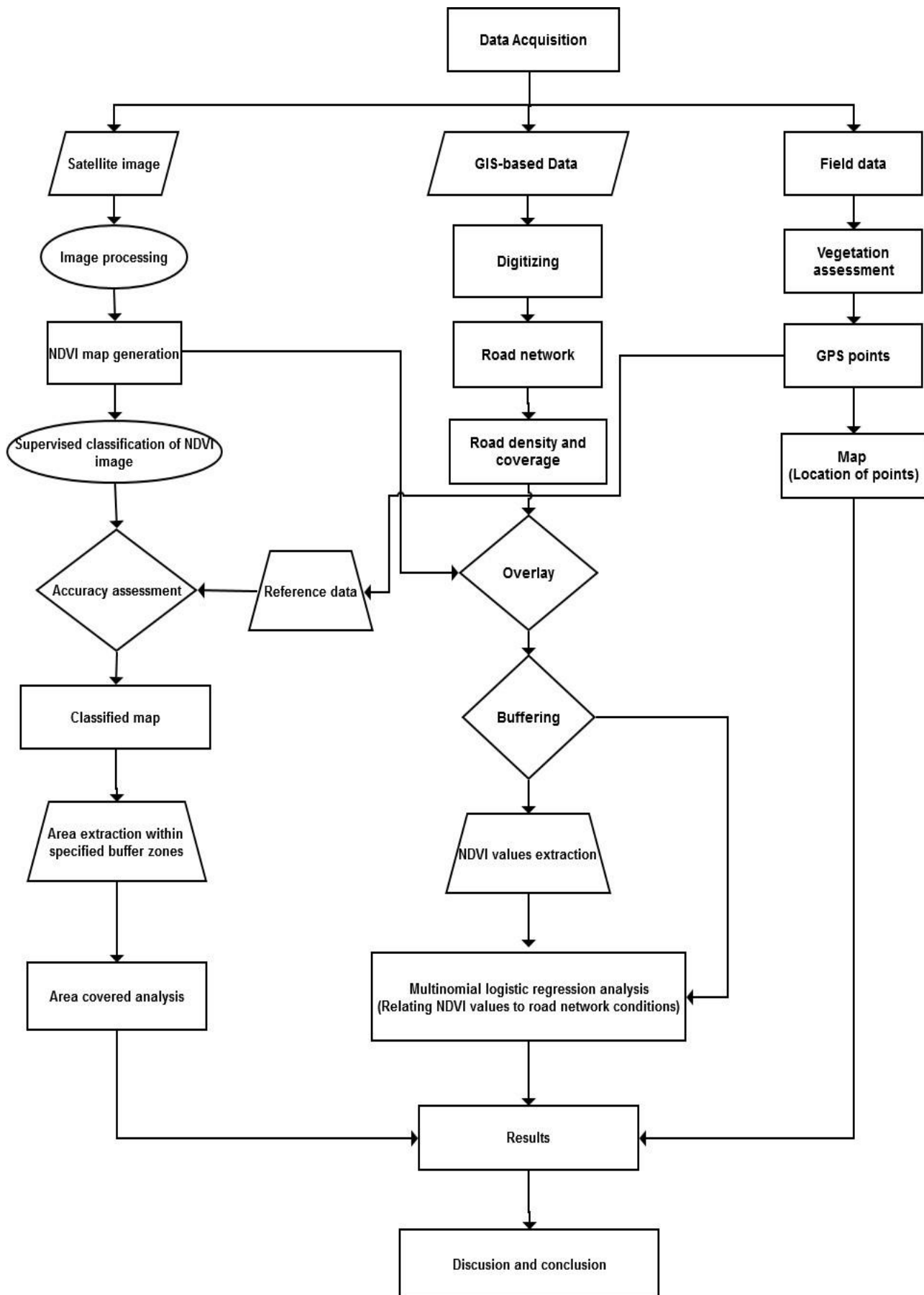


Figure 4. 1: Methodology flow chart.

4.2 GIS and Remote Sensing methods

To achieve the objectives of the proposed study, applications of different data sources were used, including remotely sensed data covering the study area, road network shapefiles and reference data for accuracy assessment. For this study, all image pre-processing and consequent image analysis were carried out using ArcGIS 10.3 software. The image acquisition and processing procedures are presented in the following sub-sections.

4.2.1 Data Acquisition

The study employed Landsat 8 OLI image which provided better classification of vegetation cover using the red and infrared bands. Landsat-8 OLI acquires images in eight spectral bands (bands 1-7, and 9) at a spatial resolution of 30-m and for Band 8 (panchromatic) at 15 meters. The study area was covered by a scene with 172/78 path/row coordinates. The Landsat 8 OLI image was downloaded from the United States Geological Survey (USGS) website (<http://earthexplorer.usgs.gov>). The Landsat 8 OLI image was received in Universal Transverse Mercator (UTM) World Geodetic System 1984 ellipsoid and was received in Geographic Tagged image file format (GEOTIFF), and subsequently exported to the ArcMap 10.3 programme, where the image was prepared for analysis. The selection of imagery was based on vegetation growing season, reasonable spatial resolution, cost-free availability and quality. A summer season was preferred because vegetation is at its peak during this season (McCoy, 2005), and for that reason, the image captured in the month of April 2017 on the 28th was acquired and Landsat_Scene_ID = LC81720782017118LGN00.

Google Earth was utilized to digitize shapefiles of the study area, the study area boundary and road network. The advantage of obtaining GIS-based data directly from Google Earth interface is that the extracted data are obtained with spatial reference attached to them (Goodchild, 2007). Field work was conducted in April-May 2017, to assess the nature of vegetation and visual observation was used to assess the conditions of the roads. Vegetation condition data was collected on the field and recorded using a vegetation field data sheet.

4.2.2 Generating road network and study boundary

4.2.2.1 Digitizing

Road network of the study area was digitized from Google Earth, because Google Earth has high resolution imagery of any area. Google Earth imagery is preferred to create updated vector data for many kinds of data, like roads (Chang *et al.*, 2009). The study area was delineated by plotting the polygon, and line shapefile files were traced from the roads in Google Earth and saved as a type.

kml. The digitized features were then converted to *.shp* type in ArcMap. The line shapefile represents roads and the polygon shapefile represents the boundary of the study area. The shapefiles were overlaid on the satellite image for the purpose of analysis in the current study.

4.2.2.2 Correction of dangling errors

Dangle errors occur during digitization process, and these errors were manually corrected using extend or trim lines tool in ArcMap 10.3. A dangle error can be caused by a line that extends too far beyond the line it is supposed to touch or by a line that doesn't extend quite far enough (Maraş *et al.*, 2010). These dangle errors are overshoots and undershoots. Undershoots were corrected by using extend tool in ArcMap, while overshoot dangling segment were trimmed back to where the lines intersect, by using trim tool in ArcMap.

4.2.3 Assessing road network conditions

This study used visual observation to assess the conditions of the roads, i.e., whether they were tarred or untarred roads. The study assessed the conditions of road networks which provide access to different locations, for instance, farming, settlements and national or main roads.

4.3 Characterizing vegetation cover and conditions

In this study, vegetation condition was assessed using Remote Sensing techniques. Vegetation cover and condition were assessed using Landsat 8 image, with the following procedure:

4.3.1 Image pre-processing

Images acquired by Landsat sensors are subject to distortion as a result of sensor, solar, atmospheric, and topographic effects (Young *et al.*, 2017). Therefore, pre-processing attempts to minimize these effects to the extent desired for a particular application. The downloaded image was at Level 1 pre-processing: ortho-rectified using ground control points, UTM projection, radiometrically calibrated, and in cubic convolution resampling. Similar to the study by Bhatti and Tripathi (2014), the acquired image was cloud-free; therefore, atmospheric corrections were not performed. The original Landsat 8 OLI image had a high prior geometric correction precision, with RMSE less than 10 m. The following pre-processing steps were applied for the acquired Landsat-8 image:

4.3.1.1 Conversion of Digital numbers (DNs) to top of atmosphere (ToA) reflectance

Digital numbers (DNs) of bands 2, 3, 4, and 5 were converted to top of atmosphere (ToA) reflectance using conversion Equations in (1) and (2) (Bhatti & Tripathi, 2014). The conversion parameter values were provided in the product metadata file downloaded along with the satellite data. DN values to TOA reflectance for OLI data uses the following conversion equation:

$$\rho\lambda' = M_{\rho}Q_{cal} + A_{\rho} \quad (1)$$

Where:

$\rho\lambda'$ = TOA planetary reflectance, without correction for solar angle

M_ρ = Band-specific multiplicative rescaling factor from the metadata (REFLECTANCE_MULT_BAND_x, where x is the band number)

Q_{cal} = DNs of the band being processed

A_ρ = is band-specific additive rescaling factor

The TOA reflectance with a correction for the sun angle was computed using

Equation (2) (Bhatti & Tripathi, 2014; USGA 2016):

$$\rho\lambda = \frac{\rho\lambda'}{\cos(\theta_{sz})} \quad (2)$$

Where:

$\rho\lambda$ = TOA planetary reflectance

θ_{sz} = is a solar zenith angle.

4.3.1.2 Subset of the image

A subset is a section of a larger image (Tuia *et al.*, 2011). An acquired satellite image covers more area than the area of interest. Therefore, Landsat data was clipped using the “Extract By Mask” tool in ArcMap to the extent of the boundary of the study area and also to be generally the same size as the digitized road network shapefiles from Google Earth. Sub-setting an area of interest increases the overall classification accuracy, thereby reducing the number of land-cover types and spectral variation, and eliminates an unnecessary data amount, which helps speeding up processing (Ehlers *et al.*, 2010).

4.3.2 Deriving NDVI

In this section, the NDVI extension of ArcMap was used for retrieving vegetation condition. Band 4 of Landsat 8, which denotes the red band and band 5 of the Near Infrared was used in calculating the NDVI. NDVI method was selected in Image Analysis Options in ArcMap. Then a normalised Difference Vegetation Index (NDVI) image was obtained using the equation (3):

$$NDVI = \frac{NIR - R}{NIR + R} \quad (3)$$

Where NIR- Near Infrared, R- Red

NDVI was an important tool in this study, to investigate the interactions between vegetation and road network. It is useful to determine the production of green vegetation as well as to detect vegetation changes. The selection of NDVI from other vegetation indices in this study was because of its ability to discriminate between vegetation and soil in cases where there is sparse vegetation cover (Pettorelli *et al.*, 2005). The impact of road network on natural vegetation is examined in Section 4.7 of this chapter.

4.3.3 Image classification method

NDVI image was used as a base from which vegetation condition classes were extracted. NDVI is useful to determine the production of green vegetation as well as to detect vegetation changes. NDVI is useful to determine the production of green vegetation as well as to detect vegetation changes. For the purpose of this study, NDVI index was developed to depict vegetation condition dependent upon the contrast between the red and near-infrared reflectance. Vegetation condition delineated based on the characteristic reflectance of green vegetation. NDVI is a standardized way to measure healthy vegetation. The result of NDVI formula generates a value between -1 and +1, where high NDVI values show healthier vegetation while low NDVI show less or no vegetation.

Two vegetation classes, namely, healthy vegetation and degraded vegetation, were extracted from the multi-temporal NDVI image. Additional categories that were also extracted from the multi-temporal NDVI images were bare surface and water. The classification of multi-temporal image was achieved by employing the supervised classification in ArcMap software. Supervised classifications means that the analysts trains the computer to recognize patterns in the data by selecting pixels that represents patterns or land cover features that it recognizes (Voisin *et al.*, 2014). The signature files thus created are then used in the classification process. All training data were collected in the image raster layer for all classes in the Maximum Likelihood classifier. These training data was used to train the system to recognize the classes based on their spectral characteristic. The process of selecting a training area for each of the four cover types were undertaken in an area that was not mixed with other cover types, or area that was homogenous cover types. The outcomes of the classified images should be tested to check the correctness of the classification result. For that reason accuracy assessment was carried out. The percentage of the classification result for the classifier was calculated by analysing the confusion matrix table (sometimes called error matrix) (Appendix A).

The supervised classification algorithm-maximum likelihood classifier was used ahead of other classifiers, as it is very accurate when compared to minimum distance to the means classifier and

parallelepiped classifier (Kuznetsov & Myasnikov, 2014). Satellite image interpretation using Maximum Likelihood approach was mostly applied for land cover classification and monitoring land use changes (Mustapha *et al.* 2010).

4.3.3.1 Classification accuracy assessment

An accuracy assessment process was performed to validate vegetation classes. Twenty points per class were verified using very high-resolution Google Earth satellite imagery, by applying stratified random sampling. A limited number of training samples were collected in this study, although more training samples are usually beneficial, as they tend to be more representative to the class population, a small number of training samples is obviously attractive for logical reasons (Hess and Bay, 1997). The main aim of performing accuracy assessment was to offer an index of the degree of precision of a map or classification (Foody, 2002). This was achieved by overlaying a reference image and simulated image (Pontius, 2000). Very high-resolution Google Earth satellite imagery was used as reference data source in this study for classification accuracy assessment. Image classified according to spectral reflectance, was compared to an image which was assumed to be correct (Google Earth image). The reliability of vegetation condition presented in this chapter was dependent onto the classification accuracy of the image. This was presented by overall accuracy and the Kappa Index of Agreement (KIA). KIA is defined as a discrete multivariate technique, which is used to statistically evaluate the accuracy of classified data (Collingwood *et al.*, 2009).

To determine the agreement, two images must be categorized into equal groups. KIA considers the effect of chance agreement in the error matrix (Collingwood *et al.*, 2009). The advantage of the KIA is that it measures both the overall and individual class accuracies (Pontius, 2000). It is against this background that the present study also used KIA for accuracy assessment. According to Gil *et al.*, (2013), classification accuracy assessment is considered significant if KIA is greater than 0.70. According to results obtained, the overall accuracy was 0.88.5, whereas the overall Kappa coefficient was 0.7992 (Appendix A). Considering the KIA value obtained, the classification accuracy was reliable (Mohammed *et al.*, 2013). The accuracy assessment for this study was based on error of omission and commission as well as the Kappa Index analysis. The Kappa Index analysis is a measure of accuracy between the classified map and reference data (Tilahun & Teferie, 2015). Error of Omission occurs when pixels of class 1 were wrongly assigned to class 2, and from class 1 perspective, these pixels should have been assigned to class 1 but were omitted. Error of Commission occurs when pixels of class 2 were wrongly assigned to class 1, and from class 1 perspective, these pixels shouldn't have been assigned to class 1 but were included.

4.4 Field survey

Field survey was conducted in April-May 2017 during the peak growing season. For this

assessment, roadsides that show little or no human disturbances were selected on the basis of absence of roadside grazing and mowing of the grass. It was also influenced by the ability to access area of interest for assessment. A total of 20 points were accessed in the field. The spatial distribution of these points is shown in Figure 4. 2. Transect based quadrats (30 m²) measurements were marked within the predetermined distances of 50 m, 100 m and 150 m from the road. This was done to preserve randomness during field work and remove bias from the selection of sample points. The centre coordinates of each plot were recorded using a Garmin eTrex hand held GPS with an accuracy of ± 3 m.

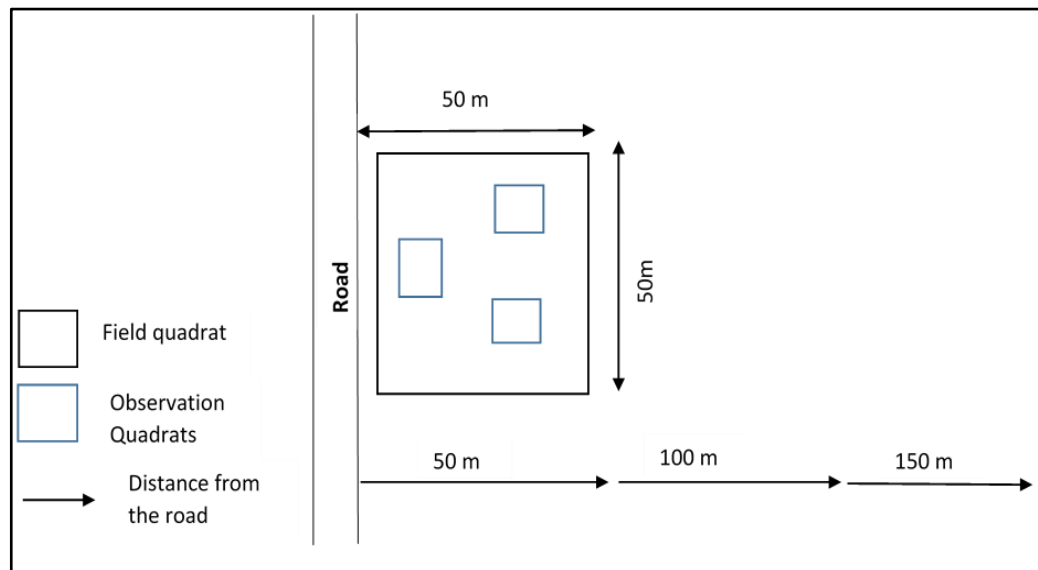


Figure 4. 2: Design of quadrats used to sample vegetation.

To assess the condition of roadside vegetation, the following procedures were followed. At 9 different sites that were sampled, variables such as plant height, canopy cover, number of plants and dominating species, grass cover and bare ground, were recorded at 3 distances (50 m, 100 m, and 150 m) from the road verge. At each of the 3 distances, 30*30 m quadrats was established by the road verge, within which we sampled 3 randomly placed 5*5 m quadrats. Figure 4. 2 shows the experimental design used in the study. Within each quadrat, data was collected, which included the percentages of the ground cover, grass and shrubs. Percentage cover of vegetation was defined as the percentage of quadrant covered by vegetation in relation to the bare surface. Vegetation analysis quadrat method is suitable for vegetation analysis because it allows determination of species population densities and frequencies (Sivicek & Taft, 2011).

A measuring tape was used to measure the diameter (d) of each tree within the plot and vegetation stick was used to measure the height of the plant (Figure 4. 3). All trees and shrubs within the quadrat were used to estimate the average height in meters. The canopy cover value was estimated using the following equation:

$$\text{Canopy area} = \pi r^2 \quad (4)$$

Where r = canopy radius ($d/2$)

The total area in the 30 m² quadrat gave a percentage of canopy cover value.



Figure 4. 3: Photo showing canopy cover and height of a plant being measured.

4.5 Overlay analysis

The road network in the study area was overlain on the NDVI image and land cover map that was generated from the classification, using overlay toolsets. The overlay analysis was used to establish whether vegetation cover condition was associated with road network in the study area.

4.6 Buffer analysis

One of the most popular proximity analysis is based on “buffering” (Narumalani *et al.*, 1997), by which in this study was generated around a road segment for different distances. Multiple buffer zones (at 50 m, 100 m and 150 m) were delineated, the vegetation condition information within these zones was then extracted and used to determine the relationship between the road and vegetation cover condition.

4.6.1 Determining areal extent covered by each vegetation condition type

Upon successful accuracy assessment of vegetation condition classes, multiple buffer zones were created around each road segment and vegetation condition classes found within this proximity were extracted. Then the area covered by each vegetation condition class within the specified proximity was calculated.

4.7 Relating vegetation cover conditions to road network

The created multiple buffer zones around each road segment were overlain onto a 2016 NDVI image. Twenty sample points were randomly digitized within each buffer zone for each road segment. Export raster was used to export NDVI values of pixels overlaid by digitized points. Exported NDVI values were recorded in MS Excel, corresponding with their respective buffer zones from which they were extracted. The extracted NDVI values were related to road network.

The multinomial logistic regression analysis was used to determine vegetation conditions as the distance extends away from road segments. The appropriateness of the Multinomial logistic Regression for this purpose was reviewed in Chapter 3, section 3.11. A multinomial logistic regression equation is as follows:

$$\begin{aligned} \logit k(x) &= \ln ((p(X)) \div (p(X))) = \beta k_0 + \beta k_1 x_1 + \beta k_2 x_2 + \dots \beta k_q x_q \\ &= X' \beta \end{aligned} \tag{5}$$

Where: X is the independent variable (covariate) vector

Y is a categorical (polychotomous) response variable with

β_k is the coefficient vector estimated for category k_1 $\beta_k = (\beta_{k0}, \beta_{k1}, \dots, \beta_{kq})$

The results obtained using the methods explained above are presented in the subsequent chapter.

CHAPTER 5

RESULTS

5.1 Introduction

The results obtained using different methods and techniques outlined in Chapter 4 are presented in this chapter. The NDVI image was used as a base image from which different vegetation classes were extracted. Supervised classification maximum likelihood algorithm was used to extract vegetation condition categories from NDVI image. This was presented by overall accuracy of 0.88.5, and the overall Kappa coefficient was 0.7992. NDVI values were used to depict variations in the vegetation condition in the study area, and as a basis for determining vegetation condition as one moves away from a road segment. NDVI values were extracted from buffer zones of different distances. The impact of road network on natural vegetation is assessed in this chapter.

5.2. Road network

The study categorised two road types (tarred and untarred) for our assessment. There are two main roads for motors vehicle traffic from other towns into Zeerust: N4 to Rustenburg and also the main road link between South Africa and Botswana, the R49 to Mahikeng and to Botswana.

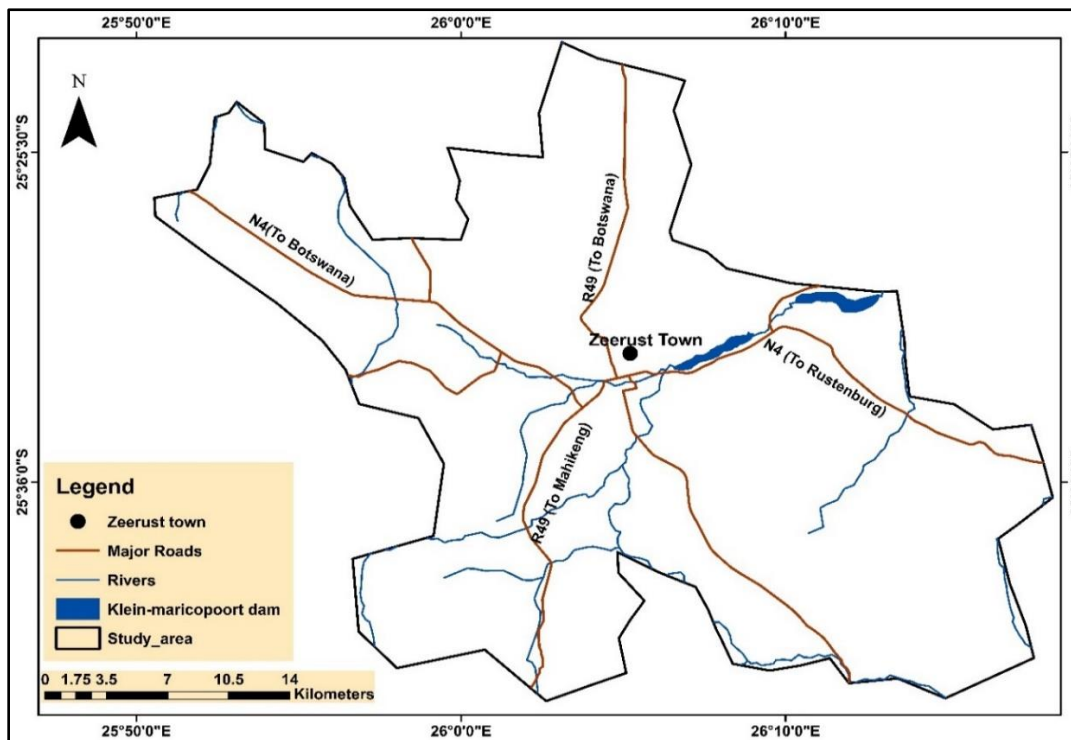


Figure 5. 1: The road network in Zeerust town

5.3 Characterization of the road-side natural vegetation condition

5.3.1 Buffer analysis

Buffer analysis is used for identifying areas surrounding geographic features. For the purpose of the current study, road buffers of different distances were built so that within each buffer zone, vegetation condition can be extracted. For visibility of road buffers, Figure 5. 2 demonstrates the road centreline and delineated multiple buffer zones (at 50m, 100m and 150m). Within each buffer zone, NDVI values were extracted, and used to depict variations in the vegetation condition within each road buffer.

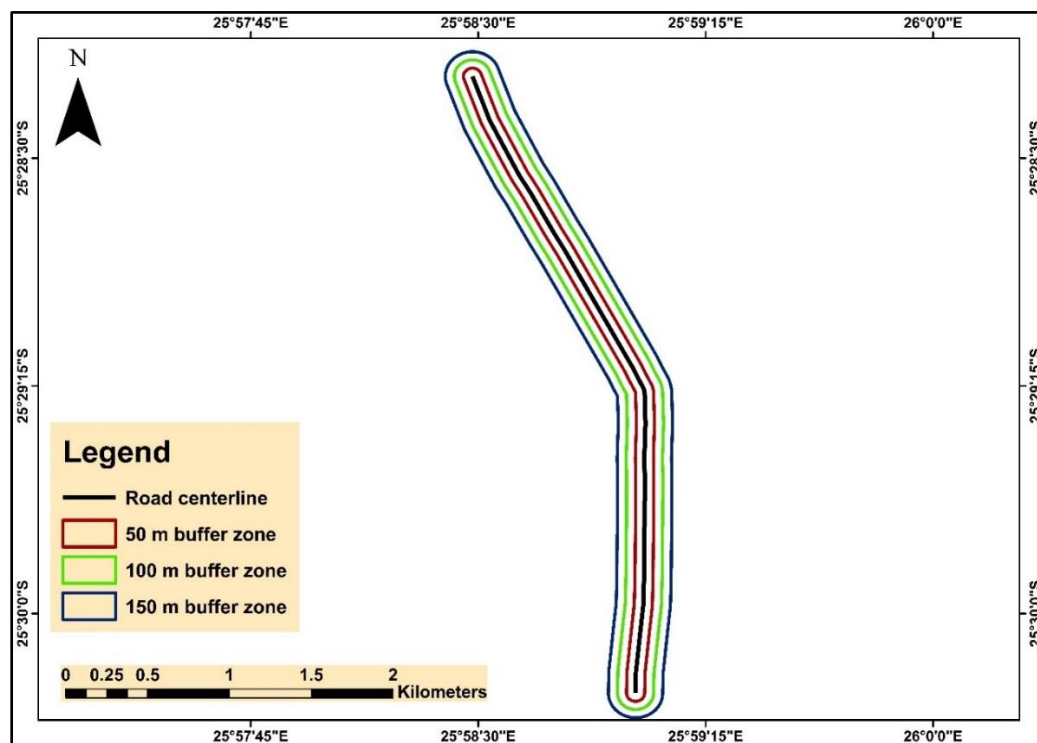


Figure 5. 2: Demonstrating the road centreline and delineated multiple buffer zones (at 50 m, 100 m and 150 m)

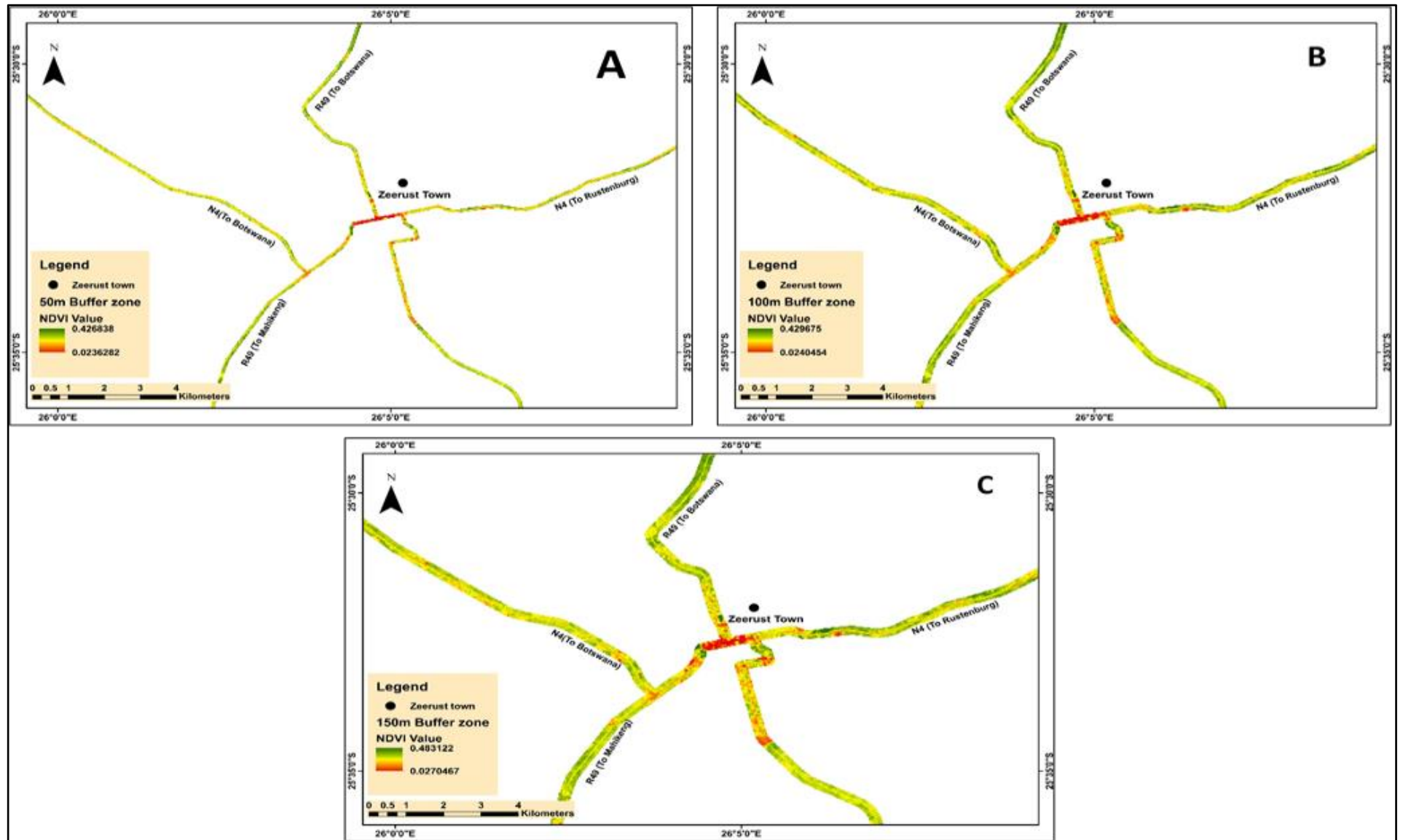


Figure 5. 3: Multiple buffer zones (at A: 50 m, B: 100 m and C: 150 m) delineated around the road segment

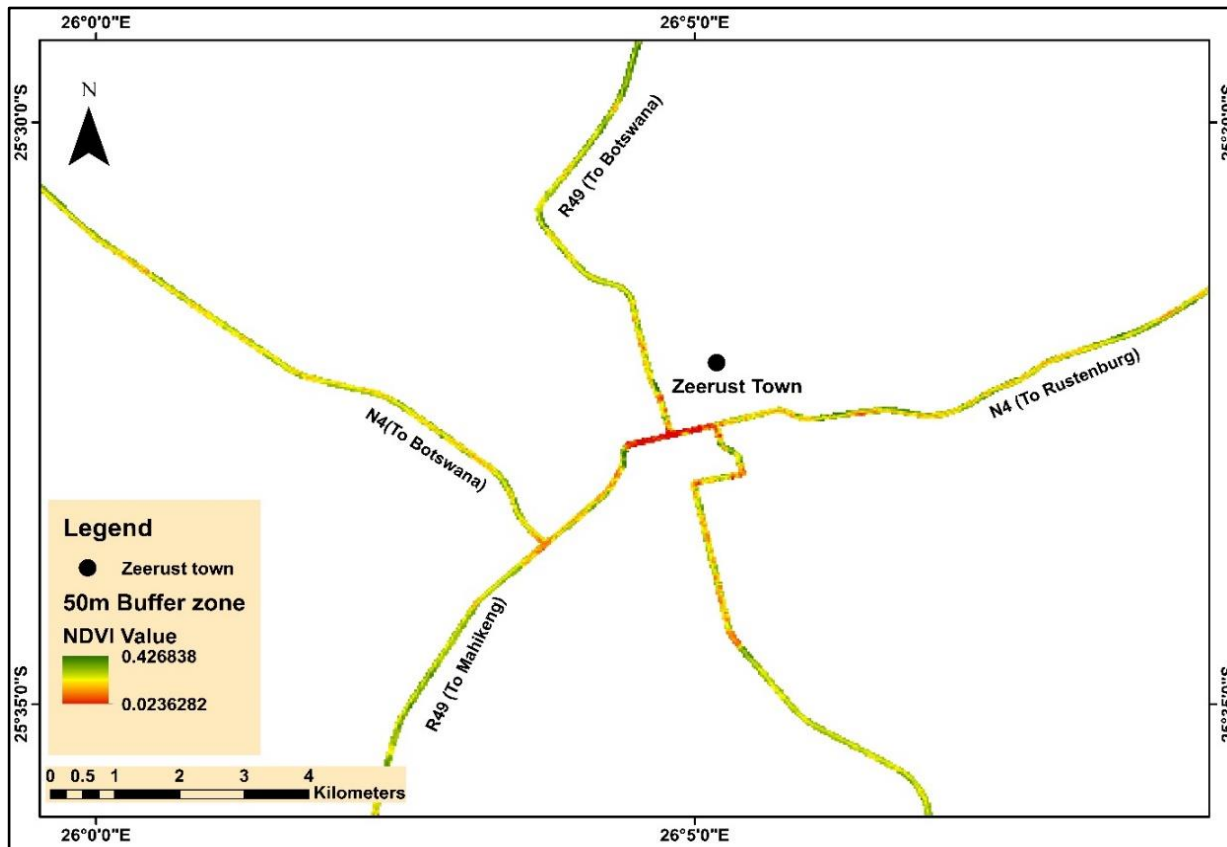


Figure 5.3. 1: Map A: 50 m buffer zone

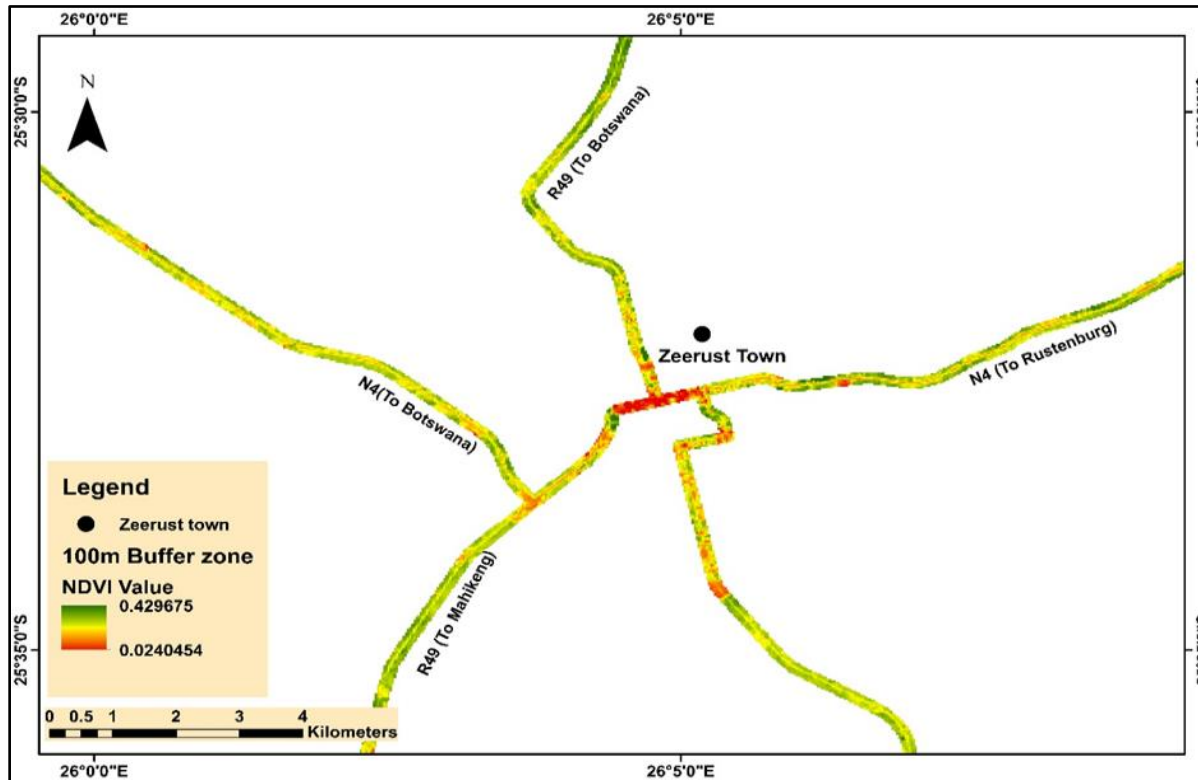


Figure 5.3. 2: Map B: 100 m buffer zone

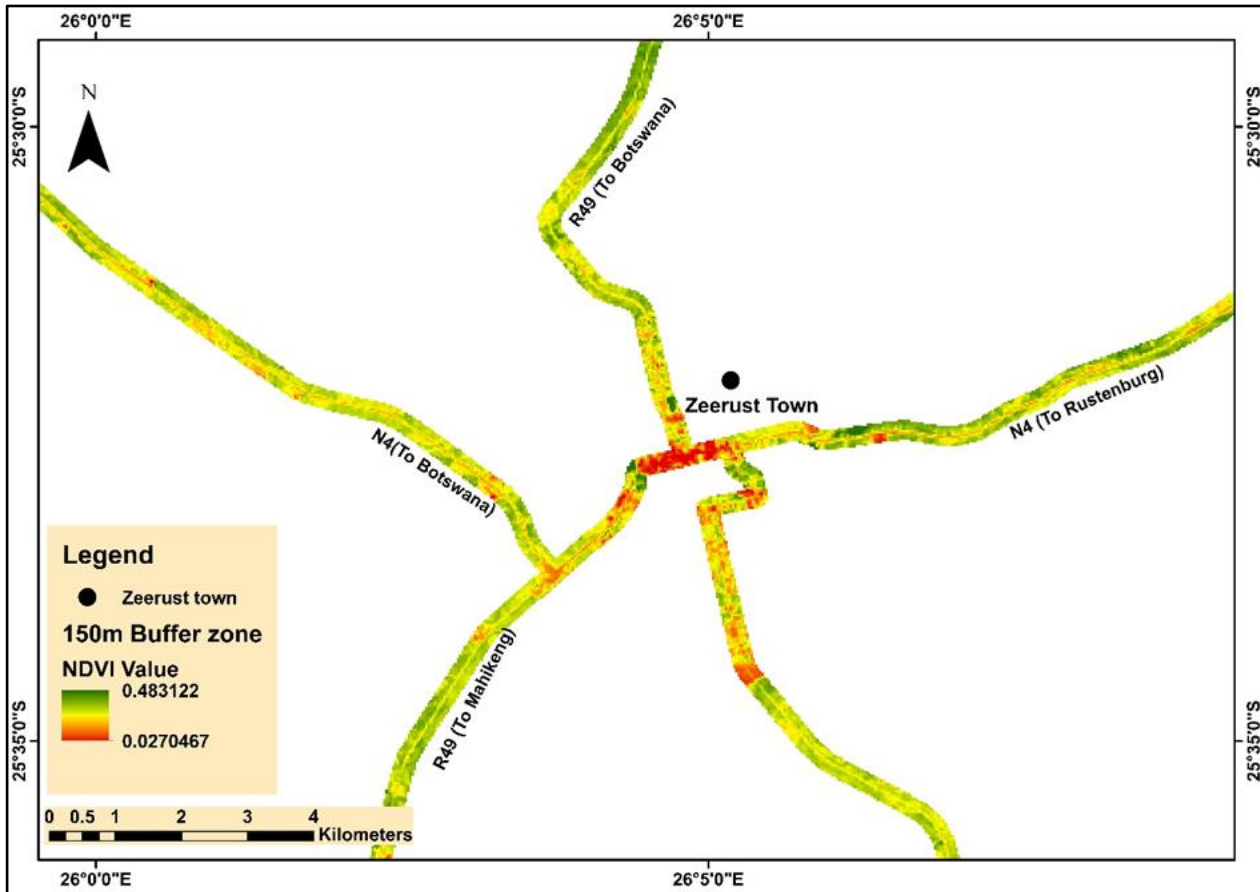


Figure 5.3. 3: Map C: 150 m buffer zone

NDVI image was used to assess vegetation conditions in this study. This index allows one to delineate the distribution of vegetation based on the characteristic reflectance of green vegetation. Multiple buffer zones at 50 m, 100 m and 150 m were created so that within each buffer zone, vegetation condition can be extracted to assess the impact of road network on vegetation. Figure 5.3 illustrates the different buffer zones of the NDVI image, showing the different NDVI values as the distance increased away from the road. Within the 50 m buffer zone (Map A), the NDVI values ranged from 0.0236282 to 0.426938. While on the 100 m buffer zone (Map B), the NDVI values ranged from 0.0240454 to 0.429675. The image showed an increase in NDVI values as the distance increased away from the road. Within the 150 m buffer zone (Map C), the NDVI values ranged from 0.0270467 to 0.483122.

5.3.2 Area covered by vegetation condition type as we move further away from the road

The road network in the study area was overlaid on the classified image of the study area. Buffer zones were generated around each road segment for different distances. Based on the identified road centrelines, multiple buffer zones (at 50 m, 100 m and 150 m) were delineated. The analysis shows that the buffer zone of 50 m around the road was the most impacted area (Figure 5.4. 1). The difference was observed at 100 m buffer zone it showed that healthy green vegetation was at its

highest while degraded vegetation and bare surface were at their lowest (Figure 5.4.2). At 150 m buffer zone, the healthy vegetation was still higher, while the degraded vegetation and bare surface had decreased. Extracted buffered zones results show that the healthy vegetation increased away from the road, with small healthy vegetation cover near the road, which means that vegetation loss mainly occurred near the roads.

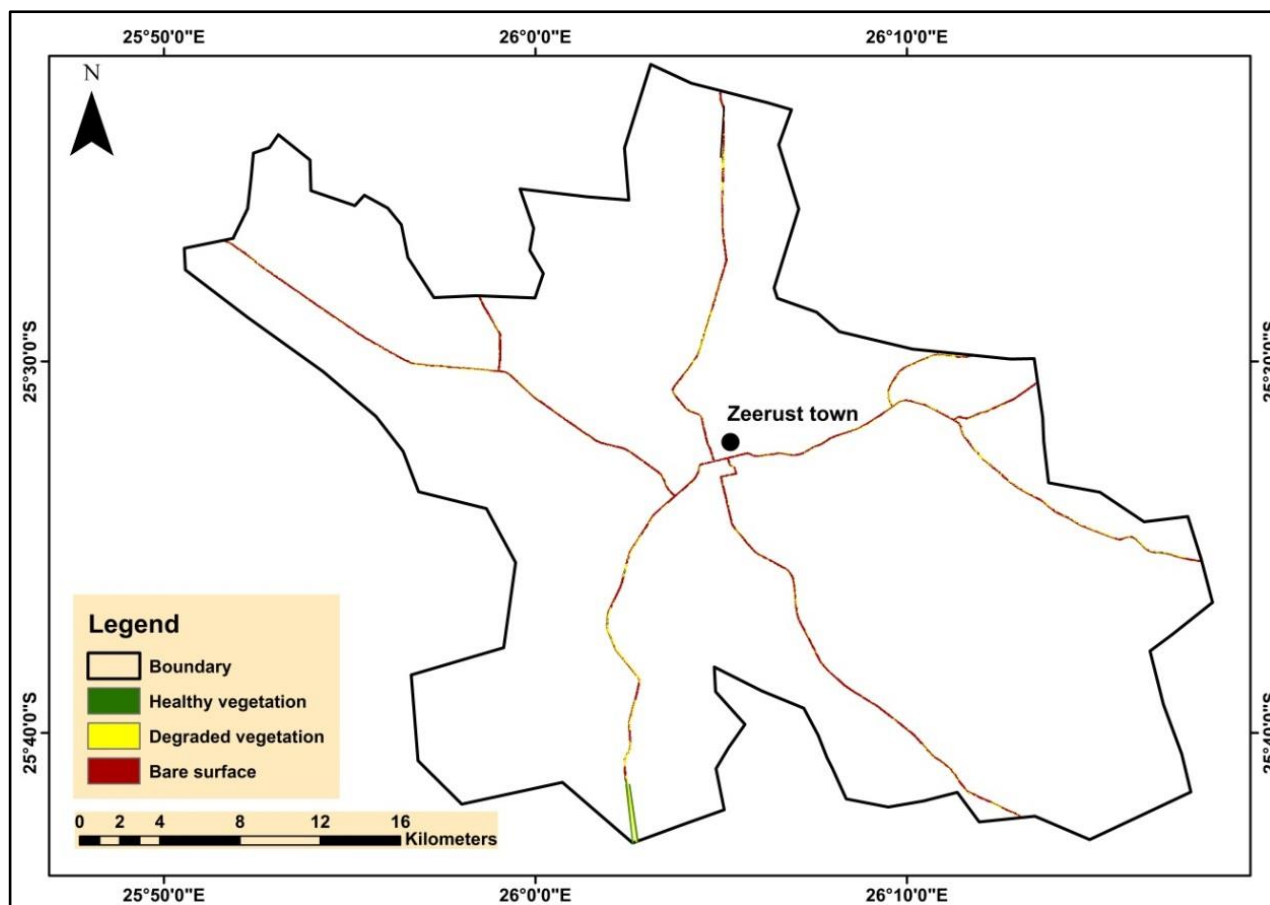


Figure 5.4. 1: Land cover classes within the 50 m buffer zone

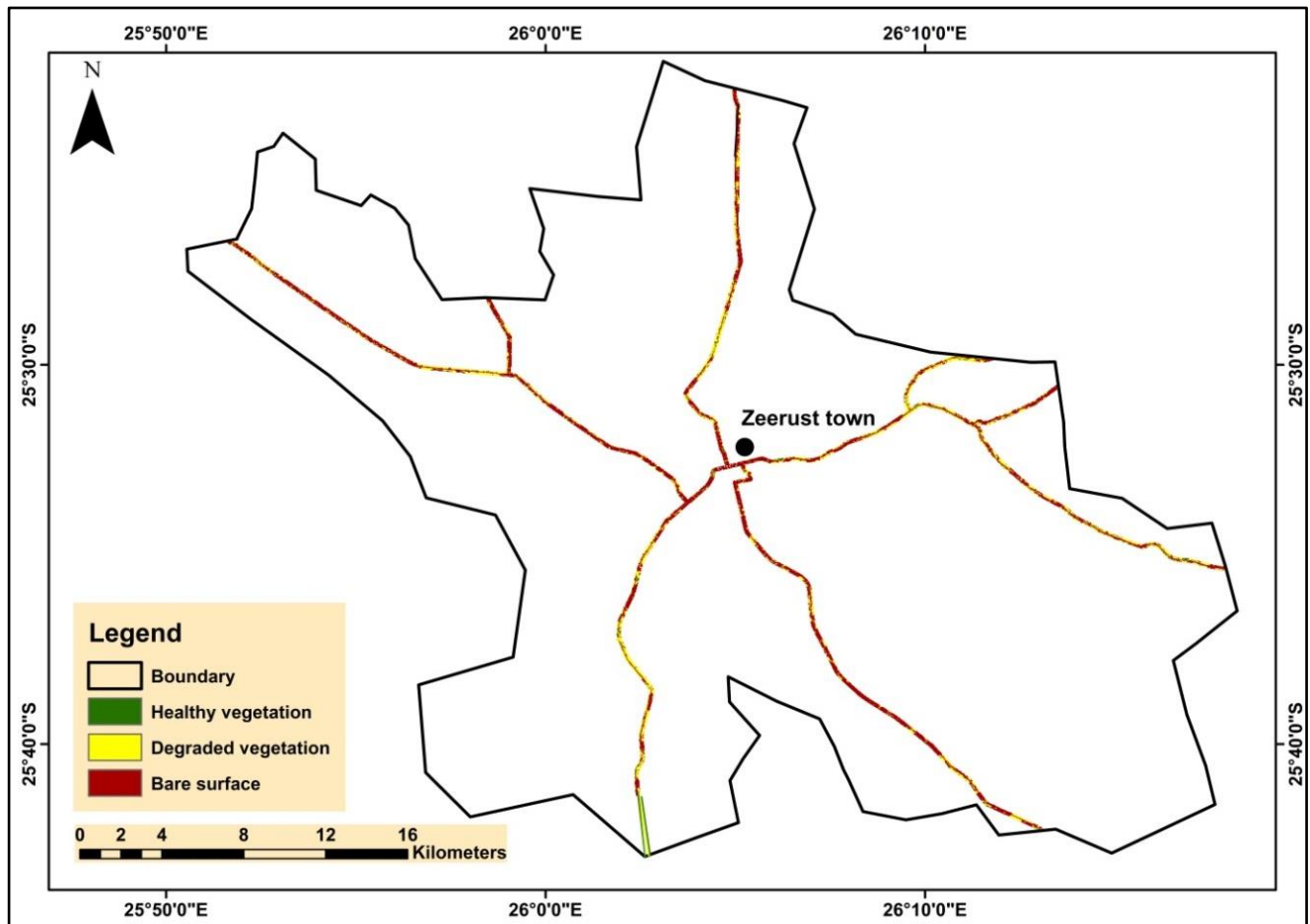


Figure 5.4. 2: Land cover classes within the 100 m buffer zone

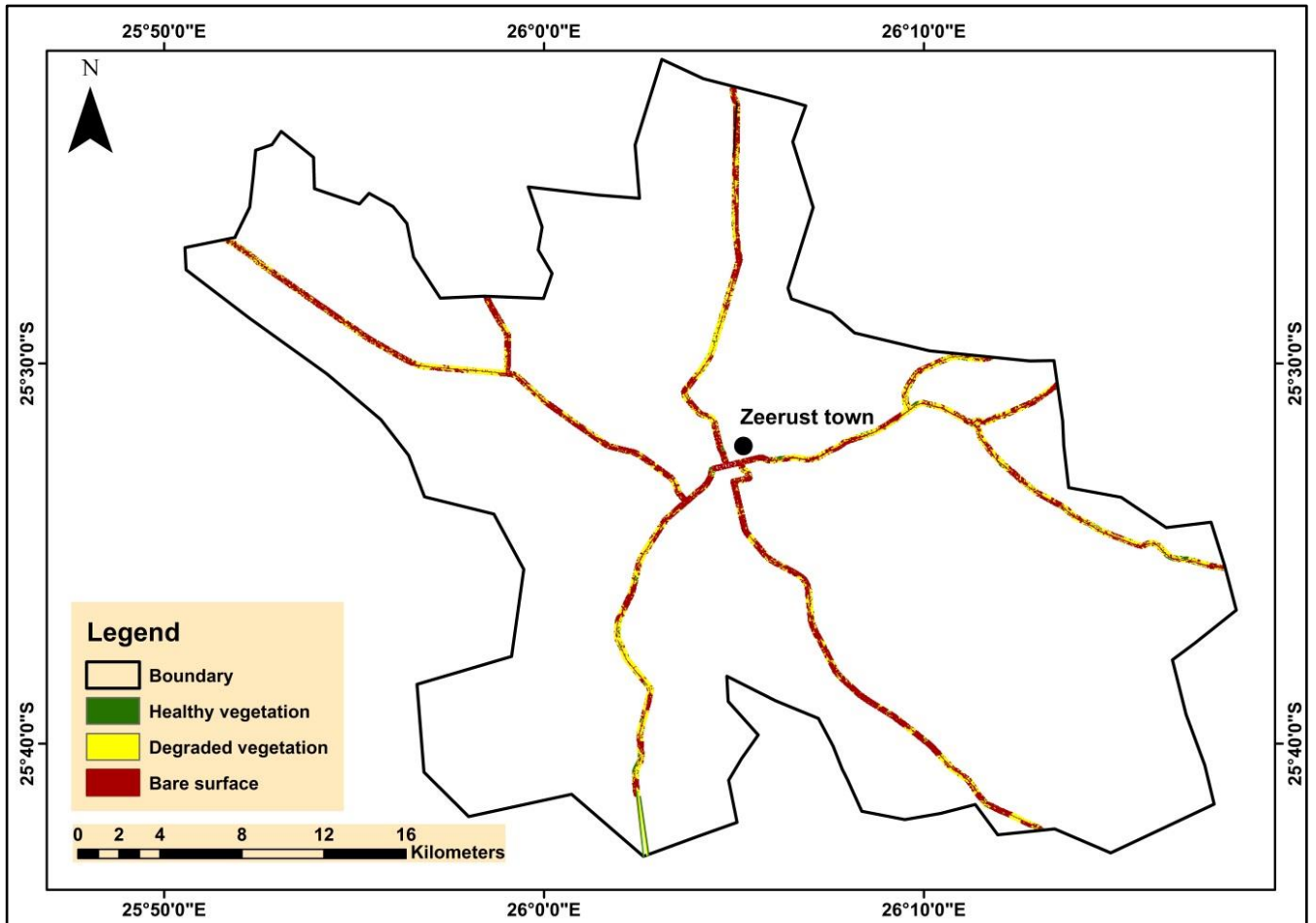


Figure 5.4. 3: Land cover classes within the 150 m buffer zone

The area covered by healthy vegetation within the 50 m road buffer contributed 1.5% of the total area within the buffer. Healthy vegetation in the study was formed by tree species, shrubs and grasses. Degraded vegetation and bare surface covered 24.5% and 74% respectively, from the total area of the buffer zone. Degraded vegetation was formed by lifeless dry trees, shrubs and grasses. Vegetation condition showed degraded vegetation within close proximity of a road segment and the healthy vegetation increased as the distance increased away from the road (Figure 5.5 and Table 5.1).

The area covered by healthy vegetation within the 100 m buffer zone was 63.9% of the total area. As the distance increased away from the road, the degraded vegetation and bare surface showed a decline and covered 33.6%) and 2.5% respectively from the total area of the buffer zone. At a buffer distance of 150 m, healthy vegetation covered a larger area and contributed 59.5% of the total area. The degraded vegetation and bare surface covered an aerial size of 37.5% and 3% respectively.

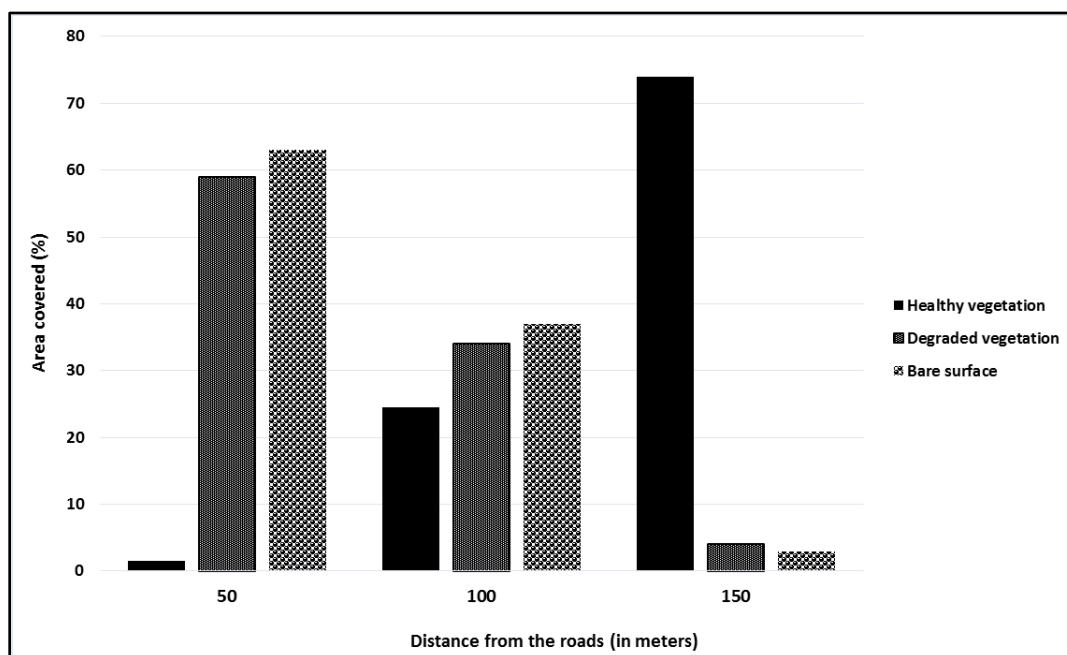


Figure 5.5: Land cover classes and their corresponding areas for 2017 in different buffer zones.

Table 5. 1: Area covered by land cover classes as distance increased further away from the road.

Vegetation condition	50 m buffer zone Area (%)	100 m buffer zone Area (%)	150 m buffer zone Area (%)
Healthy vegetation	1.53	59	63
Degraded vegetation	24.49	34	37
Bare surface	73.98	3	4
Total	100	100	100

5.4 Relating vegetation condition to road network

In this section, an attempt was made to relate vegetation condition to a road network in the study area. NDVI values were exported and then recorded in MS Excel, corresponding with their respective buffer zones from which they were extracted. The multinomial logistic regression was performed to determine the relationship between vegetation condition and road network. The multinomial logistic regression was independently performed on both tarred and untarred roads. The null hypothesis formulated was that “there is no variation in vegetation condition as we move away from the road”. The *Chi-squared* value was calculated using the multinomial logistic regression analysis tools in MS Excel. The *Chi-squared* value was compared with a critical value of 3.84, at the significance level of 0.05, to determine the significance of relationship. The *Chi-*

squared values for the tarred road was 395, 5004, and was 791.001 for the untarred roads. Based on the *Chi*-squared values, the null hypothesis was therefore rejected; “there is significant variation in vegetation as we move further away from the road”. It is therefore concluded that the road network played an important role in the condition of vegetation.

5.5 Field determination of vegetation composition against distance from the road

5.5.1 Variations in vegetation cover in relation to Distance from the road

A total of twenty sites were surveyed (refer to section 4.4). There was a distinct variation in vegetation cover with distance from roads. A high great quantity of vegetation cover was observed at a distance beyond the 50 m distance near the road, while the lowest vegetation cover was found within the 50 m distance in the surveyed sites. In the road vicinity (within 50 m from the road), the proportion of roadside vegetation was significantly lower than at distances greater than 100 m, with low NDVI values within the 50 m buffer zone and higher NDVI values further away. Roadside vegetation cover related to the road network, and statistical results suggested a strong association between the vegetation cover and distance from the road. Field survey assessment supported the findings by determining the mean frequency cover, tree canopy cover, basal cover and tree height for plants in the sampling sites.

Plate 5. 1 displays photos taken during field work, which showed vegetation cover as the distance increased from the road. Photo A shows grass and tree cover closer to the road. Photo B shows grass and tree cover at a distance of 100 m from the road verge. The photos show that there was variation in vegetation cover with increase in distance from roads in the study area. The rejection of the null hypothesis signifies the relationship between vegetation condition and road network.



Plate 5. 1: Vegetation at 50 m distance from the road and vegetation beyond 50 m distance from the road

5.5.2 Frequency distribution in relation to distance from the road

Frequency distribution shown in Figure 5.6; shows that the trees and shrub cover increased with distance as one moved further away from the road segment. On average, ± 80 trees were recorded at a distance of 150 m, and ± 50 trees were recorded at distances closer to the road segment. Figure 5.6 shows the mean frequency distribution for trees and shrubs at different distances from the road. The frequency distribution of tree species was approximately 54% within the 50 m distance from the road, and increased to approximately 73% at 100 m, and it increased to 82 % at 150 m. Shrub cover was lowest with approximately 22% at 50 m and increased to 38%, and increased to 42% at 150 m. There was a gradual increase in the frequency distribution of tree and shrub cover with distance from the roads up to a distance of 150 m, and a decreasing trend of bare surface away from the road.

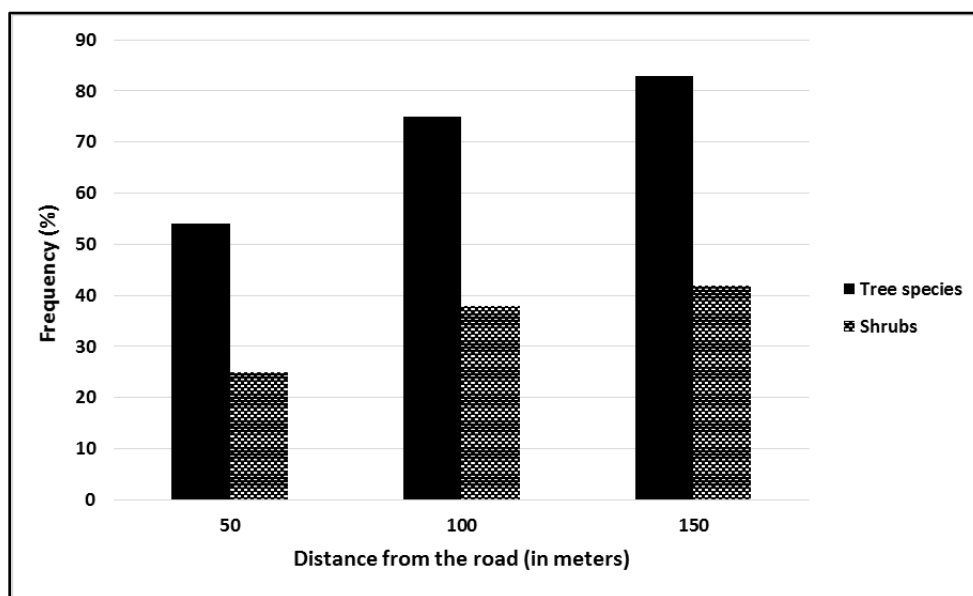


Figure 5.6: A Frequency distribution of trees and shrubs with relation to distance from road segment

5.5.3 Tree canopy cover in relation to distance from the road

The mean estimated canopy cover at different distance is shown in Figure 5.7. The total area of each tree species in the quadrat gave a percentage (%) of canopy cover estimation. The mean total canopy cover values showed variation with distance from the road. The range of estimated canopy cover in the field was 29% - 57%. The estimated canopy cover at 50 m distance was approximately 29% and increased to 34% at 100 m distance. The highest canopy cover estimation came from the distance of 150 m away from the road; the canopy cover showed an increasing trend with a coverage of approximately 57%.

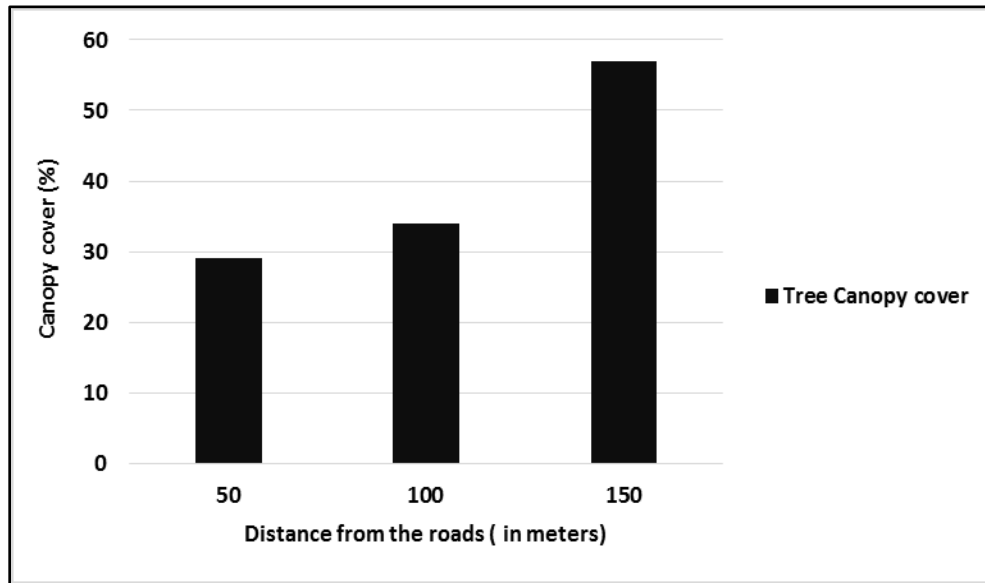


Figure 5.7: Mean percentage of tree canopy cover with relation to distance from the road

5.5.4 Basal cover in relation to distance from the road

Figure 5.8 shows the mean basal cover for trees, shrubs and grass at differing distances from the road. Basal cover showed variation with distance from the roads. For example, the mean tree basal cover was approximately 48% at a distance within 50 m from the road, and increased to approximately 69% at 100 m, and further increased to 82% at 150 m. The shrub basal cover was lowest with approximately 25% at 50 m and increased to 30%, and further increased to 38% at 150 m. Grass cover was taken into consideration to illustrate the influence of distance from the road on grass cover. It showed that at a distance of 50 m, approximately 39% of the surface was covered in grass, and increased to approximately 65% at 150 m distance from the road. Bare surface showed a decreasing trend as the distance increased away from the road; approximately 30% was bare surface and declined to approximately 20% at a distance of 100 m. There was a gradual increase in vegetation cover with distance from the roads up to a distance of 150 m. Tree, shrub and grass basal covers were estimated based on quadrat percentage cover at a fixed distance from the road.

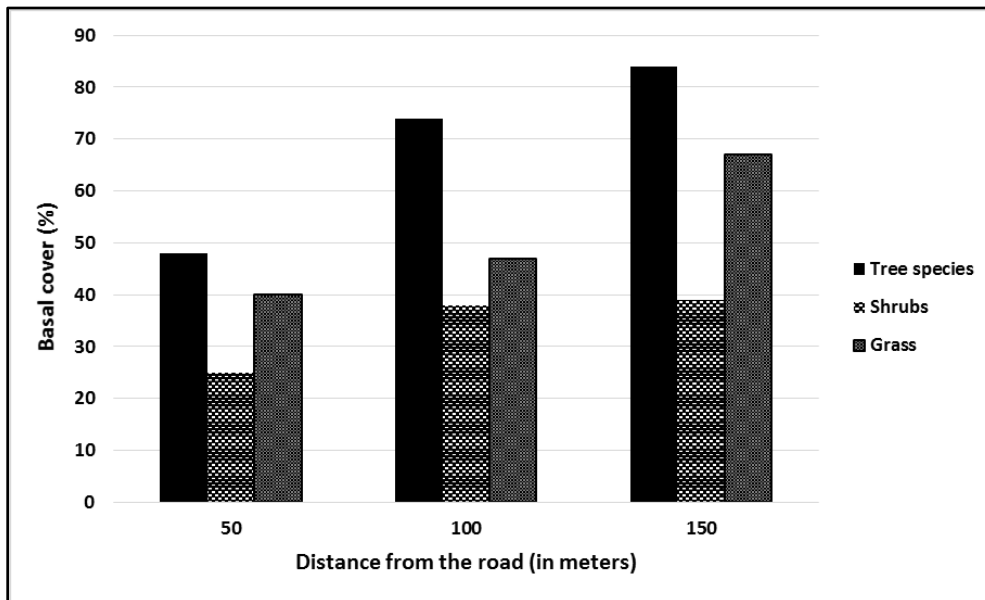


Figure 5.8: Trees, shrubs, and grass mean basal cover at various distances from the road

5.5.5 Tree heights in relation to distance from the road

The dominating tree species in the study area were the *Acacia melifera* and *Euclea undulata*. The height measurement recorded the total length of the tree from ground level to the top of the tree. For trees species surveyed, the estimated average of the tree height (m) of the sites was ± 4.76 m at 50 m distance; and showed an increasing trend as one moved further away from the road. Figure 5.9 shows the average tree heights that were recorded during the field survey.

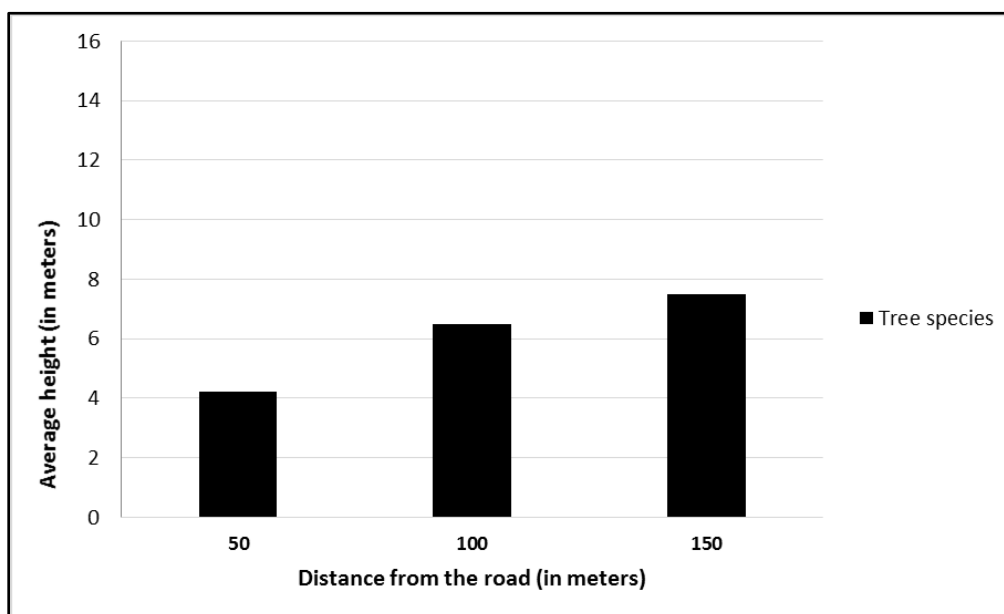


Figure 5.9: Average tree height in meters with relation to distance from the road

The Subsequent chapter provides the discussions pertaining to the results provided in the current chapter.

CHAPTER 6

DISCUSSION AND CONCLUSIONS

6.1. Introduction

This chapter provides a consolidative overview of the research methods applied and the results regarding assessment of the impacts of road network on natural vegetation cover and condition. The effectiveness and shortfalls of the techniques and methods employed to determine the impact of road network on vegetation as revealed are also discussed in this chapter. The knowledge gaps filled by this study are also included in this chapter. Recommendations substantial to address the shortcomings of the reviewed results are also discussed in this chapter. The conclusions reached in this study and directions for future research are also provided in this chapter. The direction for future research, based on results obtained and research conducted, is also brought forward.

The current study was aimed at analysing impacts of road network on natural vegetation conditions. The study aimed at analyzing the impact of road network on natural vegetation based on the progressive satellite remote sensing and GIS technologies. Particularly, the study sought to: (1) map and classify the road network, (2) characterize road-side natural vegetation condition, and (3) assess the impact of road networks on vegetation cover and condition.

6. 2. A review of research methods employed in the study

The first objective of the current study was to extract or to map road network within the study area. Geographical Information Systems (GIS), in particular, enabled spatial assessment and extraction of road network in the study area. This was achieved through digitization directly from the Google Earth GIS platform. The advantage of using the Google Earth platform is that it provides very high spectral resolution (Conroy *et al.*, 2008), which makes it easy to achieve a reasonably accurate result. Traditional method of road network mapping, such as ground surveying, proved to be labour-intensive and time-consuming (Zhang & Couloigner, 2004). Ground surveying is carried out by using GPS receivers, which is point-based, it is more relevant for very small areas rather than for large-scale road mapping (Jin *et al.*, 2012). Zhang *et al.* (2017) also noted that these traditional techniques are costly, hence they require expensive field surveying. However, GIS distinguishes itself from the traditional mapping methods principally by its fast data collection speed and low cost (He & Orvets, 2000).

Although roads can also be extracted through delineation from remotely sensed imagery, Jiang *et al.* (2014) noted that differentiating between tarred/paved and unpaved roads from some optical remote sensing platforms proved to be a challenging task. Xu *et al.* (2009) stated that several basic characteristics of roads are available and can be used to achieve accurate results if they are used for

road extraction using GIS. The results from Kahraman *et al.* (2015) indicate that road detection from high resolution satellite Google Earth platform proved to be efficient and effective. Google Earth platform is highly recommended because of its wide availability and less deployment cost for any project (Bong *et al.*, 2009). This platform enables extraction of roads reliably from images with simple contents and less obstructions.

The second objective of this study was to assess the spatial trends in vegetation condition along road network. In this study, satellite remote sensing was employed to provide information pertaining to the condition of vegetation. Remote sensing proved to be a reliable and efficient method of assessing spatial trends in vegetation condition. Landsat-8 OLI image for the year 2017 was acquired and used in the assessment of vegetation condition. Although other satellite remote sensing platforms such as SPOT, ASTER and MODIS can also facilitate detection of vegetative features, the Landsat platform has a temporal resolution advantage (Ndou, 2017). This remote sensing platform presented cost-free, cloud-free and reasonable spatial resolution data for assessing vegetation condition. This satellite platform Landsat 7-8 has free access to visible and multispectral data. Furthermore, the data quality and radiometric quantization of the OLI and TIRS is higher than the previous Landsat instruments, providing significant improvement in the ability to detect changes on the Earth's surface.

The NDVI was useful in assessing vegetation cover and condition, thereby providing the NDVI values that were used as surrogate for vegetation condition (Akay *et al.*, 2008). The ability of this vegetation index to discriminate vegetative features from the other landscape features on varied landscapes, permitted the precise identification of vegetation fragments (Glenn *et al.*, 2008; Thenkabail *et al.*, 2000). The NDVI has an upper hand when compared to other vegetation indices such as SAVI, RVI, SR and DVI, in that it indicates the amount of vegetation, distinguishes vegetation from soil and minimizes topographic effects (Gascon *et al.*, 2016). The NDVI was found to be relevant in terms of vegetation condition assessment in the study area, in that it has the capability to map vegetation condition in semi-arid environments (De Lima *et al.*, 2017), the environment of which the study area was characterized. The NDVI image derived from the Landsat-8 OLI for the year 2018 provided the platform onto which the different vegetation condition classes could be identified.

The supervised image classification method facilitated a successful extraction of different vegetation condition classes in the study area. Even though the unsupervised image classification method is also capable of grouping pixels of homogeneous spectral properties into a group, the supervised image classification provides a user with freedom in terms of types and number of classes to be extracted (Guan *et al.*, 2012). This method allowed the performance of pixel

categorization process by specifying to the computer algorithm the various land cover types represented in the scene (Hong *et al.*, 2016). The Maximum likelihood algorithm was employed to complete the supervised image classification process, in light with vegetation condition categorization. While other supervised classification algorithms, such as minimum distance to mean, K-Nearest Neighbour (KNN), K-Means clustering and parallelepiped classifiers are also capable of grouping pixels into a class, the Maximum Likelihood classifier has been found more accurate and faster in the view of computation time (Ramachandra *et al.*, 2015). This classification is more efficient since it takes advantage of information of the multivariate spreads of each classes (Lillesand *et al.*, 2014). The advantage of using this classification method is that errors can be detected by the operator and are able to be rectified (Foody & Mathur, 2006; Walter, 2004). As a result, vegetation condition was then categorized into various conditions, viz. healthy vegetation, degraded vegetation and bare surface.

No classification of remotely-sensed image is complete until a valid evaluation on its result map has been performed (Mitri & Karam, 2016). Accuracy assessment was performed using the reference data obtained and a very high Google Earth satellite imagery. Accuracy assessment aided in the identification of systematic errors in the classification scheme and improved class definitions. An accuracy assessment is based on comparing the map depiction of land cover to the true land cover condition. However in this study “ground truth” could not be practically attainable, therefore accuracy assessment was evaluated using the map land cover relative to a higher quality determination of land cover. A limited number of training samples were collected in this study, 20 samples per class evenly distributed across the image. Although more training samples are usually beneficial, as they tend to be more representative to the class population, a small number of training samples is obviously attractive for logical reasons (Hess and Bay, 1997). Foody *et al.* (2006) recommended that a training sample size for each class should not be fewer than 10-30 times the number of bands. This is usually okay for classifiers that require few parameters to be estimated like the maximum likelihood classifier when applied to a handful number of bands (Li *et al.* 2014).

According to Congalton (2001), this process can serve as an imperative learning tool to efficiently identify the most important sources of error in the image processing chain. By comparing these data, the percentage of the pixels appropriately classified was estimated. The use of overall accuracy to represent the quality of a classification performance does not clearly represent the real agreement between the reference data and the classifier (Carreiras *et al.*, 2017). Hence, more detailed statements of accuracy were derived from the error matrix in the form of individual vegetation condition class accuracies; this indicates how the accuracy is distributed across individual vegetation condition categories, hereafter, the Kappa index was used. This index was used to

account for any classification problem, as a measure of agreement between the field reference and classified map (Mitri & Karam, 2016). Therefore, the Kappa statistic provided the best estimates of the overall accuracy for all classes extracted from images in this study (Martellozzo & Clarke, 2011). Congalton, (1992) noted that Kappa can provide the most valuable information for classification accuracy assessment provided that the scale is taken into consideration.

In this study, impacts of road network on vegetation cover and condition were analysed. The multinomial logistic regression analysis was employed to determine these impacts, relying on the NDVI values as surrogate for vegetation condition. The reliability of the multinomial logistic regression analysis in determining relationships among categorical response data has made multinomial logistic analysis the perfect method for establishing the relationship between the vegetation condition and distance away from the road. Although other statistical methods such as linear regression, multiple regression and logistic regression are capable of establishing the relationship between variables, the multinomial logistic regression technique was highly preferred because of its ability to handle multiple categorical data (Jongman *et al.*, 1995).

Implications emerging from the reviewed methods suggest that the remotely sensed datasets and Geographic Information Systems techniques are reliable tools substantial in the investigation and assessment of vegetation cover and condition.

6.3. A review of the results

The main aim of this study was to analyse the impacts of road networks on vegetation conditions and cover. Analysis of the 2017 satellite image and field observations revealed variations in the vegetation composition as the distance increases away from the road. Vegetation in good condition was observed in the sites that were further away from the roads, in contrast to vegetation of poor conditions that was found in the sites closer to the roads. This was also supported by Sterck *et al.* (2014), who indicated that the presence of roads may disturb microclimatic conditions and reduce availability of resources for vegetation. Subsequently, plant species distribution may be affected and eventually, causing variations in vegetation structures and compositions (Hartshorn, 1980).

The impact of roads on local biodiversity mainly leads to alterations in species composition, especially with respect to changes in the abundance of native and alien species (Auerbach *et al.*, 1997; Forman & Alexander 1998; Gelbard & Belnap 2003). Disturbances from roads alter physicochemical states of nearby environments, thereby typically reducing the presence of nutrients and water (Forman & Alexander 1998; Greenberg *et al.*, 1997). Several studies also found that roads and their microhabitats are the mainly contributors of extinction to native species as a result of plant invasion (Forman & Alexander, 1998; Greenberg *et al.*, 1997; Mortensen *et al.*, 2009), especially

in arid and semi-arid regions (Buckley, 2001; Hochrein, 2008; Rooney, 2005). Gelbard and Belnap (2003) found that the percentage of vegetation cover of alien plant species was observed to be considerably greater at 10 m from roads than 1000 m. Da Silva *et al.* (2017) also noted that roads caused negative effects on vegetation composition to a distance of about 35 m from the road.

Implications emerging from the obtained results indicated a direct relationship between the presence of road and vegetation species cover. Greenberg *et al.* (1997) also indicated that roads improved the growth of aggressive alien plants and decreased the cover percentage of native vegetation near them. Gelbard and Belnap (2003) also found that the cover of native species was low at the roadside and high in areas further away from roads. Subsequently, lower vegetation coverage and species richness, and barer soil coverage were detected within 30 m of the road verge (Coffin, 2007). Nakanyala (2012) also highlighted in the trend toward lower basal cover and decreased biomass yield closer to roads within a distance of 50 m from the road. These results are also in agreement to those of Watkins *et al.* (2003), who found that plant species composition and abundance have been altered within close proximity to the road. In addition to that, it was observed on how frequencies of vegetation cover were maximal in less disturbed distances from the roads of up to 150 m compared to the distances of around 50 m. The low frequency of vegetation cover within a distance of 50 m suggests vegetation disturbance, and analysis of vegetation adjacent to the roads showed a significant relationship between road network and vegetation cover. Findings in the study are supported by those of Freitas *et al.* (2013), who found a stronger positive relationship between natural vegetation cover and road distance. Tree, shrub and grass species basal cover declined with increasing distance towards the roads, particularly at a distance of 50 m from roads.

The results by the current study also revealed that the presence of roads in the environment plays a substantial role in shaping the height of local vegetation. Several studies also revealed that plant species reflect different extents of vulnerability to road use intensity (Brown & Schoknecht, 2001; Kutiel *et al.*, 2000), which consequently leads to dynamics in vegetation height (Kelly, 2014; Kinugasa & Oda, 2014). In the current study, it was observed that the heights of plants responded negatively as the distance was reduced towards the road. Kutiel *et al.* (2000) also noted the decrease in the height of woody vegetation when the distance extends away from the road. Cole (1987) also reported a decline in vegetation heights near roads.

6.4 Conclusions

Findings suggest that vegetation condition can be explained by road network. The current study has provided insights into the understanding of road impacts on natural vegetation in the study area. The main aim of this study was to investigate the impacts of road networks on natural vegetation.

An assessment of the spatial extent of vegetation, using supervised classification, revealed the onset of vegetation condition deterioration within close proximity to the roads of the study area. This made it possible to extract vegetation composition classes, used to assess vegetation condition. Chapter five reported the result on the impact of road network on natural vegetation. Evidence acquired suggests that there is a statistically significant relationship between vegetation and road network. Hence it is concluded that road network has an obvious impact on roadside natural vegetation, especially vegetation within the road vicinity. In view of the above findings, the general hypothesis of this study, namely, “the amount and condition of roadside vegetation could be explained by road network conditions” is accepted. The integration of spatial data, fieldwork and satellite imagery analysis was utilized to achieve objectives of the study. Furthermore, all the methodological approaches employed in this study were found to be reliable in analysing the relationship between road network and natural vegetation. The results obtained in this study have revealed that satellite data and GIS technologies provide a free, effective and timely means of obtaining useful information on the spatial distribution of vegetation. These technologies have the ability to investigate the roadside vegetation, where detailed field work remained a challenge in getting access to survey sites in the study area. For that reason, it was concluded in this study that applications of remote sensing can help in simplifying fieldwork or to some degree, even substituting it.

6.5 Research limitations

Limitations were identified during assessment of the impact of road network on natural vegetation using an integrated GIS-remote sensing methodology. The experienced research limitations, however, did not have any significant impact on achieving the purpose of this research. Limitations identified are as follows:

- The main limiting factor in this research was to obtain ground truth data. Obtaining ground truth data was challenging for this research because some areas of interest were demarcated as protected area.
- Difficulties in the field sampling of natural vegetation due to inability to access some areas of interest that are considered private properties. Some of the natural vegetation was found in protected area and could not be included for sampling.
- The aim of the study was to utilise an image acquired in March 2017, however, it became a challenge because the area of interest was covered in clouds and as result the image acquired in April 2017 was utilised.
- Similarity in spectral characteristics of riparian vegetation and irrigation supported crops posed challenges in dealing with the spectral characteristics of healthy natural vegetation.

- The influence of riparian vegetation and cultivated land on the NDVI values for determining the condition of natural vegetation. Riparian vegetation within close proximity to the road does not show degradation because they have advantage of water availability.
- Produced NDVI maps from buffer analysis procedures were not visible enough due to a low scale.
- The influence of the environmental and climatic factors that may have contributed on the vegetation condition in the area and needs to be investigated.

6.6. Recommendations

A contemplation of the results obtained in this study revealed that roads are human-induced features that have serious negative impacts on natural vegetation condition in the study area. Having successfully determined the impacts of roads on natural vegetation cover and condition, the following recommendations are made, with regard to actions to be taken as remedial path to reversing the current situation in the study area:

- Mitigation strategies need to be put in place to decrease the impact of road network on vegetation.
- To ensure that there are limited negative impacts onto the natural resources such as vegetation, there is a need to encourage the usage of environmentally friendly materials for road upgrading.
- Remote Sensing and GIS techniques must be used in building a spatial database for roadside vegetation management.
- Using Remote Sensing data such as satellite images could enhance conservation operations because it would be easy to update digital data, creating abilities to facilitate future road extension plans.
- The Department of Transport and Safety must conduct regular assessment of roadside conditions as a diagnostic measure and to provide early warning about the deterioration of vegetation condition.

6.7 Research contribution to knowledge

This study managed to fill the gap in understanding ecological impacts of road networks using GIS and remote sensing applications; to help reduce the environmental impact of roads. The study provides a baseline knowledge regarding roadside vegetation and would be helpful in future for conservation of biodiversity along the road verges and improvements of road verges. Filling this gap is of significance to road authorities in their development and implementation of road maintenance and construction; and to the environmental conservationists.

6.8 Recommendations for further investigations

Road networks were constructed for the purpose of development, by making human mobility effective and for transportation of commodities. However, they have resulted in permanent alteration of the natural environment. The findings from this study therefore, contribute to existing research and hence further support scientific knowledge of the impacts of roads on vegetation. Additionally, the findings in this study have laid a foundation for possible environmentally friendly and sustainable road construction and maintenance systems. Implications emerging from the results of this study suggest the following recommendation:

- To investigate the impacts of road network on vegetation, focusing more on temporal scale
- To investigate the implications of the high spatial resolution data on the results obtained by the current study
- To investigate variations in plant tolerance from near-road environment to those environments further away from roads
- To investigate distribution in soil nutrients and moisture as the distance extends away from the roads
- To investigate influence of other anthropogenic activities on the conditions of vegetation in the study area

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APPENDIX A: ACCURACY ASSESSMENT RESULTS

Table 5.1 Accuracy Assessment Error Matrix (columns: truth) (rows: mapped)

Predicted	Ground truth				Totals	Error C
	Healthy vegetation	Degraded vegetation	Bare surface	Water		
Healthy vegetation	84	1	0	0	85	0.2112
Degraded vegetation	2	77	8	0	87	0.1149
Bare surface	1	11	86	0	98	0.1224
Water	0	0	0	10	10	0
Total	87	89	94	10	257	
Error O	0.4286	0.1348	0.0851	0		
Overall accuracy	0.885					
KIA	0.7992					

APPENDIX B: MULTINOMIAL REGRESSION ANALYSIS RESULTS

Table B1: Multinomial logistic regression analysis results for vegetation condition and tarred road network relationship.

XLSTAT 2017.03.45111 - Logistic regression - Start time: 2017/06/16 at 03:21:55 PM / End time: 2017/06/16 at 03:22:54 PM											
Response variable(s): Workbook = regression.xlsx / Sheet = Major roads (N4,R49) / Range = 'Major roads (N4,R49)!\$B\$1:\$B\$181 / 180 rows and 1 column											
Quantitative: Workbook = regression.xlsx / Sheet = Major roads (N4,R49) / Range = 'Major roads (N4,R49)!\$A\$1:\$A\$181 / 180 rows and 1 column											
Model: Logit											
Response type: Multinomial											
Control category: 0.079211											
Confidence interval (%): 95											
Stop conditions: Iterations = 100 / Convergence = 0.000001											
Maximization of the likelihood function using the Newton-Raphson algorithm											
Summary statistics:											
Variable	Categories	Frequencies	%								
NDVI value	0.079211	1	0.556								
	0.105689	1	0.556								
	0.112757	1	0.556								
	0.129613	1	0.556								
	0.14485	1	0.556								
	0.154624	1	0.556								
	0.155358	1	0.556								
	0.158236	1	0.556								
	0.163244	1	0.556								
	0.164542	1	0.556								
	0.173915	1	0.556								
	0.183214	1	0.556								
	0.187005	1	0.556								
	0.189694	1	0.556								

	0.190872	1	0.556								
	0.191018	1	0.556								
	0.191445	1	0.556								
	0.19398	1	0.556								
	0.194443	1	0.556								
	0.196169	1	0.556								
	0.198786	1	0.556								
	0.201558	1	0.556								
	0.202241	1	0.556								
	0.202938	1	0.556								
	0.204616	1	0.556								
	0.20521	1	0.556								
	0.20561	1	0.556								
	0.206287	1	0.556								
	0.206309	1	0.556								
	0.207248	1	0.556								
	0.20732	1	0.556								
	0.208366	1	0.556								
	0.208727	1	0.556								
	0.20875	1	0.556								
	0.208986	1	0.556								
	0.213301	1	0.556								
	0.213514	1	0.556								
	0.213621	1	0.556								
	0.213688	1	0.556								
	0.214737	1	0.556								
	0.215294	1	0.556								
	0.215298	1	0.556								
	0.215518	1	0.556								
	0.217745	1	0.556								

	0.217825	1	0.556								
	0.218597	1	0.556								
	0.21898	1	0.556								
	0.219444	1	0.556								
	0.220434	1	0.556								
	0.220835	1	0.556								
	0.221105	1	0.556								
	0.223993	1	0.556								
	0.224954	1	0.556								
	0.225589	1	0.556								
	0.228081	1	0.556								
	0.229187	1	0.556								
	0.231005	1	0.556								
	0.231644	1	0.556								
	0.232222	1	0.556								
	0.232308	1	0.556								
	0.232518	1	0.556								
	0.232853	1	0.556								
	0.233564	1	0.556								
	0.233757	1	0.556								
	0.23427	1	0.556								
	0.234522	1	0.556								
	0.234679	1	0.556								
	0.235048	1	0.556								
	0.235059	1	0.556								
	0.235532	1	0.556								
	0.235728	1	0.556								
	0.235982	1	0.556								
	0.236993	1	0.556								
	0.238476	1	0.556								

	0.238723	1	0.556								
	0.239233	1	0.556								
	0.240352	1	0.556								
	0.240864	1	0.556								
	0.242348	1	0.556								
	0.244034	1	0.556								
	0.244152	1	0.556								
	0.244571	1	0.556								
	0.246534	1	0.556								
	0.246571	1	0.556								
	0.246702	1	0.556								
	0.247218	1	0.556								
	0.247539	1	0.556								
	0.247597	1	0.556								
	0.24857	1	0.556								
	0.248848	1	0.556								
	0.249136	1	0.556								
	0.249926	1	0.556								
	0.250026	1	0.556								
	0.250071	1	0.556								
	0.250236	1	0.556								
	0.251538	1	0.556								
	0.251972	1	0.556								
	0.253332	1	0.556								
	0.253662	1	0.556								
	0.254231	1	0.556								
	0.254241	1	0.556								
	0.254824	1	0.556								
	0.2551	1	0.556								
	0.255485	1	0.556								

	0.255812	1	0.556								
	0.25614	1	0.556								
	0.256423	1	0.556								
	0.256809	1	0.556								
	0.25749	1	0.556								
	0.258041	1	0.556								
	0.258561	1	0.556								
	0.258735	1	0.556								
	0.259421	1	0.556								
	0.260528	1	0.556								
	0.261127	1	0.556								
	0.261533	1	0.556								
	0.261904	1	0.556								
	0.262237	1	0.556								
	0.262452	1	0.556								
	0.262698	1	0.556								
	0.263359	1	0.556								
	0.264426	1	0.556								
	0.265013	1	0.556								
	0.265246	1	0.556								
	0.26792	1	0.556								
	0.268885	1	0.556								
	0.269603	1	0.556								
	0.26979	1	0.556								
	0.269791	1	0.556								
	0.270417	1	0.556								
	0.271025	1	0.556								
	0.271468	1	0.556								
	0.272577	1	0.556								
	0.272753	1	0.556								

	0.27292	1	0.556								
	0.274613	1	0.556								
	0.274671	1	0.556								
	0.274811	1	0.556								
	0.276216	1	0.556								
	0.276265	1	0.556								
	0.276622	1	0.556								
	0.277414	1	0.556								
	0.277998	1	0.556								
	0.279477	1	0.556								
	0.280862	1	0.556								
	0.281509	1	0.556								
	0.282232	1	0.556								
	0.282282	1	0.556								
	0.282601	1	0.556								
	0.282819	1	0.556								
	0.283333	1	0.556								
	0.283823	1	0.556								
	0.284442	1	0.556								
	0.284937	1	0.556								
	0.28642	1	0.556								
	0.286452	1	0.556								
	0.28657	1	0.556								
	0.287065	1	0.556								
	0.288237	1	0.556								
	0.289793	1	0.556								
	0.294313	1	0.556								
	0.294795	1	0.556								
	0.297884	1	0.556								
	0.301889	1	0.556								

	0.303825	1	0.556								
	0.306336	1	0.556								
	0.307838	1	0.556								
	0.312312	1	0.556								
	0.316356	1	0.556								
	0.316847	1	0.556								
	0.319865	1	0.556								
	0.327314	1	0.556								
	0.327726	1	0.556								
	0.328854	1	0.556								
	0.329317	1	0.556								
	0.33495	1	0.556								
	0.338484	1	0.556								
	0.348283	1	0.556								
	0.370386	1	0.556								
	0.383323	1	0.556								
Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation				
Buffer zones	180	0	180	1.000	3.000	2.000	0.819				
Regression of variable NDVI value:											
Goodness of fit statistics (Variable NDVI value):											
Statistic	Independent	Full									
Observations	180	180									

Sum of weights	180.000	180.000									
DF	179	-178									
-2 Log(Likelihood)	1869.464	1473.964									
R ² (McFadden)	0.000	0.212									
R ² (Cox and Snell)	0.000	0.889									
R ² (Nagelkerke)	0.000	0.889									
AIC	2227.464	2189.964									
SBC	2799.004	3333.043									
Iterations	0	20									
Test of the null hypothesis H0: Y=0.006 (Variable NDVI value):											
Statistic	DF	Chi-square	Pr > Chi ²								
-2 Log(Likelihood)	179	395.500	< 0.0001								
Score	179	180.000	0.465								
Wald	179	0.000	1.000								
Type II analysis (Variable NDVI value):											
Source	DF	Chi-square (Wald)	Pr > Wald	Chi-square (LR)	Pr > LR						
Buffer zones	179	0.000	1.000	395.500	< 0.0001						
Model parameters (Variable NDVI value):											
Category	Source	Value	Standard error	Wald Chi-Square	Pr > Chi ²	Wald Lower bound (95%)	Wald Upper bound (95%)	Odds ratio	Odds ratio Lower bound	Odds ratio Upper bound	

									d (95%)	d (95%)	
0.106	Intercept	-159.595	70215.842	0.000	0.998	-	137780.116	137460.926			
	Buffer zones	79.798	31469.163	0.000	0.998	-61598.628	61758.224				
0.113	Intercept	-0.001	31236.896	0.000	1.000	-61223.194	61223.191				
	Buffer zones	0.001	31236.896	0.000	1.000	-61223.190	61223.193				
0.130	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.145	Intercept	-0.001	31236.905	0.000	1.000	-61223.211	61223.208				
	Buffer zones	0.001	31236.905	0.000	1.000	-61223.207	61223.210				
0.155	Intercept	-0.001	31236.899	0.000	1.000	-61223.198	61223.195				
	Buffer zones	0.001	31236.898	0.000	1.000	-61223.194	61223.197				
0.155	Intercept	-0.001	31236.942	0.000	1.000	-61223.282	61223.279				
	Buffer zones	0.001	31236.942	0.000	1.000	-61223.279	61223.282				
0.158	Intercept	-159.595	70215.888	0.000	0.998	-	137780.207	137461.017			
	Buffer zones	79.798	31469.173	0.000	0.998	-61598.648	61758.245				
0.163	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.165	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.174	Intercept	-0.001	31236.943	0.000	1.000	-61223.285	61223.282				
	Buffer zones	0.001	31236.943	0.000	1.000	-61223.282	61223.285				
0.183	Intercept	-0.001	31236.920	0.000	1.000	-61223.240	61223.237				
	Buffer zones	0.001	31236.920	0.000	1.000	-61223.237	61223.240				
0.187	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.190	Intercept	-159.595	70215.851	0.000	0.998	-	137780.133	137460.943			

	Buffer zones	79.798	31469.171	0.000	0.998	-61598.643	61758.240				
0.191	Intercept	-0.001	31236.889	0.000	1.000	-61223.179	61223.176				
	Buffer zones	0.001	31236.889	0.000	1.000	-61223.176	61223.179				
0.191	Intercept	-159.595	70215.853	0.000	0.998	-	137780.138	137460.948			
	Buffer zones	79.798	31469.175	0.000	0.998	-61598.651	61758.247				
0.191	Intercept	-0.001	31236.948	0.000	1.000	-61223.294	61223.292				
	Buffer zones	0.001	31236.948	0.000	1.000	-61223.291	61223.294				
0.194	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.194	Intercept	-159.595	70215.857	0.000	0.998	-	137780.146	137460.956			
	Buffer zones	79.798	31469.164	0.000	0.998	-61598.629	61758.226				
0.196	Intercept	-159.595	70215.878	0.000	0.998	-	137780.187	137460.997			
	Buffer zones	79.798	31469.180	0.000	0.998	-61598.661	61758.258				
0.199	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.202	Intercept	-159.595	70215.842	0.000	0.998	-	137780.116	137460.926			
	Buffer zones	79.798	31469.158	0.000	0.998	-61598.619	61758.215				
0.202	Intercept	-0.001	31236.918	0.000	1.000	-61223.235	61223.232				
	Buffer zones	0.001	31236.917	0.000	1.000	-61223.232	61223.235				
0.203	Intercept	-159.595	70215.845	0.000	0.998	-	137780.123	137460.933			
	Buffer zones	79.798	31469.160	0.000	0.998	-61598.623	61758.219				
0.205	Intercept	-0.001	31236.910	0.000	1.000	-61223.219	61223.217				
	Buffer zones	0.001	31236.910	0.000	1.000	-61223.216	61223.219				
0.205	Intercept	-0.001	31236.902	0.000	1.000	-61223.204	61223.201				
	Buffer zones	0.001	31236.902	0.000	1.000	-61223.201	61223.204				
0.206	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				

	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.206	Intercept	-159.595	70215.857	0.000	0.998	-	137780.146	137460.957			
	Buffer zones	79.798	31469.172	0.000	0.998	-61598.646	61758.242				
0.206	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.207	Intercept	-0.001	31236.887	0.000	1.000	-61223.174	61223.171				
	Buffer zones	0.001	31236.887	0.000	1.000	-61223.171	61223.174				
0.207	Intercept	-159.595	70215.862	0.000	0.998	-	137780.155	137460.965			
	Buffer zones	79.798	31469.175	0.000	0.998	-61598.652	61758.248				
0.208	Intercept	-0.001	31236.901	0.000	1.000	-61223.202	61223.199				
	Buffer zones	0.001	31236.900	0.000	1.000	-61223.198	61223.201				
0.209	Intercept	-0.001	31236.953	0.000	1.000	-61223.304	61223.301				
	Buffer zones	0.001	31236.953	0.000	1.000	-61223.301	61223.304				
0.209	Intercept	-0.001	31236.863	0.000	1.000	-61223.127	61223.124				
	Buffer zones	0.001	31236.863	0.000	1.000	-61223.124	61223.127				
0.209	Intercept	-159.595	70215.848	0.000	0.998	-	137780.128	137460.939			
	Buffer zones	79.798	31469.170	0.000	0.998	-61598.642	61758.238				
0.213	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.214	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.214	Intercept	-159.595	70215.858	0.000	0.998	-	137780.148	137460.959			
	Buffer zones	79.798	31469.163	0.000	0.998	-61598.629	61758.225				
0.214	Intercept	-159.595	70215.845	0.000	0.998	-	137780.123	137460.933			
	Buffer zones	79.798	31469.159	0.000	0.998	-61598.621	61758.217				
0.215	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				

	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.215	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.215	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.216	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.218	Intercept	-159.595	70215.821	0.000	0.998	-	137780.074	137460.885			
	Buffer zones	79.798	31469.150	0.000	0.998	-61598.603	61758.199				
0.218	Intercept	-159.595	70215.824	0.000	0.998	-	137780.082	137460.892			
	Buffer zones	79.798	31469.151	0.000	0.998	-61598.604	61758.200				
0.219	Intercept	-0.001	31236.899	0.000	1.000	-61223.198	61223.195				
	Buffer zones	0.001	31236.899	0.000	1.000	-61223.195	61223.198				
0.219	Intercept	-159.595	70215.828	0.000	0.998	-	137780.088	137460.898			
	Buffer zones	79.798	31469.153	0.000	0.998	-61598.608	61758.204				
0.219	Intercept	-0.001	31236.940	0.000	1.000	-61223.280	61223.277				
	Buffer zones	0.001	31236.940	0.000	1.000	-61223.276	61223.279				
0.220	Intercept	-0.001	31236.887	0.000	1.000	-61223.175	61223.172				
	Buffer zones	0.001	31236.887	0.000	1.000	-61223.172	61223.175				
0.221	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.221	Intercept	-159.595	70215.833	0.000	0.998	-	137780.099	137460.909			
	Buffer zones	79.798	31469.163	0.000	0.998	-61598.628	61758.225				
0.224	Intercept	-159.595	70215.818	0.000	0.998	-	137780.069	137460.880			
	Buffer zones	79.798	31469.150	0.000	0.998	-61598.602	61758.199				
0.225	Intercept	-0.001	31236.917	0.000	1.000	-61223.235	61223.232				

	Buffer zones	0.001	31236.917	0.000	1.000	-61223.231	61223.234				
0.226	Intercept	-159.595	70215.829	0.000	0.998	-	137780.090	137460.900			
	Buffer zones	79.798	31469.162	0.000	0.998	-61598.625	61758.221				
0.228	Intercept	-0.001	31236.854	0.000	1.000	-61223.111	61223.108				
	Buffer zones	0.001	31236.854	0.000	1.000	-61223.108	61223.110				
0.229	Intercept	-159.595	70215.815	0.000	0.998	-	137780.063	137460.873			
	Buffer zones	79.798	31469.158	0.000	0.998	-61598.619	61758.215				
0.231	Intercept	-0.001	31236.910	0.000	1.000	-61223.219	61223.216				
	Buffer zones	0.001	31236.910	0.000	1.000	-61223.216	61223.219				
0.232	Intercept	-0.001	31236.882	0.000	1.000	-61223.165	61223.162				
	Buffer zones	0.001	31236.882	0.000	1.000	-61223.162	61223.164				
0.232	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.232	Intercept	-159.595	70215.840	0.000	0.998	-	137780.112	137460.922			
	Buffer zones	79.798	31469.165	0.000	0.998	-61598.632	61758.228				
0.233	Intercept	-0.001	31236.891	0.000	1.000	-61223.183	61223.180				
	Buffer zones	0.001	31236.891	0.000	1.000	-61223.180	61223.183				
0.233	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.234	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.234	Intercept	-0.001	31236.920	0.000	1.000	-61223.240	61223.237				
	Buffer zones	0.001	31236.920	0.000	1.000	-61223.237	61223.240				
0.234	Intercept	-159.595	70215.846	0.000	0.998	-	137780.124	137460.934			
	Buffer zones	79.798	31469.158	0.000	0.998	-61598.618	61758.215				
0.235	Intercept	-0.001	31236.905	0.000	1.000	-61223.210	61223.207				
	Buffer zones	0.001	31236.905	0.000	1.000	-61223.206	61223.209				

0.235	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.235	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.235	Intercept	-159.595	70215.833	0.000	0.998	-	137780.098	137460.909			
	Buffer zones	79.798	31469.156	0.000	0.998	-61598.614	61758.210				
0.236	Intercept	-0.001	31236.895	0.000	1.000	-61223.190	61223.187				
	Buffer zones	0.001	31236.895	0.000	1.000	-61223.187	61223.190				
0.236	Intercept	-0.001	31236.887	0.000	1.000	-61223.174	61223.171				
	Buffer zones	0.001	31236.886	0.000	1.000	-61223.171	61223.174				
0.236	Intercept	-159.595	70215.836	0.000	0.998	-	137780.105	137460.915			
	Buffer zones	79.798	31469.166	0.000	0.998	-61598.633	61758.229				
0.237	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.238	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.239	Intercept	-159.595	70215.861	0.000	0.998	-	137780.153	137460.963			
	Buffer zones	79.798	31469.161	0.000	0.998	-61598.625	61758.221				
0.239	Intercept	-0.001	31236.896	0.000	1.000	-61223.192	61223.189				
	Buffer zones	0.001	31236.895	0.000	1.000	-61223.189	61223.191				
0.240	Intercept	-0.001	31236.953	0.000	1.000	-61223.305	61223.302				
	Buffer zones	0.001	31236.953	0.000	1.000	-61223.302	61223.305				
0.241	Intercept	-0.001	31236.879	0.000	1.000	-61223.160	61223.157				
	Buffer zones	0.001	31236.879	0.000	1.000	-61223.157	61223.160				
0.242	Intercept	-159.595	70215.799	0.000	0.998	-	137780.031	137460.842			
	Buffer zones	79.798	31469.147	0.000	0.998	-61598.597	61758.193				
0.244	Intercept	-0.001	31236.902	0.000	1.000	-61223.205	61223.202				

	Buffer zones	0.001	31236.902	0.000	1.000	-61223.202	61223.205				
0.244	Intercept	-159.595	70215.886	0.000	0.998	-	137780.202	137461.012			
	Buffer zones	79.798	31469.178	0.000	0.998	-61598.658	61758.254				
0.245	Intercept	-0.001	31236.914	0.000	1.000	-61223.229	61223.226				
	Buffer zones	0.001	31236.914	0.000	1.000	-61223.226	61223.228				
0.247	Intercept	-0.001	31236.929	0.000	1.000	-61223.258	61223.255				
	Buffer zones	0.001	31236.929	0.000	1.000	-61223.255	61223.258				
0.247	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.247	Intercept	-159.595	70215.845	0.000	0.998	-	137780.121	137460.932			
	Buffer zones	79.798	31469.168	0.000	0.998	-61598.637	61758.234				
0.247	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.248	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.248	Intercept	-159.595	70215.861	0.000	0.998	-	137780.153	137460.964			
	Buffer zones	79.798	31469.164	0.000	0.998	-61598.630	61758.226				
0.249	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.249	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.249	Intercept	-159.595	70215.870	0.000	0.998	-	137780.172	137460.982			
	Buffer zones	79.798	31469.176	0.000	0.998	-61598.653	61758.249				
0.250	Intercept	-0.001	31236.890	0.000	1.000	-61223.182	61223.179				
	Buffer zones	0.001	31236.890	0.000	1.000	-61223.179	61223.182				
0.250	Intercept	-0.001	31236.929	0.000	1.000	-61223.258	61223.255				
	Buffer zones	0.001	31236.929	0.000	1.000	-61223.254	61223.257				

0.250	Intercept	-0.001	31236.894	0.000	1.000	-61223.189	61223.186				
	Buffer zones	0.001	31236.894	0.000	1.000	-61223.186	61223.189				
0.250	Intercept	-0.001	31236.891	0.000	1.000	-61223.183	61223.180				
	Buffer zones	0.001	31236.891	0.000	1.000	-61223.179	61223.182				
0.252	Intercept	-159.595	70215.856	0.000	0.998	-	137780.145	137460.955			
	Buffer zones	79.798	31469.161	0.000	0.998	-61598.625	61758.221				
0.252	Intercept	-0.001	31236.943	0.000	1.000	-61223.285	61223.282				
	Buffer zones	0.001	31236.943	0.000	1.000	-61223.282	61223.285				
0.253	Intercept	-159.595	70215.863	0.000	0.998	-	137780.157	137460.967			
	Buffer zones	79.798	31469.163	0.000	0.998	-61598.629	61758.225				
0.254	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.254	Intercept	-0.001	31236.905	0.000	1.000	-61223.210	61223.207				
	Buffer zones	0.001	31236.905	0.000	1.000	-61223.207	61223.210				
0.254	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.255	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.255	Intercept	-159.595	70215.859	0.000	0.998	-	137780.150	137460.961			
	Buffer zones	79.798	31469.163	0.000	0.998	-61598.629	61758.225				
0.255	Intercept	-159.595	70215.800	0.000	0.998	-	137780.033	137460.844			
	Buffer zones	79.798	31469.151	0.000	0.998	-61598.604	61758.200				
0.256	Intercept	-0.001	31236.882	0.000	1.000	-61223.165	61223.162				
	Buffer zones	0.001	31236.882	0.000	1.000	-61223.162	61223.165				
0.256	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.256	Intercept	-0.001	31236.885	0.000	1.000	-61223.172	61223.169				

	Buffer zones	0.001	31236.885	0.000	1.000	-61223.168	61223.171				
0.257	Intercept	-0.001	31236.895	0.000	1.000	-61223.190	61223.187				
	Buffer zones	0.001	31236.895	0.000	1.000	-61223.187	61223.190				
0.257	Intercept	-159.595	70215.868	0.000	0.998	-	137780.167	137460.978			
	Buffer zones	79.798	31469.165	0.000	0.998	-61598.633	61758.229				
0.258	Intercept	-0.001	31236.884	0.000	1.000	-61223.170	61223.167				
	Buffer zones	0.001	31236.884	0.000	1.000	-61223.167	61223.170				
0.259	Intercept	-0.001	31236.852	0.000	1.000	-61223.106	61223.103				
	Buffer zones	0.001	31236.852	0.000	1.000	-61223.103	61223.106				
0.259	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.259	Intercept	-159.595	70215.840	0.000	0.998	-	137780.113	137460.923			
	Buffer zones	79.798	31469.171	0.000	0.998	-61598.643	61758.239				
0.261	Intercept	-0.001	31236.896	0.000	1.000	-61223.193	61223.190				
	Buffer zones	0.001	31236.896	0.000	1.000	-61223.190	61223.193				
0.261	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.262	Intercept	-0.001	31236.928	0.000	1.000	-61223.255	61223.253				
	Buffer zones	0.001	31236.928	0.000	1.000	-61223.252	61223.255				
0.262	Intercept	-159.595	70215.843	0.000	0.998	-	137780.119	137460.930			
	Buffer zones	79.798	31469.169	0.000	0.998	-61598.639	61758.235				
0.262	Intercept	-0.001	31236.885	0.000	1.000	-61223.170	61223.167				
	Buffer zones	0.001	31236.885	0.000	1.000	-61223.167	61223.170				
0.262	Intercept	-159.595	70215.877	0.000	0.998	-	137780.185	137460.995			
	Buffer zones	79.798	31469.167	0.000	0.998	-61598.635	61758.231				
0.263	Intercept	-159.595	70215.851	0.000	0.998	-	137780.133	137460.943			

	Buffer zones	79.798	31469.160	0.000	0.998	-61598.621	61758.218				
0.263	Intercept	-159.595	70215.844	0.000	0.998	-	137780.120	137460.930			
	Buffer zones	79.798	31469.160	0.000	0.998	-61598.621	61758.218				
0.264	Intercept	-0.001	31236.890	0.000	1.000	-61223.181	61223.178				
	Buffer zones	0.001	31236.890	0.000	1.000	-61223.178	61223.181				
0.265	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.265	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.268	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.269	Intercept	-159.595	70215.770	0.000	0.998	-	137779.975	137460.786			
	Buffer zones	79.798	31469.151	0.000	0.998	-61598.604	61758.200				
0.270	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.270	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.270	Intercept	-159.595	70215.786	0.000	0.998	-	137780.006	137460.816			
	Buffer zones	79.798	31469.154	0.000	0.998	-61598.610	61758.206				
0.270	Intercept	-159.595	70215.860	0.000	0.998	-	137780.152	137460.962			
	Buffer zones	79.798	31469.161	0.000	0.998	-61598.623	61758.219				
0.271	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.271	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.273	Intercept	-0.001	31236.839	0.000	1.000	-61223.081	61223.078				
	Buffer zones	0.001	31236.839	0.000	1.000	-61223.078	61223.081				

0.273	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.273	Intercept	-159.595	70215.804	0.000	0.998	-	137780.041	137460.851			
	Buffer zones	79.798	31469.147	0.000	0.998	-61598.597	61758.193				
0.275	Intercept	-159.595	70215.807	0.000	0.998	-	137780.047	137460.857			
	Buffer zones	79.798	31469.158	0.000	0.998	-61598.619	61758.215				
0.275	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.275	Intercept	-0.001	31236.843	0.000	1.000	-61223.090	61223.087				
	Buffer zones	0.001	31236.843	0.000	1.000	-61223.086	61223.089				
0.276	Intercept	-0.001	31236.875	0.000	1.000	-61223.151	61223.148				
	Buffer zones	0.001	31236.875	0.000	1.000	-61223.148	61223.151				
0.276	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.277	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.277	Intercept	-159.595	70215.856	0.000	0.998	-	137780.143	137460.953			
	Buffer zones	79.798	31469.162	0.000	0.998	-61598.626	61758.222				
0.278	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.279	Intercept	-0.001	31236.926	0.000	1.000	-61223.252	61223.249				
	Buffer zones	0.001	31236.926	0.000	1.000	-61223.249	61223.252				
0.281	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.282	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.282	Intercept	-0.001	31236.873	0.000	1.000	-61223.148	61223.145				
	Buffer zones	0.001	31236.873	0.000	1.000	-61223.145	61223.148				

0.282	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.283	Intercept	-159.595	70215.819	0.000	0.998	-	137780.072	137460.882			
	Buffer zones	79.798	31469.153	0.000	0.998	-61598.609	61758.205				
0.283	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.283	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.284	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.284	Intercept	-0.001	31236.899	0.000	1.000	-61223.199	61223.196				
	Buffer zones	0.001	31236.899	0.000	1.000	-61223.196	61223.198				
0.285	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.286	Intercept	-0.001	31236.842	0.000	1.000	-61223.086	61223.083				
	Buffer zones	0.001	31236.841	0.000	1.000	-61223.083	61223.086				
0.286	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.287	Intercept	-159.595	70215.846	0.000	0.998	-	137780.125	137460.935			
	Buffer zones	79.798	31469.164	0.000	0.998	-61598.631	61758.227				
0.287	Intercept	-0.001	31236.882	0.000	1.000	-61223.166	61223.163				
	Buffer zones	0.001	31236.882	0.000	1.000	-61223.162	61223.165				
0.288	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.290	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.294	Intercept	-159.595	70215.819	0.000	0.998	-	137780.071	137460.882			
	Buffer zones	79.798	31469.169	0.000	0.998	-61598.641	61758.237				

0.295	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.298	Intercept	-0.001	31236.904	0.000	1.000	-61223.208	61223.205				
	Buffer zones	0.001	31236.904	0.000	1.000	-61223.205	61223.208				
0.302	Intercept	-159.595	70215.830	0.000	0.998	-	137780.093	137460.904			
	Buffer zones	79.798	31469.172	0.000	0.998	-61598.645	61758.241				
0.304	Intercept	-159.595	70215.835	0.000	0.998	-	137780.103	137460.914			
	Buffer zones	79.798	31469.162	0.000	0.998	-61598.626	61758.222				
0.306	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.308	Intercept	-159.595	70215.848	0.000	0.998	-	137780.128	137460.939			
	Buffer zones	79.798	31469.176	0.000	0.998	-61598.654	61758.250				
0.312	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.316	Intercept	-0.001	31236.847	0.000	1.000	-61223.096	61223.093				
	Buffer zones	0.001	31236.847	0.000	1.000	-61223.093	61223.096				
0.317	Intercept	-159.595	70215.842	0.000	0.998	-	137780.117	137460.927			
	Buffer zones	79.798	31469.164	0.000	0.998	-61598.629	61758.225				
0.320	Intercept	-159.595	70215.850	0.000	0.998	-	137780.133	137460.943			
	Buffer zones	79.798	31469.165	0.000	0.998	-61598.632	61758.229				
0.327	Intercept	-0.001	31236.861	0.000	1.000	-61223.124	61223.121				
	Buffer zones	0.001	31236.861	0.000	1.000	-61223.121	61223.124				
0.328	Intercept	-159.595	70215.827	0.000	0.998	-	137780.087	137460.897			
	Buffer zones	79.798	31469.169	0.000	0.998	-61598.640	61758.237				
0.329	Intercept	-159.595	70215.863	0.000	0.998	-	137780.158	137460.968			

	Buffer zones	79.798	31469.168	0.000	0.998	-61598.637	61758.234				
0.329	Intercept	-159.595	70215.857	0.000	0.998	-	137780.146	137460.956			
	Buffer zones	79.798	31469.166	0.000	0.998	-61598.634	61758.230				
0.335	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.338	Intercept	-159.595	70215.828	0.000	0.998	-	137780.088	137460.899			
	Buffer zones	79.798	31469.169	0.000	0.998	-61598.640	61758.236				
0.348	Intercept	-159.595	70215.806	0.000	0.998	-	137780.046	137460.857			
	Buffer zones	79.798	31469.167	0.000	0.998	-61598.635	61758.231				
0.370	Intercept	-59.794	37099.929	0.000	0.999	-72774.319	72654.731				
	Buffer zones	39.900	26657.678	0.000	0.999	-52208.189	52287.988				
0.383	Intercept	-159.595	70215.797	0.000	0.998	-	137780.027	137460.838			
	Buffer zones	79.798	31469.164	0.000	0.998	-61598.629	61758.226				

Table B1: Multinomial logistic regression analysis results for vegetation condition and untarred road network relationship.

XLSTAT 2017.03.45137 - Logistic regression - Start time: 2017/06/16 at 06:10:06 PM / End time: 2017/06/16 at 06:19:58 PM											
Response variable(s): Workbook = regression.xlsx / Sheet = Local roads / Range = 'Local roads'!\$B:\$B / 360 rows and 1 column											
Quantitative: Workbook = regression.xlsx / Sheet = Local roads / Range = 'Local roads'!\$A\$1:\$A\$361 / 360 rows and 1 column											
Model: Logit											
Response type: Multinomial											
Control category: 0.111566											
Confidence interval (%): 95											
Stop conditions: Iterations = 100 / Convergence = 0.000001											
Maximization of the likelihood function using the Newton-Raphson algorithm											
Summary statistics:											
Variable	Categories	Frequencies	%								
NDVI VALUE	0.111566	1	0.278								
	0.123023	1	0.278								
	0.123699	1	0.278								
	0.129229	1	0.278								
	0.134143	1	0.278								
	0.138506	1	0.278								
	0.142336	1	0.278								
	0.14338	1	0.278								
	0.144308	1	0.278								
	0.14719	1	0.278								
	0.150754	1	0.278								

	0.15202	1	0.278								
	0.152255	1	0.278								
	0.152437	1	0.278								
	0.154355	1	0.278								
	0.155343	1	0.278								
	0.156942	1	0.278								
	0.164266	1	0.278								
	0.165035	1	0.278								
	0.165791	1	0.278								
	0.16719	1	0.278								
	0.167222	1	0.278								
	0.16844	1	0.278								
	0.170596	1	0.278								
	0.17143	1	0.278								
	0.17154	1	0.278								
	0.171717	1	0.278								
	0.173051	1	0.278								
	0.174726	1	0.278								
	0.175159	1	0.278								
	0.17687	1	0.278								
	0.177232	1	0.278								
	0.181502	1	0.278								
	0.181766	1	0.278								
	0.182165	1	0.278								
	0.182373	1	0.278								
	0.18279	1	0.278								
	0.183492	1	0.278								
	0.18376	1	0.278								
	0.184508	1	0.278								
	0.184685	1	0.278								

	0.185999	1	0.278								
	0.186285	1	0.278								
	0.186572	1	0.278								
	0.187154	1	0.278								
	0.18749	1	0.278								
	0.18785	1	0.278								
	0.188387	1	0.278								
	0.189801	1	0.278								
	0.189923	1	0.278								
	0.189973	1	0.278								
	0.191311	1	0.278								
	0.191902	1	0.278								
	0.192532	1	0.278								
	0.193108	1	0.278								
	0.193302	1	0.278								
	0.19375	1	0.278								
	0.195024	1	0.278								
	0.1957	1	0.278								
	0.197178	1	0.278								
	0.197412	1	0.278								
	0.197431	1	0.278								
	0.197963	1	0.278								
	0.198844	1	0.278								
	0.199256	1	0.278								
	0.199378	1	0.278								
	0.199918	1	0.278								
	0.200629	1	0.278								
	0.202546	1	0.278								
	0.202914	1	0.278								
	0.203871	1	0.278								

	0.204091	1	0.278								
	0.204193	1	0.278								
	0.204348	1	0.278								
	0.20448	1	0.278								
	0.20462	1	0.278								
	0.204848	1	0.278								
	0.204964	1	0.278								
	0.20574	1	0.278								
	0.205878	1	0.278								
	0.205885	1	0.278								
	0.206589	1	0.278								
	0.20664	1	0.278								
	0.20712	1	0.278								
	0.207134	1	0.278								
	0.207316	1	0.278								
	0.207349	1	0.278								
	0.207412	1	0.278								
	0.207994	1	0.278								
	0.208323	1	0.278								
	0.208477	1	0.278								
	0.209322	1	0.278								
	0.210259	1	0.278								
	0.210712	1	0.278								
	0.211193	1	0.278								
	0.211295	1	0.278								
	0.211318	1	0.278								
	0.211592	1	0.278								
	0.212386	1	0.278								
	0.212448	1	0.278								
	0.212646	1	0.278								

	0.212659	1	0.278								
	0.212847	1	0.278								
	0.212954	1	0.278								
	0.213095	1	0.278								
	0.213139	1	0.278								
	0.213641	1	0.278								
	0.213982	1	0.278								
	0.214278	1	0.278								
	0.214307	1	0.278								
	0.214413	1	0.278								
	0.214916	1	0.278								
	0.215151	1	0.278								
	0.215848	1	0.278								
	0.217119	1	0.278								
	0.217286	1	0.278								
	0.218321	1	0.278								
	0.218502	1	0.278								
	0.218556	1	0.278								
	0.218618	1	0.278								
	0.218864	1	0.278								
	0.219805	1	0.278								
	0.220175	1	0.278								
	0.220265	1	0.278								
	0.220711	1	0.278								
	0.220721	1	0.278								
	0.220835	1	0.278								
	0.220855	1	0.278								
	0.220881	1	0.278								
	0.221097	1	0.278								
	0.221582	1	0.278								

	0.22184	1	0.278								
	0.222484	1	0.278								
	0.222508	1	0.278								
	0.222516	1	0.278								
	0.222876	1	0.278								
	0.223145	1	0.278								
	0.223157	1	0.278								
	0.223521	1	0.278								
	0.223806	1	0.278								
	0.223832	1	0.278								
	0.223926	1	0.278								
	0.224643	1	0.278								
	0.225349	1	0.278								
	0.225764	1	0.278								
	0.226286	1	0.278								
	0.226363	1	0.278								
	0.226766	1	0.278								
	0.227224	1	0.278								
	0.227309	1	0.278								
	0.227708	1	0.278								
	0.228107	1	0.278								
	0.228195	1	0.278								
	0.228577	1	0.278								
	0.228596	1	0.278								
	0.229275	1	0.278								
	0.22932	1	0.278								
	0.2296	1	0.278								
	0.229663	1	0.278								
	0.229798	1	0.278								
	0.230035	1	0.278								

	0.230184	1	0.278								
	0.230379	1	0.278								
	0.230391	1	0.278								
	0.230411	1	0.278								
	0.230464	1	0.278								
	0.230623	1	0.278								
	0.230671	1	0.278								
	0.230729	1	0.278								
	0.231075	1	0.278								
	0.231387	1	0.278								
	0.231564	1	0.278								
	0.231584	1	0.278								
	0.231611	1	0.278								
	0.23209	1	0.278								
	0.232096	1	0.278								
	0.232138	1	0.278								
	0.23233	1	0.278								
	0.23268	1	0.278								
	0.233081	1	0.278								
	0.233132	1	0.278								
	0.233252	1	0.278								
	0.233491	1	0.278								
	0.233627	1	0.278								
	0.233768	1	0.278								
	0.234732	1	0.278								
	0.235291	1	0.278								
	0.235591	1	0.278								
	0.235988	1	0.278								
	0.23634	1	0.278								
	0.236401	1	0.278								

	0.236529	1	0.278								
	0.236541	1	0.278								
	0.237064	1	0.278								
	0.237783	1	0.278								
	0.238709	1	0.278								
	0.239466	1	0.278								
	0.239723	1	0.278								
	0.239827	1	0.278								
	0.240363	1	0.278								
	0.240947	1	0.278								
	0.240964	1	0.278								
	0.241301	1	0.278								
	0.241706	1	0.278								
	0.241861	1	0.278								
	0.242411	1	0.278								
	0.242459	1	0.278								
	0.242703	1	0.278								
	0.242989	1	0.278								
	0.243046	1	0.278								
	0.243171	1	0.278								
	0.243326	1	0.278								
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	0.243511	1	0.278								
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	0.244971	1	0.278								
	0.244978	1	0.278								
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	0.245968	1	0.278								
	0.246554	1	0.278								

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	0.247071	1	0.278								
	0.247198	1	0.278								
	0.247426	1	0.278								
	0.247812	1	0.278								
	0.248534	1	0.278								
	0.248981	1	0.278								
	0.249155	1	0.278								
	0.249331	1	0.278								
	0.249787	1	0.278								
	0.249914	1	0.278								
	0.250185	1	0.278								
	0.250382	1	0.278								
	0.250558	1	0.278								
	0.250899	1	0.278								
	0.250941	1	0.278								
	0.251274	1	0.278								
	0.251649	1	0.278								
	0.251717	1	0.278								
	0.252195	1	0.278								
	0.253508	1	0.278								
	0.253659	1	0.278								
	0.254298	1	0.278								
	0.255421	1	0.278								
	0.255434	1	0.278								
	0.256075	1	0.278								
	0.256326	1	0.278								
	0.256565	1	0.278								
	0.256611	1	0.278								

	0.256975	1	0.278								
	0.257267	1	0.278								
	0.257945	1	0.278								
	0.258289	1	0.278								
	0.258551	1	0.278								
	0.259209	1	0.278								
	0.25998	1	0.278								
	0.259982	1	0.278								
	0.260087	1	0.278								
	0.260217	1	0.278								
	0.26069	1	0.278								
	0.261305	1	0.278								
	0.261916	1	0.278								
	0.262957	1	0.278								
	0.263093	1	0.278								
	0.263671	1	0.278								
	0.263785	1	0.278								
	0.264551	1	0.278								
	0.264935	1	0.278								
	0.265391	1	0.278								
	0.26562	1	0.278								
	0.265883	1	0.278								
	0.266653	1	0.278								
	0.2667	1	0.278								
	0.267014	1	0.278								
	0.26714	1	0.278								
	0.267145	1	0.278								
	0.267945	1	0.278								
	0.268813	1	0.278								
	0.268947	1	0.278								

	0.269147	1	0.278								
	0.269362	1	0.278								
	0.270493	1	0.278								
	0.271298	1	0.278								
	0.271805	1	0.278								
	0.272219	1	0.278								
	0.272441	1	0.278								
	0.272699	1	0.278								
	0.273132	1	0.278								
	0.273455	1	0.278								
	0.273854	1	0.278								
	0.273897	1	0.278								
	0.275121	1	0.278								
	0.275539	1	0.278								
	0.276433	1	0.278								
	0.276661	1	0.278								
	0.277228	1	0.278								
	0.27734	1	0.278								
	0.277945	1	0.278								
	0.278062	1	0.278								
	0.278709	1	0.278								
	0.279579	1	0.278								
	0.281115	1	0.278								
	0.281581	1	0.278								
	0.281786	1	0.278								
	0.28262	1	0.278								
	0.282806	1	0.278								
	0.282926	1	0.278								
	0.283601	1	0.278								
	0.283694	1	0.278								

	0.283839	1	0.278								
	0.284328	1	0.278								
	0.284981	1	0.278								
	0.285168	1	0.278								
	0.28553	1	0.278								
	0.286201	1	0.278								
	0.286509	1	0.278								
	0.287845	1	0.278								
	0.288412	1	0.278								
	0.28853	1	0.278								
	0.291181	1	0.278								
	0.291855	1	0.278								
	0.294569	1	0.278								
	0.295864	1	0.278								
	0.297327	1	0.278								
	0.297851	1	0.278								
	0.298529	1	0.278								
	0.300036	1	0.278								
	0.302219	1	0.278								
	0.303536	1	0.278								
	0.304853	1	0.278								
	0.305474	1	0.278								
	0.306392	1	0.278								
	0.308162	1	0.278								
	0.308419	1	0.278								
	0.311082	1	0.278								
	0.313821	1	0.278								
	0.31634	1	0.278								
	0.326298	1	0.278								
	0.330213	1	0.278								

	0.331777	1	0.278								
	0.335418	1	0.278								
	0.335681	1	0.278								
	0.335968	1	0.278								
	0.343273	1	0.278								
	0.343811	1	0.278								
	0.344147	1	0.278								
	0.353537	1	0.278								
	0.354975	1	0.278								
	0.375282	1	0.278								
	0.382957	1	0.278								
	0.384289	1	0.278								
	0.385113	1	0.278								
	0.395536	1	0.278								
	0.395768	1	0.278								
	0.410758	1	0.278								
	0.439831	1	0.278								
	0.4426	1	0.278								
	0.481805	1	0.278								
Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation				
Buffer zone	360	0	360	1.000	3.000	2.000	0.818				
Regression of variable NDVI VALUE:											
Goodness of fit statistics (Variable NDVI VALUE):											

Statistic	Independent	Full									
Observations	360	360									
Sum of weights	360.000	360.000									
DF	359	-358									
-2 Log(Likelihood)	4237.995	3446.994									
R ² (McFadden)	0.000	0.187									
R ² (Cox and Snell)	0.000	0.889									
R ² (Nagelkerke)	0.000	0.889									
AIC	4955.995	4882.994									
SBC	6351.106	7673.217									
Iterations	0	21									
Test of the null hypothesis H0: Y=0.003 (Variable NDVI VALUE):											
Statistic	DF	Chi-square	Pr > Chi ²								
-2 Log(Likelihood)	359	791.001	< 0.0001								
Score	359	360.000	0.475								
Wald	359	0.000	1.000								
Type II analysis (Variable NDVI VALUE):											
Source	DF	Chi-square (Wald)	Pr > Wald	Chi-square (LR)	Pr > LR						
Buffer zone	359	0.000	1.000	791.001	< 0.0001						
Model parameters (Variable NDVI VALUE):											

Category	Source	Value	Standard error	Wald Chi-Square	Pr > Chi²	Wald Lower bound (95%)	Wald Upper bound (95%)	Odds ratio	Odds ratio Lower bound (95%)	Odds ratio Upper bound (95%)
0.123	Intercept	-0.014	51911.797	0.000	1.000	- 101745.267	101745.239			
	Buffer zone	0.014	51911.797	0.000	1.000	- 101745.238	101745.267			
0.124	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321			
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147			
0.129	Intercept	-0.014	51911.756	0.000	1.000	- 101745.186	101745.157			
	Buffer zone	0.014	51911.755	0.000	1.000	- 101745.157	101745.185			
0.134	Intercept	-0.014	51911.769	0.000	1.000	- 101745.212	101745.183			
	Buffer zone	0.014	51911.769	0.000	1.000	- 101745.183	101745.212			
0.139	Intercept	-0.014	51911.577	0.000	1.000	- 101744.836	101744.807			
	Buffer zone	0.014	51911.577	0.000	1.000	- 101744.807	101744.836			
0.142	Intercept	-167.607	115600.486	0.000	0.999	- 226740.397	226405.183			
	Buffer zone	83.811	52104.131	0.000	0.999	- 102038.409	102206.031			
0.143	Intercept	-167.607	115599.648	0.000	0.999	- 226738.754	226403.540			
	Buffer zone	83.811	52103.868	0.000	0.999	- 102037.893	102205.515			

0.144	Intercept	-167.607	115600.677	0.000	0.999	- 226740.771	226405.557				
	Buffer zone	83.811	52104.182	0.000	0.999	- 102038.509	102206.130				
0.147	Intercept	-0.014	51912.285	0.000	1.000	- 101746.224	101746.195				
	Buffer zone	0.014	51912.285	0.000	1.000	- 101746.195	101746.224				
0.151	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.152	Intercept	-0.014	51911.727	0.000	1.000	- 101745.131	101745.102				
	Buffer zone	0.014	51911.727	0.000	1.000	- 101745.102	101745.130				
0.152	Intercept	-0.014	51911.758	0.000	1.000	- 101745.191	101745.162				
	Buffer zone	0.014	51911.758	0.000	1.000	- 101745.162	101745.191				
0.152	Intercept	-167.607	115599.482	0.000	0.999	- 226738.429	226403.215				
	Buffer zone	83.811	52103.823	0.000	0.999	- 102037.806	102205.427				
0.154	Intercept	-0.014	51911.729	0.000	1.000	- 101745.133	101745.104				
	Buffer zone	0.014	51911.729	0.000	1.000	- 101745.104	101745.133				
0.155	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.157	Intercept	-167.607	115600.506	0.000	0.999	- 226740.436	226405.222				
	Buffer zone	83.811	52104.141	0.000	0.999	- 102038.430	102206.051				

0.164	Intercept	-0.014	51911.767	0.000	1.000	- 101745.208	101745.180				
	Buffer zone	0.014	51911.767	0.000	1.000	- 101745.179	101745.208				
0.165	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.166	Intercept	-0.014	51912.164	0.000	1.000	- 101745.985	101745.956				
	Buffer zone	0.014	51912.163	0.000	1.000	- 101745.956	101745.985				
0.167	Intercept	-167.607	115600.949	0.000	0.999	- 226741.304	226406.090				
	Buffer zone	83.811	52104.327	0.000	0.999	- 102038.794	102206.415				
0.167	Intercept	-0.014	51911.601	0.000	1.000	- 101744.882	101744.853				
	Buffer zone	0.014	51911.601	0.000	1.000	- 101744.853	101744.882				
0.168	Intercept	-0.014	51911.668	0.000	1.000	- 101745.015	101744.986				
	Buffer zone	0.014	51911.668	0.000	1.000	- 101744.986	101745.014				
0.171	Intercept	-167.607	115599.715	0.000	0.999	- 226738.886	226403.672				
	Buffer zone	83.811	52103.955	0.000	0.999	- 102038.065	102205.687				
0.171	Intercept	-0.014	51911.806	0.000	1.000	- 101745.285	101745.257				
	Buffer zone	0.014	51911.806	0.000	1.000	- 101745.256	101745.285				
0.172	Intercept	-0.014	51911.795	0.000	1.000	- 101745.262	101745.234				

	Buffer zone	0.014	51911.795	0.000	1.000	- 101745.233	101745.262				
0.172	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.173	Intercept	-0.014	51911.738	0.000	1.000	- 101745.152	101745.123				
	Buffer zone	0.014	51911.738	0.000	1.000	- 101745.123	101745.152				
0.175	Intercept	-0.014	51911.666	0.000	1.000	- 101745.010	101744.981				
	Buffer zone	0.014	51911.666	0.000	1.000	- 101744.981	101745.010				
0.175	Intercept	-0.014	51911.476	0.000	1.000	- 101744.638	101744.609				
	Buffer zone	0.014	51911.476	0.000	1.000	- 101744.609	101744.638				
0.177	Intercept	-0.014	51911.763	0.000	1.000	- 101745.201	101745.172				
	Buffer zone	0.014	51911.763	0.000	1.000	- 101745.172	101745.201				
0.177	Intercept	-167.607	115600.258	0.000	0.999	- 226739.949	226404.735				
	Buffer zone	83.811	52104.012	0.000	0.999	- 102038.177	102205.798				
0.182	Intercept	-0.014	51912.036	0.000	1.000	- 101745.735	101745.706				
	Buffer zone	0.014	51912.036	0.000	1.000	- 101745.706	101745.735				
0.182	Intercept	-0.014	51911.844	0.000	1.000	- 101745.360	101745.331				
	Buffer zone	0.014	51911.844	0.000	1.000	- 101745.331	101745.360				

0.182	Intercept	-167.607	115599.765	0.000	0.999	- 226738.984	226403.770				
	Buffer zone	83.811	52103.896	0.000	0.999	- 102037.949	102205.570				
0.182	Intercept	-0.014	51911.585	0.000	1.000	- 101744.852	101744.823				
	Buffer zone	0.014	51911.585	0.000	1.000	- 101744.823	101744.852				
0.183	Intercept	-0.014	51911.850	0.000	1.000	- 101745.372	101745.343				
	Buffer zone	0.014	51911.850	0.000	1.000	- 101745.343	101745.372				
0.183	Intercept	-0.014	51911.522	0.000	1.000	- 101744.727	101744.698				
	Buffer zone	0.014	51911.521	0.000	1.000	- 101744.698	101744.727				
0.184	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.185	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.185	Intercept	-167.607	115600.542	0.000	0.999	- 226740.505	226405.291				
	Buffer zone	83.811	52104.157	0.000	0.999	- 102038.461	102206.083				
0.186	Intercept	-0.014	51911.892	0.000	1.000	- 101745.454	101745.425				
	Buffer zone	0.014	51911.892	0.000	1.000	- 101745.425	101745.453				
0.186	Intercept	-167.607	115600.500	0.000	0.999	- 226740.423	226405.209				
	Buffer zone	83.811	52104.144	0.000	0.999	- 102038.435	102206.057				

0.187	Intercept	-0.014	51911.492	0.000	1.000	- 101744.668	101744.640				
	Buffer zone	0.014	51911.492	0.000	1.000	- 101744.639	101744.668				
0.187	Intercept	-0.014	51911.772	0.000	1.000	- 101745.218	101745.189				
	Buffer zone	0.014	51911.772	0.000	1.000	- 101745.189	101745.218				
0.187	Intercept	-0.014	51911.759	0.000	1.000	- 101745.193	101745.164				
	Buffer zone	0.014	51911.759	0.000	1.000	- 101745.164	101745.193				
0.188	Intercept	-167.607	115600.281	0.000	0.999	- 226739.994	226404.780				
	Buffer zone	83.811	52104.093	0.000	0.999	- 102038.334	102205.956				
0.188	Intercept	-167.607	115599.917	0.000	0.999	- 226739.280	226404.066				
	Buffer zone	83.811	52103.933	0.000	0.999	- 102038.022	102205.643				
0.190	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.190	Intercept	-167.607	115600.338	0.000	0.999	- 226740.107	226404.893				
	Buffer zone	83.811	52104.074	0.000	0.999	- 102038.299	102205.920				
0.190	Intercept	-0.014	51911.534	0.000	1.000	- 101744.752	101744.723				
	Buffer zone	0.014	51911.534	0.000	1.000	- 101744.723	101744.752				
0.191	Intercept	-0.014	51912.075	0.000	1.000	- 101745.812	101745.783				

	Buffer zone	0.014	51912.075	0.000	1.000	- 101745.783	101745.812				
0.192	Intercept	-167.607	115600.932	0.000	0.999	- 226741.270	226406.056				
	Buffer zone	83.811	52104.277	0.000	0.999	- 102038.695	102206.316				
0.193	Intercept	-0.014	51911.555	0.000	1.000	- 101744.793	101744.764				
	Buffer zone	0.014	51911.555	0.000	1.000	- 101744.764	101744.793				
0.193	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.193	Intercept	-0.014	51911.812	0.000	1.000	- 101745.295	101745.267				
	Buffer zone	0.014	51911.811	0.000	1.000	- 101745.267	101745.295				
0.194	Intercept	-167.607	115599.743	0.000	0.999	- 226738.940	226403.726				
	Buffer zone	83.811	52103.975	0.000	0.999	- 102038.103	102205.724				
0.195	Intercept	-0.014	51911.519	0.000	1.000	- 101744.722	101744.693				
	Buffer zone	0.014	51911.519	0.000	1.000	- 101744.693	101744.722				
0.196	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.197	Intercept	-0.014	51911.762	0.000	1.000	- 101745.197	101745.169				
	Buffer zone	0.014	51911.762	0.000	1.000	- 101745.169	101745.197				
0.197	Intercept	-167.607	115601.000	0.000	0.999	- 226741.404	226406.190				

	Buffer zone	83.811	52104.295	0.000	0.999	- 102038.732	- 102206.353				
0.197	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	- 120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.198	Intercept	-0.014	51911.679	0.000	1.000	- 101745.035	- 101745.006				
	Buffer zone	0.014	51911.679	0.000	1.000	- 101745.006	- 101745.035				
0.199	Intercept	-0.014	51912.025	0.000	1.000	- 101745.713	- 101745.684				
	Buffer zone	0.014	51912.025	0.000	1.000	- 101745.684	- 101745.713				
0.199	Intercept	-0.014	51911.814	0.000	1.000	- 101745.301	- 101745.272				
	Buffer zone	0.014	51911.814	0.000	1.000	- 101745.272	- 101745.301				
0.199	Intercept	-0.014	51911.680	0.000	1.000	- 101745.038	- 101745.009				
	Buffer zone	0.014	51911.680	0.000	1.000	- 101745.009	- 101745.038				
0.200	Intercept	-0.014	51911.535	0.000	1.000	- 101744.753	- 101744.725				
	Buffer zone	0.014	51911.535	0.000	1.000	- 101744.725	- 101744.753				
0.201	Intercept	-167.607	115600.595	0.000	0.999	- 226740.610	- 226405.396				
	Buffer zone	83.811	52104.167	0.000	0.999	- 102038.480	- 102206.102				
0.203	Intercept	-0.014	51911.812	0.000	1.000	- 101745.297	- 101745.268				
	Buffer zone	0.014	51911.812	0.000	1.000	- 101745.268	- 101745.297				

0.203	Intercept	-0.014	51911.695	0.000	1.000	- 101745.067	101745.039				
	Buffer zone	0.014	51911.695	0.000	1.000	- 101745.039	101745.067				
0.204	Intercept	-167.607	115600.192	0.000	0.999	- 226739.821	226404.607				
	Buffer zone	83.811	52103.996	0.000	0.999	- 102038.145	102205.766				
0.204	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.204	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.204	Intercept	-0.014	51911.633	0.000	1.000	- 101744.945	101744.916				
	Buffer zone	0.014	51911.633	0.000	1.000	- 101744.916	101744.945				
0.204	Intercept	-167.607	115600.430	0.000	0.999	- 226740.287	226405.073				
	Buffer zone	83.811	52104.091	0.000	0.999	- 102038.332	102205.953				
0.205	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.205	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.205	Intercept	-0.014	51911.702	0.000	1.000	- 101745.080	101745.052				
	Buffer zone	0.014	51911.702	0.000	1.000	- 101745.051	101745.080				
0.206	Intercept	-0.014	51911.723	0.000	1.000	- 101745.121	101745.092				

	Buffer zone	0.014	51911.722	0.000	1.000	- 101745.092	101745.121				
0.206	Intercept	-0.014	51912.003	0.000	1.000	- 101745.672	101745.643				
	Buffer zone	0.014	51912.003	0.000	1.000	- 101745.643	101745.671				
0.206	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.207	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.207	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.207	Intercept	-167.607	115600.327	0.000	0.999	- 226740.085	226404.871				
	Buffer zone	83.811	52104.128	0.000	0.999	- 102038.404	102206.025				
0.207	Intercept	-0.014	51911.877	0.000	1.000	- 101745.424	101745.395				
	Buffer zone	0.014	51911.877	0.000	1.000	- 101745.395	101745.424				
0.207	Intercept	-167.607	115600.047	0.000	0.999	- 226739.537	226404.322				
	Buffer zone	83.811	52103.992	0.000	0.999	- 102038.137	102205.758				
0.207	Intercept	-167.607	115600.323	0.000	0.999	- 226740.076	226404.862				
	Buffer zone	83.811	52104.056	0.000	0.999	- 102038.263	102205.884				
0.207	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				

0.208	Intercept	-0.014	51911.910	0.000	1.000	- 101745.489	101745.460				
	Buffer zone	0.014	51911.910	0.000	1.000	- 101745.460	101745.489				
0.208	Intercept	-0.014	51911.781	0.000	1.000	- 101745.236	101745.207				
	Buffer zone	0.014	51911.781	0.000	1.000	- 101745.207	101745.236				
0.208	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.209	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.210	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.211	Intercept	-0.014	51912.340	0.000	1.000	- 101746.332	101746.303				
	Buffer zone	0.014	51912.340	0.000	1.000	- 101746.303	101746.332				
0.211	Intercept	-167.607	115599.851	0.000	0.999	- 226739.152	226403.937				
	Buffer zone	83.811	52103.935	0.000	0.999	- 102038.025	102205.646				
0.211	Intercept	-0.014	51911.515	0.000	1.000	- 101744.714	101744.686				
	Buffer zone	0.014	51911.515	0.000	1.000	- 101744.686	101744.714				
0.211	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.212	Intercept	-0.014	51912.087	0.000	1.000	- 101745.836	101745.807				

	Buffer zone	0.014	51912.087	0.000	1.000	- 101745.807	101745.835				
0.212	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.212	Intercept	-0.014	51911.639	0.000	1.000	- 101744.957	101744.929				
	Buffer zone	0.014	51911.639	0.000	1.000	- 101744.929	101744.957				
0.213	Intercept	-0.014	51912.018	0.000	1.000	- 101745.700	101745.671				
	Buffer zone	0.014	51912.018	0.000	1.000	- 101745.671	101745.700				
0.213	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.213	Intercept	-0.014	51911.892	0.000	1.000	- 101745.453	101745.424				
	Buffer zone	0.014	51911.892	0.000	1.000	- 101745.424	101745.453				
0.213	Intercept	-0.014	51911.658	0.000	1.000	- 101744.995	101744.966				
	Buffer zone	0.014	51911.658	0.000	1.000	- 101744.966	101744.995				
0.213	Intercept	-167.607	115600.683	0.000	0.999	- 226740.782	226405.568				
	Buffer zone	83.811	52104.200	0.000	0.999	- 102038.545	102206.167				
0.213	Intercept	-0.014	51911.899	0.000	1.000	- 101745.466	101745.438				
	Buffer zone	0.014	51911.899	0.000	1.000	- 101745.438	101745.466				
0.214	Intercept	-0.014	51911.690	0.000	1.000	- 101745.057	101745.028				

	Buffer zone	0.014	51911.690	0.000	1.000	- 101745.028	101745.057				
0.214	Intercept	-0.014	51911.366	0.000	1.000	- 101744.422	101744.393				
	Buffer zone	0.014	51911.366	0.000	1.000	- 101744.393	101744.422				
0.214	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.214	Intercept	-0.014	51911.953	0.000	1.000	- 101745.572	101745.543				
	Buffer zone	0.014	51911.953	0.000	1.000	- 101745.543	101745.572				
0.214	Intercept	-167.607	115600.878	0.000	0.999	- 226741.165	226405.951				
	Buffer zone	83.811	52104.247	0.000	0.999	- 102038.637	102206.258				
0.215	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.215	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.216	Intercept	-167.607	115600.242	0.000	0.999	- 226739.918	226404.704				
	Buffer zone	83.811	52104.029	0.000	0.999	- 102038.209	102205.831				
0.217	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.217	Intercept	-0.014	51911.603	0.000	1.000	- 101744.887	101744.859				
	Buffer zone	0.014	51911.603	0.000	1.000	- 101744.858	101744.887				

0.218	Intercept	-167.607	115600.296	0.000	0.999	- 226740.024	226404.809				
	Buffer zone	83.811	52104.055	0.000	0.999	- 102038.260	102205.881				
0.219	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.219	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.219	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.219	Intercept	-0.014	51912.035	0.000	1.000	- 101745.733	101745.705				
	Buffer zone	0.014	51912.035	0.000	1.000	- 101745.705	101745.733				
0.220	Intercept	-0.014	51911.819	0.000	1.000	- 101745.309	101745.280				
	Buffer zone	0.014	51911.818	0.000	1.000	- 101745.280	101745.309				
0.220	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.220	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.221	Intercept	-0.014	51912.006	0.000	1.000	- 101745.677	101745.648				
	Buffer zone	0.014	51912.006	0.000	1.000	- 101745.648	101745.677				
0.221	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				

	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.221	Intercept	-0.014	51911.934	0.000	1.000	-	101745.535	101745.507			
	Buffer zone	0.014	51911.934	0.000	1.000	-	101745.507	101745.535			
0.221	Intercept	-167.607	115600.248	0.000	0.999	-	226739.930	226404.716			
	Buffer zone	83.811	52104.040	0.000	0.999	-	102038.231	102205.853			
0.221	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321			
	Buffer zone	41.913	44379.507	0.000	0.999	-	86940.322	87024.147			
0.221	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321			
	Buffer zone	41.913	44379.507	0.000	0.999	-	86940.322	87024.147			
0.222	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321			
	Buffer zone	41.913	44379.507	0.000	0.999	-	86940.322	87024.147			
0.222	Intercept	-167.607	115600.464	0.000	0.999	-	226740.352	226405.138			
	Buffer zone	83.811	52104.170	0.000	0.999	-	102038.486	102206.108			
0.222	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321			
	Buffer zone	41.913	44379.507	0.000	0.999	-	86940.322	87024.147			
0.223	Intercept	-0.014	51911.677	0.000	1.000	-	101745.031	101745.002			
	Buffer zone	0.014	51911.677	0.000	1.000	-	101745.002	101745.031			
0.223	Intercept	-0.014	51912.056	0.000	1.000	-	101745.775	101745.746			
	Buffer zone	0.014	51912.056	0.000	1.000	-	101745.746	101745.775			

0.223	Intercept	-0.014	51911.520	0.000	1.000	- 101744.724	101744.696				
	Buffer zone	0.014	51911.520	0.000	1.000	- 101744.696	101744.724				
0.223	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.223	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.224	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.224	Intercept	-167.607	115599.703	0.000	0.999	- 226738.861	226403.647				
	Buffer zone	83.811	52103.909	0.000	0.999	- 102037.973	102205.595				
0.224	Intercept	-167.607	115600.053	0.000	0.999	- 226739.547	226404.333				
	Buffer zone	83.811	52104.055	0.000	0.999	- 102038.261	102205.883				
0.224	Intercept	-0.014	51912.018	0.000	1.000	- 101745.700	101745.672				
	Buffer zone	0.014	51912.018	0.000	1.000	- 101745.672	101745.700				
0.225	Intercept	-167.607	115600.226	0.000	0.999	- 226739.887	226404.673				
	Buffer zone	83.811	52104.091	0.000	0.999	- 102038.332	102205.953				
0.225	Intercept	-167.607	115600.139	0.000	0.999	- 226739.716	226404.502				
	Buffer zone	83.811	52104.153	0.000	0.999	- 102038.452	102206.074				

0.226	Intercept	-167.607	115600.497	0.000	0.999	- 226740.418	226405.204				
	Buffer zone	83.811	52104.158	0.000	0.999	- 102038.463	102206.085				
0.226	Intercept	-167.607	115600.508	0.000	0.999	- 226740.439	226405.225				
	Buffer zone	83.811	52104.083	0.000	0.999	- 102038.315	102205.936				
0.226	Intercept	-0.014	51911.888	0.000	1.000	- 101745.445	101745.416				
	Buffer zone	0.014	51911.888	0.000	1.000	- 101745.416	101745.445				
0.227	Intercept	-167.607	115600.404	0.000	0.999	- 226740.236	226405.021				
	Buffer zone	83.811	52104.134	0.000	0.999	- 102038.415	102206.037				
0.227	Intercept	-0.014	51911.903	0.000	1.000	- 101745.475	101745.446				
	Buffer zone	0.014	51911.903	0.000	1.000	- 101745.446	101745.475				
0.227	Intercept	-0.014	51911.572	0.000	1.000	- 101744.825	101744.796				
	Buffer zone	0.014	51911.571	0.000	1.000	- 101744.796	101744.825				
0.228	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.228	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.228	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				

0.229	Intercept	-0.014	51911.740	0.000	1.000	- 101745.156	101745.127				
	Buffer zone	0.014	51911.740	0.000	1.000	- 101745.127	101745.155				
0.229	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.229	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.229	Intercept	-0.014	51911.847	0.000	1.000	- 101745.366	101745.337				
	Buffer zone	0.014	51911.847	0.000	1.000	- 101745.337	101745.366				
0.230	Intercept	-167.607	115600.683	0.000	0.999	- 226740.783	226405.569				
	Buffer zone	83.811	52104.155	0.000	0.999	- 102038.456	102206.078				
0.230	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.230	Intercept	-0.014	51911.617	0.000	1.000	- 101744.914	101744.885				
	Buffer zone	0.014	51911.617	0.000	1.000	- 101744.885	101744.913				
0.230	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.230	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.230	Intercept	-0.014	51911.478	0.000	1.000	- 101744.641	101744.612				

	Buffer zone	0.014	51911.478	0.000	1.000	- 101744.612	- 101744.641				
0.230	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	- 120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.230	Intercept	-167.607	115600.316	0.000	0.999	- 226740.062	- 226404.848				
	Buffer zone	83.811	52104.136	0.000	0.999	- 102038.419	- 102206.041				
0.230	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	- 120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.231	Intercept	-167.607	115600.340	0.000	0.999	- 226740.111	- 226404.897				
	Buffer zone	83.811	52104.062	0.000	0.999	- 102038.274	- 102205.896				
0.231	Intercept	-167.607	115599.861	0.000	0.999	- 226739.171	- 226403.956				
	Buffer zone	83.811	52103.970	0.000	0.999	- 102038.094	- 102205.715				
0.231	Intercept	-0.014	51911.582	0.000	1.000	- 101744.846	- 101744.818				
	Buffer zone	0.014	51911.582	0.000	1.000	- 101744.817	- 101744.846				
0.231	Intercept	-167.607	115600.185	0.000	0.999	- 226739.806	- 226404.592				
	Buffer zone	83.811	52104.024	0.000	0.999	- 102038.200	- 102205.821				
0.231	Intercept	-0.014	51911.363	0.000	1.000	- 101744.417	- 101744.388				
	Buffer zone	0.014	51911.363	0.000	1.000	- 101744.388	- 101744.417				
0.232	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	- 120192.321				

	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.232	Intercept	-0.014	51911.918	0.000	1.000	-	101745.504	101745.476			
	Buffer zone	0.014	51911.918	0.000	1.000	-	101745.475	101745.504			
0.232	Intercept	-0.014	51911.878	0.000	1.000	-	101745.425	101745.397			
	Buffer zone	0.014	51911.878	0.000	1.000	-	101745.397	101745.425			
0.232	Intercept	-167.607	115599.993	0.000	0.999	-	226739.429	226404.215			
	Buffer zone	83.811	52104.016	0.000	0.999	-	102038.183	102205.805			
0.232	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321			
	Buffer zone	41.913	44379.507	0.000	0.999	-	-86940.322	87024.147			
0.232	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321			
	Buffer zone	41.913	44379.507	0.000	0.999	-	-86940.322	87024.147			
0.232	Intercept	-0.014	51911.964	0.000	1.000	-	101745.595	101745.566			
	Buffer zone	0.014	51911.964	0.000	1.000	-	101745.566	101745.595			
0.233	Intercept	-0.014	51911.761	0.000	1.000	-	101745.196	101745.168			
	Buffer zone	0.014	51911.761	0.000	1.000	-	101745.168	101745.196			
0.233	Intercept	-0.014	51911.500	0.000	1.000	-	101744.685	101744.656			
	Buffer zone	0.014	51911.500	0.000	1.000	-	101744.656	101744.685			
0.233	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321			
	Buffer zone	41.913	44379.507	0.000	0.999	-	-86940.322	87024.147			

0.233	Intercept	-167.607	115600.206	0.000	0.999	- 226739.847	226404.633				
	Buffer zone	83.811	52104.024	0.000	0.999	- 102038.199	102205.821				
0.233	Intercept	-167.607	115600.872	0.000	0.999	- 226741.153	226405.939				
	Buffer zone	83.811	52104.342	0.000	0.999	- 102038.823	102206.445				
0.234	Intercept	-0.014	51911.787	0.000	1.000	- 101745.248	101745.219				
	Buffer zone	0.014	51911.787	0.000	1.000	- 101745.219	101745.247				
0.234	Intercept	-167.607	115600.411	0.000	0.999	- 226740.250	226405.036				
	Buffer zone	83.811	52104.102	0.000	0.999	- 102038.352	102205.974				
0.235	Intercept	-167.607	115599.531	0.000	0.999	- 226738.524	226403.310				
	Buffer zone	83.811	52103.957	0.000	0.999	- 102038.069	102205.690				
0.235	Intercept	-0.014	51911.644	0.000	1.000	- 101744.966	101744.938				
	Buffer zone	0.014	51911.644	0.000	1.000	- 101744.937	101744.966				
0.236	Intercept	-0.014	51912.287	0.000	1.000	- 101746.228	101746.199				
	Buffer zone	0.014	51912.287	0.000	1.000	- 101746.199	101746.228				
0.236	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.236	Intercept	-167.607	115600.743	0.000	0.999	- 226740.900	226405.686				

	Buffer zone	83.811	52104.239	0.000	0.999	- 102038.621	- 102206.242				
0.236	Intercept	-167.607	115600.141	0.000	0.999	- 226739.720	- 226404.506				
	Buffer zone	83.811	52104.093	0.000	0.999	- 102038.335	- 102205.957				
0.237	Intercept	-0.014	51911.670	0.000	1.000	- 101745.019	- 101744.990				
	Buffer zone	0.014	51911.670	0.000	1.000	- 101744.990	- 101745.019				
0.237	Intercept	-167.607	115600.158	0.000	0.999	- 226739.754	- 226404.540				
	Buffer zone	83.811	52104.153	0.000	0.999	- 102038.452	- 102206.073				
0.237	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	- 120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	- 87024.147				
0.238	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	- 120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	- 87024.147				
0.239	Intercept	-0.014	51911.649	0.000	1.000	- 101744.977	- 101744.949				
	Buffer zone	0.014	51911.649	0.000	1.000	- 101744.948	- 101744.977				
0.239	Intercept	-167.607	115599.903	0.000	0.999	- 226739.253	- 226404.039				
	Buffer zone	83.811	52103.980	0.000	0.999	- 102038.113	- 102205.735				
0.240	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	- 120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	- 87024.147				
0.240	Intercept	-167.607	115599.910	0.000	0.999	- 226739.268	- 226404.054				

	Buffer zone	83.811	52103.989	0.000	0.999	- 102038.131	- 102205.752				
0.240	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	- 120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.241	Intercept	-167.607	115600.471	0.000	0.999	- 226740.368	- 226405.154				
	Buffer zone	83.811	52104.102	0.000	0.999	- 102038.353	- 102205.974				
0.241	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	- 120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.241	Intercept	-167.607	115600.681	0.000	0.999	- 226740.779	- 226405.565				
	Buffer zone	83.811	52104.234	0.000	0.999	- 102038.612	- 102206.233				
0.242	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	- 120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.242	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	- 120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.242	Intercept	-0.014	51912.334	0.000	1.000	- 101746.319	- 101746.290				
	Buffer zone	0.014	51912.334	0.000	1.000	- 101746.290	- 101746.319				
0.242	Intercept	-167.607	115600.071	0.000	0.999	- 226739.582	- 226404.368				
	Buffer zone	83.811	52104.032	0.000	0.999	- 102038.216	- 102205.837				
0.243	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	- 120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				

0.243	Intercept	-0.014	51912.211	0.000	1.000	- 101746.079	101746.050				
	Buffer zone	0.014	51912.211	0.000	1.000	- 101746.050	101746.078				
0.243	Intercept	-0.014	51912.015	0.000	1.000	- 101745.694	101745.665				
	Buffer zone	0.014	51912.015	0.000	1.000	- 101745.665	101745.694				
0.243	Intercept	-0.014	51911.845	0.000	1.000	- 101745.362	101745.333				
	Buffer zone	0.014	51911.845	0.000	1.000	- 101745.333	101745.362				
0.243	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.243	Intercept	-167.607	115600.559	0.000	0.999	- 226740.540	226405.326				
	Buffer zone	83.811	52104.204	0.000	0.999	- 102038.552	102206.174				
0.244	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.244	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.245	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.245	Intercept	-167.607	115600.255	0.000	0.999	- 226739.944	226404.730				
	Buffer zone	83.811	52104.200	0.000	0.999	- 102038.545	102206.166				
0.245	Intercept	-167.607	115600.319	0.000	0.999	- 226740.069	226404.855				

	Buffer zone	83.811	52104.212	0.000	0.999	- 102038.568	102206.189				
0.246	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.246	Intercept	-167.607	115600.759	0.000	0.999	- 226740.931	226405.717				
	Buffer zone	83.811	52104.242	0.000	0.999	- 102038.628	102206.249				
0.247	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.247	Intercept	-167.607	115600.432	0.000	0.999	- 226740.290	226405.076				
	Buffer zone	83.811	52104.169	0.000	0.999	- 102038.483	102206.105				
0.247	Intercept	-167.607	115600.339	0.000	0.999	- 226740.108	226404.894				
	Buffer zone	83.811	52104.147	0.000	0.999	- 102038.440	102206.061				
0.247	Intercept	-0.014	51912.026	0.000	1.000	- 101745.715	101745.686				
	Buffer zone	0.014	51912.026	0.000	1.000	- 101745.686	101745.715				
0.247	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.247	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.248	Intercept	-167.607	115600.394	0.000	0.999	- 226740.215	226405.001				
	Buffer zone	83.811	52104.161	0.000	0.999	- 102038.469	102206.090				

0.249	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147					
0.249	Intercept	-167.607	115601.313	0.000	0.999	-	226742.018	226406.804				
	Buffer zone	83.811	52104.455	0.000	0.999	-	102039.044	102206.666				
0.249	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147					
0.249	Intercept	-0.014	51911.773	0.000	1.000	-	101745.220	101745.192				
	Buffer zone	0.014	51911.773	0.000	1.000	-	101745.192	101745.220				
0.250	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147					
0.250	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147					
0.250	Intercept	-0.014	51911.809	0.000	1.000	-	101745.291	101745.263				
	Buffer zone	0.014	51911.809	0.000	1.000	-	101745.262	101745.291				
0.250	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147					
0.251	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147					
0.251	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147					

0.251	Intercept	-167.607	115600.292	0.000	0.999	- 226740.017	226404.803				
	Buffer zone	83.811	52104.140	0.000	0.999	- 102038.428	102206.049				
0.251	Intercept	-0.014	51911.989	0.000	1.000	- 101745.644	101745.615				
	Buffer zone	0.014	51911.989	0.000	1.000	- 101745.615	101745.644				
0.252	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.252	Intercept	-167.607	115600.911	0.000	0.999	- 226741.230	226406.016				
	Buffer zone	83.811	52104.361	0.000	0.999	- 102038.859	102206.481				
0.252	Intercept	-167.607	115601.192	0.000	0.999	- 226741.780	226406.566				
	Buffer zone	83.811	52104.432	0.000	0.999	- 102038.999	102206.620				
0.254	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.254	Intercept	-167.607	115601.247	0.000	0.999	- 226741.888	226406.673				
	Buffer zone	83.811	52104.387	0.000	0.999	- 102038.912	102206.533				
0.254	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.255	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.255	Intercept	-167.607	115600.390	0.000	0.999	- 226740.209	226404.995				

	Buffer zone	83.811	52104.162	0.000	0.999	- 102038.471	102206.092				
0.256	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.256	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.257	Intercept	-167.607	115600.264	0.000	0.999	- 226739.961	226404.747				
	Buffer zone	83.811	52104.074	0.000	0.999	- 102038.298	102205.920				
0.257	Intercept	-167.607	115600.751	0.000	0.999	- 226740.915	226405.701				
	Buffer zone	83.811	52104.256	0.000	0.999	- 102038.654	102206.275				
0.257	Intercept	-167.607	115600.916	0.000	0.999	- 226741.238	226406.024				
	Buffer zone	83.811	52104.294	0.000	0.999	- 102038.728	102206.350				
0.257	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.258	Intercept	-167.607	115600.295	0.000	0.999	- 226740.022	226404.808				
	Buffer zone	83.811	52104.165	0.000	0.999	- 102038.477	102206.098				
0.258	Intercept	-167.607	115600.563	0.000	0.999	- 226740.547	226405.332				
	Buffer zone	83.811	52104.209	0.000	0.999	- 102038.562	102206.184				
0.259	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				

0.259	Intercept	-167.607	115600.564	0.000	0.999	- 226740.549	226405.335				
	Buffer zone	83.811	52104.149	0.000	0.999	- 102038.445	102206.066				
0.260	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.260	Intercept	-0.014	51911.862	0.000	1.000	- 101745.395	101745.366				
	Buffer zone	0.014	51911.862	0.000	1.000	- 101745.366	101745.395				
0.260	Intercept	-167.607	115600.210	0.000	0.999	- 226739.855	226404.641				
	Buffer zone	83.811	52104.053	0.000	0.999	- 102038.256	102205.877				
0.260	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.261	Intercept	-167.607	115600.307	0.000	0.999	- 226740.045	226404.831				
	Buffer zone	83.811	52104.141	0.000	0.999	- 102038.429	102206.050				
0.261	Intercept	-167.607	115600.723	0.000	0.999	- 226740.861	226405.647				
	Buffer zone	83.811	52104.258	0.000	0.999	- 102038.659	102206.280				
0.262	Intercept	-0.014	51911.942	0.000	1.000	- 101745.551	101745.523				
	Buffer zone	0.014	51911.942	0.000	1.000	- 101745.523	101745.551				
0.263	Intercept	-167.607	115600.413	0.000	0.999	- 226740.254	226405.040				
	Buffer zone	83.811	52104.111	0.000	0.999	- 102038.371	102205.992				

0.263	Intercept	-0.014	51911.814	0.000	1.000	- 101745.300	101745.271				
	Buffer zone	0.014	51911.814	0.000	1.000	- 101745.271	101745.300				
0.264	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.264	Intercept	-167.607	115600.528	0.000	0.999	- 226740.479	226405.265				
	Buffer zone	83.811	52104.278	0.000	0.999	- 102038.697	102206.318				
0.265	Intercept	-0.014	51911.979	0.000	1.000	- 101745.624	101745.595				
	Buffer zone	0.014	51911.979	0.000	1.000	- 101745.595	101745.624				
0.265	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.265	Intercept	-0.014	51911.995	0.000	1.000	- 101745.655	101745.627				
	Buffer zone	0.014	51911.995	0.000	1.000	- 101745.626	101745.655				
0.266	Intercept	-167.607	115600.542	0.000	0.999	- 226740.507	226405.293				
	Buffer zone	83.811	52104.205	0.000	0.999	- 102038.554	102206.175				
0.266	Intercept	-0.014	51912.122	0.000	1.000	- 101745.903	101745.875				
	Buffer zone	0.014	51912.122	0.000	1.000	- 101745.875	101745.903				
0.267	Intercept	-167.607	115600.322	0.000	0.999	- 226740.075	226404.861				
	Buffer zone	83.811	52104.080	0.000	0.999	- 102038.309	102205.931				

0.267	Intercept	-167.607	115600.075	0.000	0.999	- 226739.591	226404.376				
	Buffer zone	83.811	52104.017	0.000	0.999	- 102038.187	102205.808				
0.267	Intercept	-167.607	115600.244	0.000	0.999	- 226739.921	226404.707				
	Buffer zone	83.811	52104.135	0.000	0.999	- 102038.416	102206.038				
0.267	Intercept	-167.607	115600.326	0.000	0.999	- 226740.083	226404.869				
	Buffer zone	83.811	52104.117	0.000	0.999	- 102038.381	102206.003				
0.267	Intercept	-0.014	51912.143	0.000	1.000	- 101745.946	101745.917				
	Buffer zone	0.014	51912.143	0.000	1.000	- 101745.917	101745.946				
0.268	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.269	Intercept	-167.607	115600.986	0.000	0.999	- 226741.376	226406.162				
	Buffer zone	83.811	52104.318	0.000	0.999	- 102038.776	102206.397				
0.269	Intercept	-0.014	51911.934	0.000	1.000	- 101745.535	101745.507				
	Buffer zone	0.014	51911.934	0.000	1.000	- 101745.507	101745.535				
0.269	Intercept	-167.607	115599.956	0.000	0.999	- 226739.357	226404.143				
	Buffer zone	83.811	52103.987	0.000	0.999	- 102038.127	102205.748				
0.269	Intercept	-0.014	51911.779	0.000	1.000	- 101745.232	101745.204				

	Buffer zone	0.014	51911.779	0.000	1.000	- 101745.204	- 101745.232				
0.270	Intercept	-167.607	115600.699	0.000	0.999	- 226740.814	- 226405.600				
	Buffer zone	83.811	52104.244	0.000	0.999	- 102038.632	- 102206.253				
0.271	Intercept	-0.014	51911.789	0.000	1.000	- 101745.251	- 101745.222				
	Buffer zone	0.014	51911.789	0.000	1.000	- 101745.222	- 101745.251				
0.272	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	- 120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	- 87024.147				
0.272	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	- 120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	- 87024.147				
0.272	Intercept	-167.607	115601.141	0.000	0.999	- 226741.681	- 226406.467				
	Buffer zone	83.811	52104.435	0.000	0.999	- 102039.006	- 102206.627				
0.273	Intercept	-167.607	115600.422	0.000	0.999	- 226740.271	- 226405.057				
	Buffer zone	83.811	52104.178	0.000	0.999	- 102038.503	- 102206.124				
0.273	Intercept	-167.607	115600.866	0.000	0.999	- 226741.142	- 226405.928				
	Buffer zone	83.811	52104.295	0.000	0.999	- 102038.732	- 102206.353				
0.273	Intercept	-0.014	51912.305	0.000	1.000	- 101746.262	- 101746.233				
	Buffer zone	0.014	51912.304	0.000	1.000	- 101746.233	- 101746.262				
0.274	Intercept	-167.607	115600.384	0.000	0.999	- 226740.196	- 226404.982				

	Buffer zone	83.811	52104.108	0.000	0.999	- 102038.364	102205.986				
0.274	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.275	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.276	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.276	Intercept	-167.607	115600.597	0.000	0.999	- 226740.614	226405.399				
	Buffer zone	83.811	52104.159	0.000	0.999	- 102038.465	102206.087				
0.277	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.277	Intercept	-167.607	115600.330	0.000	0.999	- 226740.090	226404.876				
	Buffer zone	83.811	52104.095	0.000	0.999	- 102038.339	102205.960				
0.277	Intercept	-167.607	115600.250	0.000	0.999	- 226739.933	226404.719				
	Buffer zone	83.811	52104.077	0.000	0.999	- 102038.304	102205.925				
0.278	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.278	Intercept	-167.607	115600.457	0.000	0.999	- 226740.339	226405.125				
	Buffer zone	83.811	52104.208	0.000	0.999	- 102038.561	102206.182				

0.279	Intercept	-167.607	115600.285	0.000	0.999	- 226740.003	226404.789				
	Buffer zone	83.811	52104.082	0.000	0.999	- 102038.313	102205.934				
0.280	Intercept	-0.014	51912.006	0.000	1.000	- 101745.676	101745.647				
	Buffer zone	0.014	51912.006	0.000	1.000	- 101745.647	101745.676				
0.281	Intercept	-0.014	51911.763	0.000	1.000	- 101745.199	101745.171				
	Buffer zone	0.014	51911.763	0.000	1.000	- 101745.171	101745.199				
0.282	Intercept	-0.014	51911.895	0.000	1.000	- 101745.458	101745.429				
	Buffer zone	0.014	51911.895	0.000	1.000	- 101745.429	101745.458				
0.282	Intercept	-0.014	51911.870	0.000	1.000	- 101745.410	101745.382				
	Buffer zone	0.014	51911.870	0.000	1.000	- 101745.382	101745.410				
0.283	Intercept	-167.607	115600.632	0.000	0.999	- 226740.683	226405.469				
	Buffer zone	83.811	52104.182	0.000	0.999	- 102038.509	102206.130				
0.283	Intercept	-0.014	51911.772	0.000	1.000	- 101745.218	101745.189				
	Buffer zone	0.014	51911.772	0.000	1.000	- 101745.189	101745.218				
0.283	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.284	Intercept	-0.014	51911.482	0.000	1.000	- 101744.649	101744.621				

	Buffer zone	0.014	51911.482	0.000	1.000	- 101744.621	101744.649				
0.284	Intercept	-0.014	51912.205	0.000	1.000	- 101746.067	101746.038				
	Buffer zone	0.014	51912.205	0.000	1.000	- 101746.038	101746.067				
0.284	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.284	Intercept	-167.607	115600.340	0.000	0.999	- 226740.111	226404.897				
	Buffer zone	83.811	52104.101	0.000	0.999	- 102038.350	102205.972				
0.285	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.285	Intercept	-0.014	51911.913	0.000	1.000	- 101745.494	101745.465				
	Buffer zone	0.014	51911.913	0.000	1.000	- 101745.465	101745.493				
0.286	Intercept	-0.014	51911.901	0.000	1.000	- 101745.471	101745.442				
	Buffer zone	0.014	51911.901	0.000	1.000	- 101745.442	101745.471				
0.286	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.287	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.288	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				

0.288	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-	-86940.322	87024.147				
0.289	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-	-86940.322	87024.147				
0.291	Intercept	-0.014	51911.900	0.000	1.000	-	101745.468	101745.439				
	Buffer zone	0.014	51911.900	0.000	1.000	-	101745.439	101745.468				
0.292	Intercept	-167.607	115601.872	0.000	0.999	-	226743.113	226407.899				
	Buffer zone	83.811	52104.620	0.000	0.999	-	102039.368	102206.989				
0.295	Intercept	-167.607	115600.350	0.000	0.999	-	226740.129	226404.915				
	Buffer zone	83.811	52104.163	0.000	0.999	-	102038.472	102206.093				
0.296	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-	-86940.322	87024.147				
0.297	Intercept	-167.607	115600.281	0.000	0.999	-	226739.994	226404.780				
	Buffer zone	83.811	52104.074	0.000	0.999	-	102038.299	102205.920				
0.298	Intercept	-167.607	115600.193	0.000	0.999	-	226739.823	226404.609				
	Buffer zone	83.811	52104.061	0.000	0.999	-	102038.272	102205.893				
0.299	Intercept	-167.607	115600.526	0.000	0.999	-	226740.474	226405.260				
	Buffer zone	83.811	52104.221	0.000	0.999	-	102038.586	102206.207				

0.300	Intercept	-167.607	115600.238	0.000	0.999	- 226739.911	226404.697				
	Buffer zone	83.811	52104.064	0.000	0.999	- 102038.279	102205.900				
0.302	Intercept	-167.607	115600.779	0.000	0.999	- 226740.970	226405.756				
	Buffer zone	83.811	52104.237	0.000	0.999	- 102038.617	102206.238				
0.304	Intercept	-0.014	51912.006	0.000	1.000	- 101745.676	101745.647				
	Buffer zone	0.014	51912.006	0.000	1.000	- 101745.647	101745.676				
0.305	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.305	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.306	Intercept	-167.607	115600.743	0.000	0.999	- 226740.899	226405.685				
	Buffer zone	83.811	52104.273	0.000	0.999	- 102038.689	102206.310				
0.308	Intercept	-167.607	115600.563	0.000	0.999	- 226740.548	226405.334				
	Buffer zone	83.811	52104.162	0.000	0.999	- 102038.469	102206.091				
0.308	Intercept	-167.607	115600.559	0.000	0.999	- 226740.539	226405.325				
	Buffer zone	83.811	52104.145	0.000	0.999	- 102038.438	102206.059				
0.311	Intercept	-167.607	115600.346	0.000	0.999	- 226740.122	226404.908				
	Buffer zone	83.811	52104.096	0.000	0.999	- 102038.340	102205.962				

0.314	Intercept	-167.607	115600.727	0.000	0.999	- 226740.869	226405.654				
	Buffer zone	83.811	52104.257	0.000	0.999	- 102038.657	102206.279				
0.316	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.326	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.330	Intercept	-167.607	115600.466	0.000	0.999	- 226740.357	226405.143				
	Buffer zone	83.811	52104.137	0.000	0.999	- 102038.421	102206.043				
0.332	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.335	Intercept	-167.607	115600.291	0.000	0.999	- 226740.013	226404.799				
	Buffer zone	83.811	52104.151	0.000	0.999	- 102038.449	102206.070				
0.336	Intercept	-167.607	115600.825	0.000	0.999	- 226741.061	226405.847				
	Buffer zone	83.811	52104.227	0.000	0.999	- 102038.598	102206.219				
0.336	Intercept	-167.607	115600.662	0.000	0.999	- 226740.741	226405.527				
	Buffer zone	83.811	52104.184	0.000	0.999	- 102038.513	102206.135				
0.343	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	- -86940.322	87024.147				
0.344	Intercept	-62.807	61355.784	0.000	0.999	- 120317.935	120192.321				

	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147				
0.344	Intercept	-167.607	115600.672	0.000	0.999	-	226405.547				
	Buffer zone	83.811	52104.179	0.000	0.999	-	102038.503				
0.354	Intercept	-0.014	51912.048	0.000	1.000	-	101745.729				
	Buffer zone	0.014	51912.048	0.000	1.000	-	101745.729				
0.355	Intercept	-62.807	61355.784	0.000	0.999	-	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-	87024.147				
0.375	Intercept	-62.807	61355.784	0.000	0.999	-	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-	87024.147				
0.383	Intercept	-167.607	115600.671	0.000	0.999	-	226405.544				
	Buffer zone	83.811	52104.250	0.000	0.999	-	102038.643				
0.384	Intercept	-0.014	51911.920	0.000	1.000	-	101745.480				
	Buffer zone	0.014	51911.920	0.000	1.000	-	101745.508				
0.385	Intercept	-167.607	115600.089	0.000	0.999	-	226404.404				
	Buffer zone	83.811	52104.025	0.000	0.999	-	102038.202				
0.396	Intercept	-0.014	51911.813	0.000	1.000	-	101745.270				
	Buffer zone	0.014	51911.813	0.000	1.000	-	101745.298				
0.396	Intercept	-62.807	61355.784	0.000	0.999	-	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-	87024.147				

0.411	Intercept	-62.807	61355.784	0.000	0.999	-	120317.935	120192.321				
	Buffer zone	41.913	44379.507	0.000	0.999	-86940.322	87024.147					
0.440	Intercept	-167.607	115600.711	0.000	0.999	-	226740.837	226405.623				
	Buffer zone	83.811	52104.199	0.000	0.999	-	102038.543	102206.165				
0.443	Intercept	-167.607	115600.601	0.000	0.999	-	226740.622	226405.408				
	Buffer zone	83.811	52104.170	0.000	0.999	-	102038.487	102206.108				
0.482	Intercept	-167.607	115600.307	0.000	0.999	-	226740.045	226404.830				
	Buffer zone	83.811	52104.080	0.000	0.999	-	102038.309	102205.930				

APPENDIX C: VEGETATION DATA SHEET

Vegetation Data Sheet

GPS Datum (Circle one): WGS84 / GDA9A / AGD66 GPS MODEL:

Date: _____ Observer(s): _____ Site No:

Latitude _____ Longitude _____ Elevation: _____
Distance from the road: _____

Vegetation Count

Type of vegetation	Percentage	Type of vegetation	Percentage	Type of vegetation	Percentage
Trees		Shrubs		Cactus	

Survey Data

I.D NO.	Type of vegetation (Tree, Cactus, shrub)	Species name	Average height (m)	Canopy cover (m2)	Vegetation density	Vegetation cover (%)	Frequency