THE INVESTIGATION OF WATER RESOURCES RESPONSE TO LAND USE CHANGE *AT WILLOWFONTEIN*

by

SINDISIWE NYIDE

Research submitted in partial fulfilment of the requirement for the

MASTER'S DEGREE

in

DISASTER RISK MANAGEMENT

in the

FACULTY OF NATURAL & AGRICULTURAL SCIENCES

at the

UNIVERSITY OF THE FREE STATE

SUPERVISOR: Mr. A. JORDAAN

December 2009

Declaration

I declare that the work contained in this dissertation is my original work. All sources quoted and collaborative discussion have been indicated and acknowledged by complete references. This dissertation was not previously submitted by me or any other person for degree purposes at this university or any other university.

Signature……...

Date……

Dedication

Dedicated to my late, living and future family members

Acknowledgements

First and for most I would like to thank God, the Almighty for giving me strength to embark on this journey. I certainly would not have done this, without His blessings.

My sincere gratitude goes to CSIR, DWAF, and NDMC for the joint partnership for granting me the opportunity to study Disaster Management at University of the Free State.

I express my heartfelt thanks to my supervisor, Mr Jordaan. I thank him for his supervision, guidance and constructive advices. I really appreciate his time and moreover for agreeing to be my study leader.

Thank you to the Dimtec office at UFS for your help throughout my studying at the University. My special thanks go to Ms Alice Ncube and Ms Olivia Kunguma. I would also like to thank my lecturers for giving me the basics of Disaster Management.

I express my heartfelt thanks to all the interviewees and organizations that gave me data; during my data collection process. Thank you to all the Wilowfontein community, who assisted me with data. Their time was highly appreciated. I really appreciate everything that Mr Sandile Ndawonde and Mrs Chamane helped me with. Their help would be forever appreciated.

I would like to thank Dr. Delson Chikobvu for helping me when I was constructing my questionnaires. I am grateful to Ms Nthabiseng Mohlakoana for helping me with SPSS. I managed to statistically analyze my questionnaires, through her technical help.

I would like to extend my appreciation to a special person in my life, Mr Ramapulana Nkoana. He gave me strength from the inception of my research to the last minute. He made it possible for me to complete my studies. I thank him for being there, when I needed him.

I express my honest and sincere gratitude towards my family for their encouragement, throughout my study. It was their love and support that gave me strength to complete my masters successfully. I love them all. I also express my thanks to my friends for all their support.

Finally I would like to thank myself for all the sacrifices I made. Well done to me!

Abstract

Land use change has been occurring all over the world and its effects can be devastating. Studies have shown that it can affect water resources. A research was conducted to investigate the effects of land use change on water resources in Willowfontein, which had been affected by drought in the past years. The land in the area was mainly used for residential purposes.

The effects of land use change on water resources in Willowfontein were investigated by determining both the natural and anthropogenic factors. The sample of the study comprised of twenty community project members, who were involved in various agricultural projects in an area. It also had people who were knowledgeable about the research topic. Data was collected using questionnaires, interviews, direct observations, secondary land use change, population, water demand, water runoff, and rainfall data.

The collected data was analyzed using Microsoft Excel, the Statistical Package for the Social Science (SPSS) Software. Major findings were that people perceived rainfall shortage as the primary and direct cause of drought in an area. However evidence showed that rainfall did not change much in the past years. The correlation between rainfall and runoff was 0.646699147, which was insignificant. Change in land use was the possibility of frequent drought occurrence in an area.

Based on the findings and conclusions of the study, specific recommendations were suggested. Moreover the areas that needed more research were identified.

Key words:

Drought, Land Cover Change, Population, Water Demand, Water Runoff, Rainfall, Willowfontein, Msunduzi Municipality, Trend Line, Correlation

Table of Contents

List of Figures

List of Tables

Abbreviations & Acronyms and Symbols

CARA	Consortium for Atlantic Regional Assessment
CCU	CIESIN Columbia University
CSIR	Council for Scientific Institution Research
DWAF	Department of Water Affairs and Forestry
DMF	Drought Management Forum
DOA	Department of Agriculture
DOH	Department of Health
DLA	Department of Land Affairs
GIS	Geographic Information System
IWR	Institute of Water Research
km	kilometers
km^2	kilometre squared
KZN	KwaZulu-Natal
LCLUC	Land Use Land Cover Change
mm	millimetres
MLM	Msunduzi Local Municipality
NDMC	National Drought Mitigation Centre
PMB	Pietermaritzburg
SA	South Africa
SADMA	South African Disaster Management Act
SAWS	South African Weather Service
SSA	Statistics South Africa
TDDMPRI	The Development of a Drought Management Plan for Rhode Island
TODMT	The Oklahoma Drought Management Team
TONR	The Ojos Negros Research Group
TWDCC	The Western Drought Coordination Council
UKZN	University of kwaZulu-Natal
UP	University of Pretoria
USSCCP	US Science Climate Change Program
USCCSPLR	US Science Climate Program Final Report
WC	Western Cape
^0C	Degrees Celsius

Definition of Terms

The following definitions were provided to ensure uniformity and understanding of the terms throughout the study (Hofstee 2006: 88).

Disaster – It is a natural or manmade event, occurring with or without warning, widespread or local, causing or threatening death, injury or disease, and damage to property, infrastructure or the environment. When there is a disaster affected individuals cannot cope with its effects using only their own resources (South African Disaster Management Act (SADMA) 52 2002: 5).

Hazard- It is an event or physical condition that has the potential of causing deaths, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, or other types of harm or loss (FEMA/EMI 2000: 1).

Land cover: It is the physical state of the land. It describes the number and type of vegetation and other material that take place on the earth's surface. Land cover can be described as the end result of land use (Asubonteng 2007: 14& Institute of Water Research (IWR) 1997: sp). The land cover includes vegetation, structures or other features that cover the land. (Asubonteng 2007: 14& Vanderpost *et al* 2009: 1).

Land use: It refers to the economic and cultural activities upon land by humans. It usually emphasizes the importance of land in an economic activity (Asubonteng 2007: 14, & Cruz 2004: 20).

Risk – It is the probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, disrupted economic activity or environmental damage) resulting from interactions between natural or human induced hazards and vulnerable conditions (SADMA 52 2002: 6).

Vulnerability - The capacity that limit an individual, a household, a community, an area, a province or a country's capacity to anticipate, manage, resist or recover from the impact of a hazard in a long or short term (FEMA/EMI 2000: 1 & SADMA 52 2002:9).

CHAPTER 1: INTRODUCTION

1.1 Introduction

The land has to be changed in one way or another to have a well developed area. Change in land use may have positive or negative effects on people and the environment (Vanderpost & Ringrose 2009:1). It is crucial to make sure that the change in land use does not affect the water availability in any way and put people at risk. Therefore change in urban land use should take into account the importance of preserving water and making sure that there is always adequate water for different purposes (Consortium for Atlantic Regional Assessment (CARA) 2006: 1).

The study was based on the research done in Willowfontein. Willowfontein area often experienced drought hazard (Wikepedia 2007: s.p.). The river had become dry and water sources had limited water available (Chamane 2009: 1). In order to understand the causes of drought, vulnerable people had to know the factors that contributed to drought occurrence. It was therefore significant to investigate if land use change had effects on water resources (Verburg, deNijis van Eck, Visser, deJong 2003: 667-690). The focus was on five variables namely; land use change, population, water demand, water runoff, and rainfall analysis. The next section discussed the overall background of the study area.

1.2 Background of the Study Area

The section described the location, climate, the population, the employment, livelihood, and educational level of the study area. The location was discussed first.

1.2.1 Location

Willowfontein, formerly known as Wilgerfontein farm is located in the continent of Africa, country known as South Africa (Malima 2009: 1 & Jaca 2009: 1). It is situated in KwaZulu-Natal (KZN) Province, in Mgungundlovu District Municipality (MDM), specifically Msunduzi Local Municipality (MLM): kz 225, on the west side of Pietermaritzburg (PMB) city (Statistics South Africa (SSA): 2006:1-10, Mlokoti 2005: 1 & Mkhize 2009: 1). The area covers 12.477 square kilometers (km^2), with the whole municipality covering 633km^2, Figure: 1 .1 (South African Cities Network (SACN) 2008: 1).

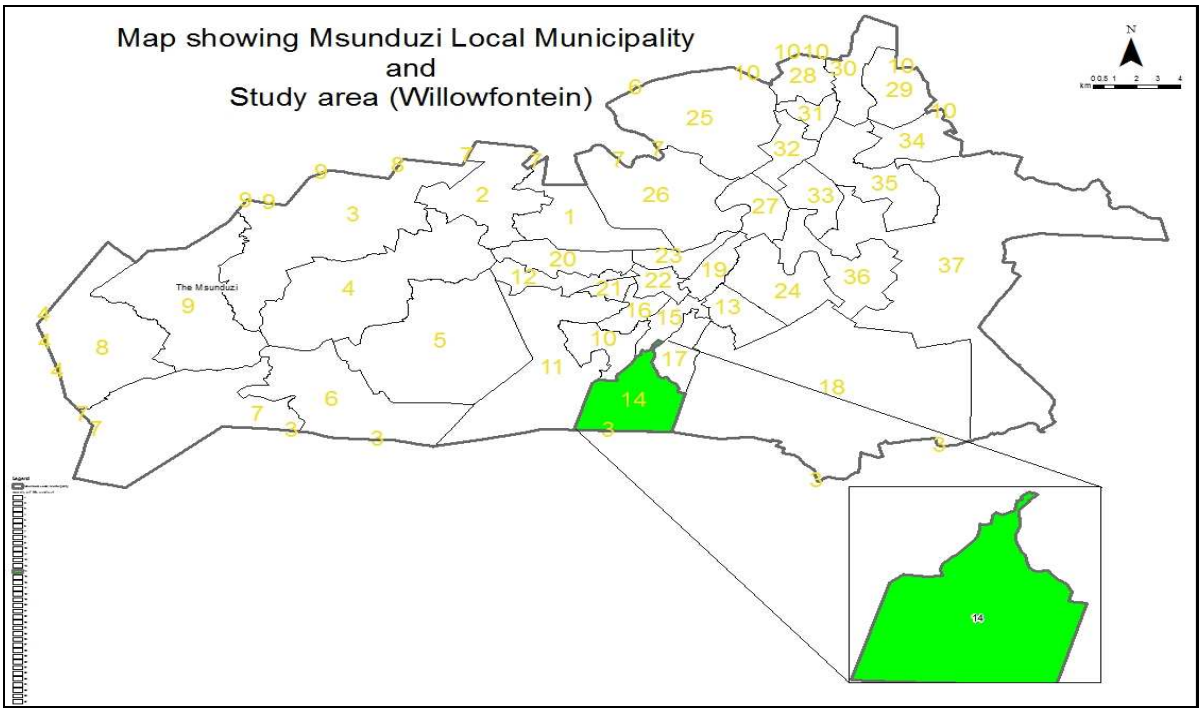


Figure 1.1: Msunduzi Local Municipality wards (University of Free State (UFS) 2009: 1)

Willowfontein's electoral ward is ward number 14, Figure 1.1 (Jaca 2009:1).

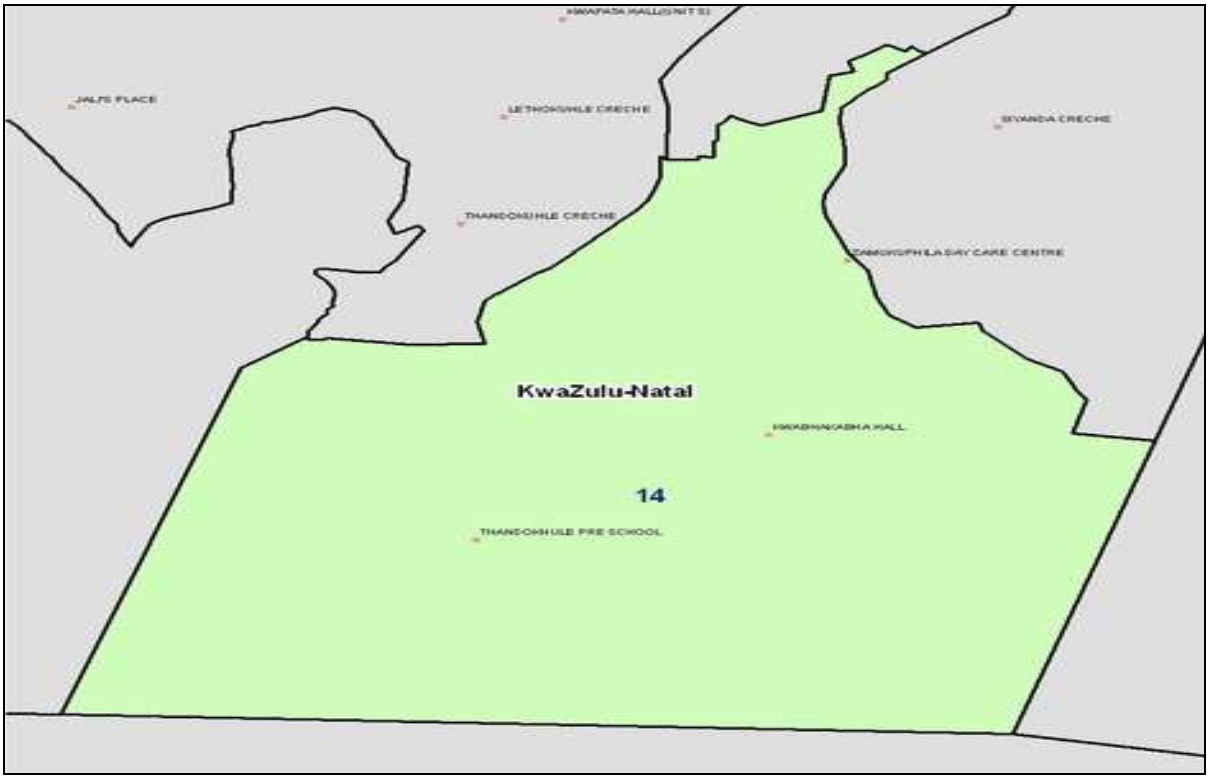


Figure 1.2: Willowfontein area: ward number 14 (SSA 2006:1)

The land was steep. The steep landscape might not have the ability to retain water in the event of drought (Dolph Rotfeld Engineering. 2009: 133). The climate of an area was discussed next.

1.2.2 Climate

The highest recorded temperature in PMB, Willowfontein was 42 Degrees Celsius (^{O}C). The average daily maximum temperature was 26 ^{O}C, with the average daily minimum temperature being 11^{O}C. The lowest recorded temperature in Pietermaritzburg was -4 ^{O}C. On average monthly precipitation was 844 millimeters (mm). The average number of rain days less than 1 mm was 138 days per annum (Wikipedia 2009: 1-4 & Gcabhashe 2008: 1). Warmer climate produced a more humid global environment. This would result in higher rates of evapotranspiration and moisture transport (Ranjan 2007: 1). The section below discussed the population of an area.

1.2.3 Population

Willowfontein had the population of 16650. The highest number of people were those aged between 10 and 14 years and the lowest number were people who were 80 years and above. The numbers were 2083 and 102 respectively. The local municipality's average growth rate was 0.89% per annum (SSA 2006:1-10). A public water supplier needed adequate volume of water to satisfy customer demand (Smith s.a. 249). High population density put a large pressure on land resources in long term. This meant there could be less water available per person in the area, since water demand would be high (Dolph Rotfeld Engineering 2009: 133 & Verburg, Veldkamp, & Bouma 1999: 1). The next section looked at the most common livelihood in the area.

1.2.4 Agricultural Community

There were agricultural community projects, where the project members got their only income, since they were unemployed. Consequently, when there was no water to irrigate crops and for animals to drink farmers lost a lot of money because they lost their source of income. People who were also depending on the income they got from selling agricultural products to the big supermarkets around town and community members lost a lot of money because the production decreased, hence they could not make profit (Chamane 2008:1). As agriculture was solely dependent on rainfall, the droughts reduced the capacity of land to produce. Drought killed crops, so everyone who depended on agriculture for income was impoverished (Solcosmhouse 2008: 1-3). Furthermore the study looked at the employment statistics of the area.

1.2.5 Employment

According to 2001 official census 2188 people were working. This was only 13% of the entire population. About 3271 people were not economic active, either because they were still young to work or they had retired. The salary ranged from R100 to R102 400 per month, Table: 1.1 (SSA 2006:1-10). High unemployment rate affected the community because the community was highly relying on agriculture. Drought disrupted cropping programme, killed animals, and reduced productivity of farms. (Russell 2009: 1).

Table 1.1: Salary Range of Willowfontein Community (SSA 2006:1-10)

Income	Number of people
No income	13044
R1 - R400	988
R401 - R800	1646
R801 - R1 600	680
R1 601 – R3 200	232
R3 201 – R6 400	43
R6 401 – R12 800	9
R12 801 - R25 600	3
R25 601 - R51 200	4
R51 201 - R102 400	4
R102401-R204800	0
R204 801 or more	0

The number of people who did not receive salary at all was 13044. Most people (1646) were earning below R401-R800. No one was earning more than R102401 in the area (SSA: 2006:1-10). The area's economy suffered as the community imported food and subsequently the unemployed and starving number of people might have grown (Russell 2009: 1).

1.2.6 Educational level

About 160 people had qualifications beyond grade 12 in Willowfontein. A total of 982 had never been to school. (SSA 2006:1-10). The educational level and number of people in each level were shown in Table 1.2 below. Educational in Willowfontein was very low. People did not have other skills to use to get money. Furthermore lack of knowledge about drought causing factors made people more vulnerable to drought (Cheianu-Andrei & Černík 2008: 2, 7, 8).

Table 1.2: Educational level in Willowfontein (SSA: 2006:1-10)

Educational Level	Number of people
No schooling	982
Some primary	2288
Complete primary	803
Some secondary	3442
Std 10/Grade 12	1226
Higher	160

The majority of people, 3442 attended secondary school, but dropped out. From the statistics 1226 people had grade 12 certificates (SSA: 2006:1-10).

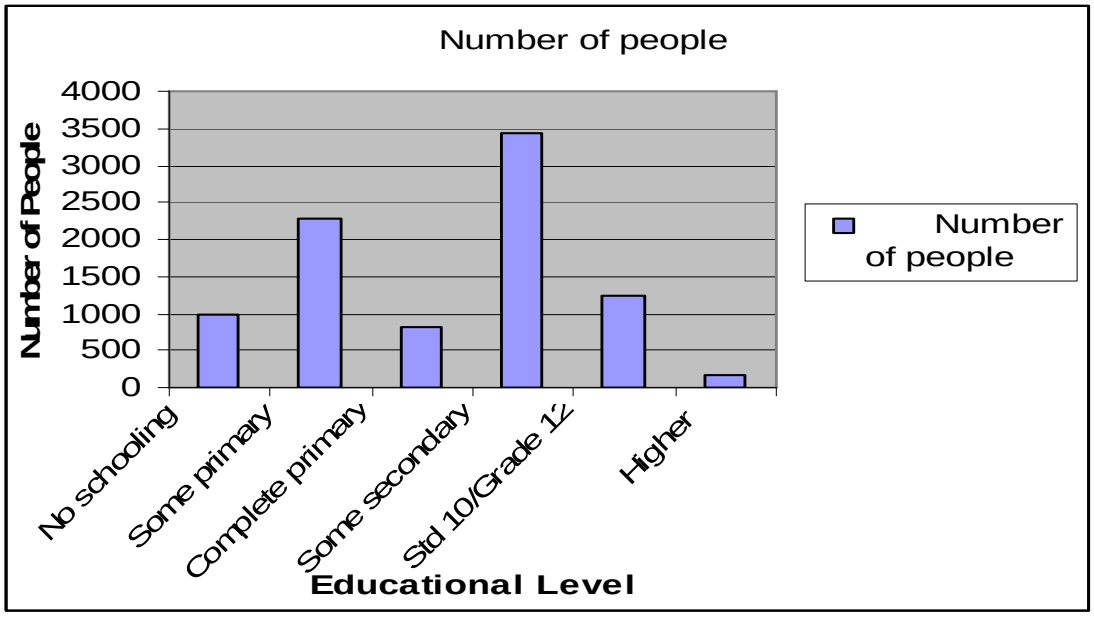


Figure 1.3: Educational level of the Community

People could not get sustainable jobs because they did not have qualifications to apply for better jobs (Cheianu-Andrei & Černík 2008: 2, 7, 8). The background of the study was discussed next.

1.3 Background to the Study

Drought occurs in virtually all climatic zones, but its causes vary significantly from one area to another. Different areas are more prone to certain types of drought than others (Wikepedia 2008: 1, National Drought Mitigation Centre (NDMC) 2006: 1. & The Ojos Negros Research Group

(TONRG) 2004: 1). Drought impacts on society might result from the interplay between a natural event: less precipitation than expected resulting from natural climatic variability and the demand people place on water supply (NDMC 2006: 1. & MTP Programme 2004: 14 and The Development of a Drought Management Plan for Rhode Island (TDDMPRI) 2007: 1).

Among the significant human induced changes that have the effect on the functioning of the earth system are changes in land cover and land use (Verburg *et al* 2003: 667-690). Land cover and land use change can indirectly exacerbate the vulnerability of places and people (Verburg *et al* 2003: 667-690, US Science Climate Change Program (USSCCP) 2003: s.p. & CIESI Columbia University (CCU) 2007: 1). The key variables that need to be understood when studying drought causes were types of drought, population, rainfall, land use change, water supply, and stream flow (Chorpa 2006: 1 & Gcabhashe 2008: 1). The next section discussed some of the variables in detail, starting with drought definitions.

1.3.1 Drought Definitions

Drought definitions varied in time and space, depending on the area's water budget. Other important factors included water stored in the soil and that which runs over land (Gadisso 2007: 7 & Smith s.a. 247). Exploring the definitions of drought allows people to fully understand the concept of drought. The common definitions of drought, from different sectors and people were:

- Palmer stated that drought occurs on a monthly or yearly basis. During this time the moisture in an area is below the experienced amount of moisture supplied (Chorpa 2006: 2).
- Drought is seen as a dangerous hazard of nature. It occurs when there is deficiency of precipitation over an extended period of time, usually a season or more. There will be a lack of water for some activity, group, or environmental sector (NDMC 2006: s.p.).
- Fleng described drought as a period of rainfall deficiency. The period occurs for months or years. The consequences are that crops and pasturage for stock are affected. Water supplies in reservoirs are dried up and livestock perishes (Chorpa 2006: 2).
- Another definition of drought was that, it is the abnormally dry weather, when it occurs over the long period of time. It causes hydrological imbalances (Gadisso 2007: 7).

From the above definitions, it was concluded that drought could be described from several perspectives. Drought is defined to suit different specific situations; hence there were various definitions of drought (IFRD 2007: 9). Drought concept is much debated; however an

interpretation which was relevant to the study was the definition by The Director of Common Wealth Bureaus of Meteorology, in 1965 who described drought as a “severe water shortage” (Chorpa 2006: 2). To further understand the concept of drought better, types of drought were discussed.

1.3.2 Types of Drought

Types of drought needed to be distinguished in order to understand the causes and effects of drought. Droughts could be classified into four major categories, namely: Meteorological, hydrological, agricultural, and socio-economic (NDMC 2006: sp & van Lanen 2007: 1).

Meteorological and hydrological droughts are physical events. Agricultural drought is the impact of meteorological, hydrological drought. It affects agricultural production (NDMC 2006: sp). Smith emphasized that even though drought types overlap, there were major differences in the definition, severity, reduction strategies, and mitigation responses (Smith s.a. 249).Thus it was necessary to treat each type separately, as it was done below.

1.3.2.1 Meteorological Drought

Meteorological Drought occurs when there is reduction, below a specific amount in rainfall for a specified period: day, month, season or year (NDMC 2006: sp). It is whereby precipitation is reduced by more than 25% from normal, in any given area. Atmospheric conditions that result in deficiencies of precipitation change from area to area (Chorpa 2006: 2). Meteorological Drought focuses on physical characteristics of drought: precipitation, not on the impacts of drought (Gadisso 2007: 7 & Smith s.a. 247, 249, 151). Agricultural drought follows after meteorological drought (Gadisso 2007: 7).

1.3.2.2 Agricultural Drought

Agricultural drought is a drought, whereby the amount of moisture in the soil no longer meets the needs of a particular crop. It is more closely related with the lack of soil moisture than precipitation shortages. Agricultural drought mainly affects food production and farming (Smith s.a. 249). Deficient topsoil moisture at planting may stop germination, leading to low plant populations. Smith stated that rainfall does not supply water to plants; the soil does this. The affected soil would prevent plants from acquiring required water (Smith s.a. 247, 257-260). Agricultural drought links characteristics of meteorological drought and hydrological drought, which was discussed next (Chorpa 2006: 2).

1.3.2.3 Hydrological Drought

Water used by people on a day to day basis comes directly from rainfall. It is temporarily stored in rivers, lakes, or in ground water aquifers (NDMC 2006: sp). A rainfall deficiency create water supply problems much more quickly in an area that relies on rivers, and other surface sources, rather than in one that draws water from aquifers (Smith s.a. 249, 253, 254). Hydrological drought affects components of the hydrological system such as stream flow, and ground water and reservoir levels (Chorpa 2006: 2 & Smith s.a. 247). There was evidence that hydrological drought can be influenced by land use change, urbanization, surface water imports and exports (van Lanen 2007: 1-3). The final type of drought was socio-economic drought.

1.3.2.4 Socio-economic Drought

It refers to a situation whereby physical water shortages begin to affect people, as individuals and as a community (Gadisso 2007: 7). In worst cases it could result in death, due to starvation (Smith s.a. 249). The next section discussed the relationship between different types of drought.

1.3.3 Relationship between Types of Drought

In Narenda's view classification of drought types was based on defining indicators and the main drought hazard impacts. Disaster potential increases from left to right across the diagram, Figure 1.4 (Narendra 2008: 5).

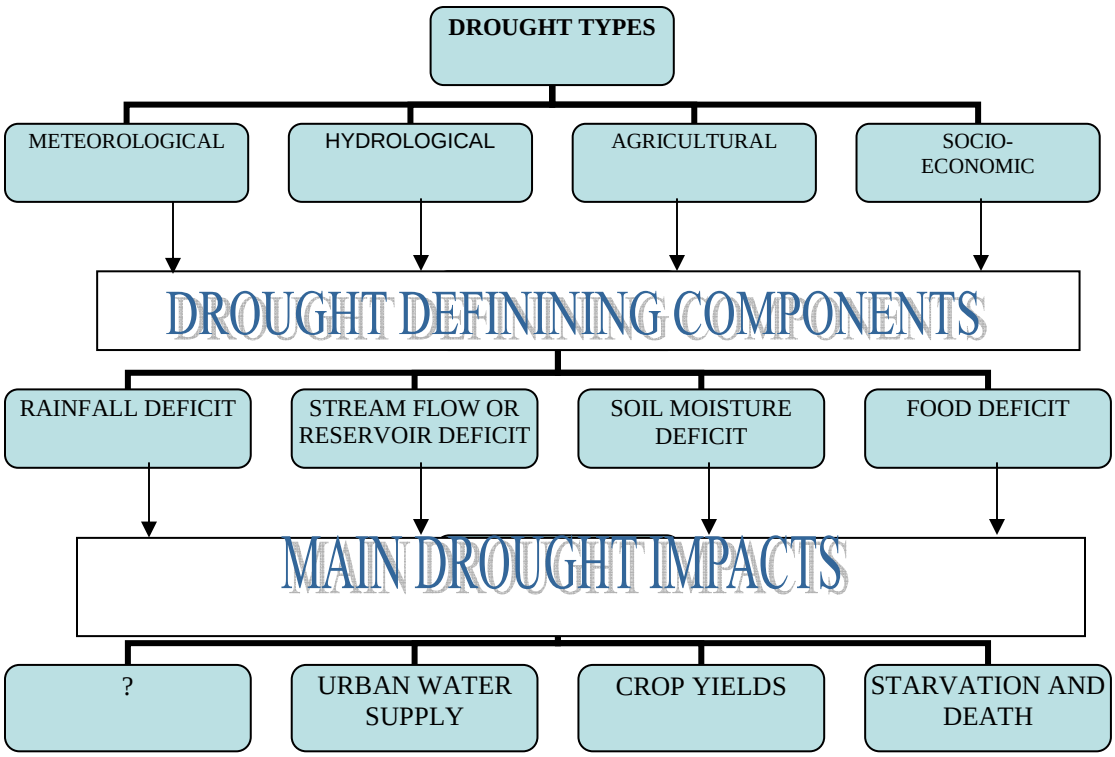


Figure 1.4: A relationship between meteorological, hydrological agricultural, socio-economic Drought (Smith s.a. 249)

When there is no rainfall, drought begins. The longer and the more area affected by the lack of precipitation, other types of drought occur (Gadisso 2007: 7). Basically deficit of rainfall alone does not always produce visible impacts (Smith s.a. 249). The effects depend on the characteristics of the hydrologic system and water use requirements (Smith s.a. 246,249). Drought monitoring is done to determine climate and water supply trends (Narendra 2008: 5 & van Lanen n.d. s.p.). Drought indicators were discussed below.

1.3.4 Drought Identification

Drought monitoring has the ability to detect and predict the occurrence and severity of drought (Narendra 2008: 5 & van Lanen n.d. s.p.). Different drought indicators can be used for different types of drought. The indicators used should be simple, so that there would be straightforward interpretation (Gadisso 2007: 1&The Oklahoma Drought Management Team (TODMT) 1997: 17). Some indicators were illustrated in Figure 1.5 (NDMC 2006: sp).

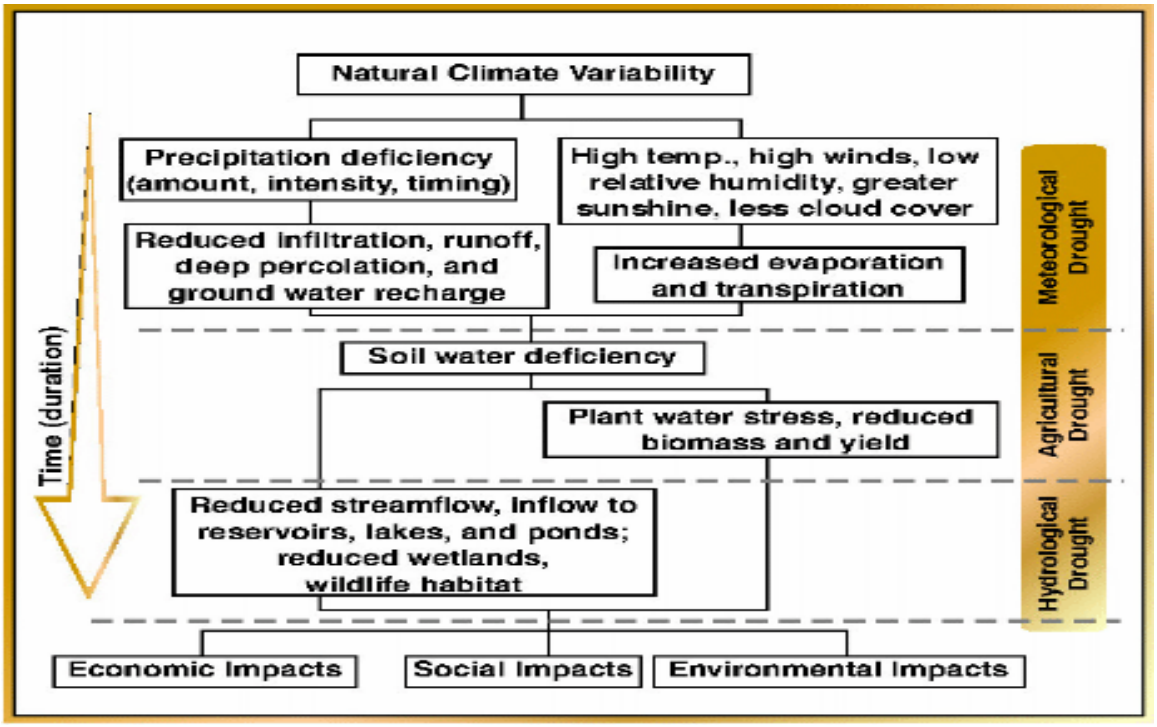


Figure 1.5: Sequence of Drought Impacts (NDMC 2006: sp)

It would be difficult to monitor drought, using a single indicator. A large historical datasets are needed (Gadisso 2007: 1). The study used 5 variables to monitor drought occurrence in an area. One of the variables used to determine the cause of drought was land use change.

1.3.5 Land Use as a Dynamic Concept

There is a relationship between the land, men, and how men act upon this relationship. It is thus correct to conclude that land use is a process than an output. Land use change does not happen at the same time. The land might take months or even years to change the way it looks. For example, land change may occur after the developments in an area (Cruz 2004: 20). Cruz's definition does not take into account that people can use land just for social purposes; build houses to reside on as families. The next section looked at the relationship between population and land use change.

1.3.6 Population and Land Use Change

As a result of the rapid urban growth happening all over the world, it was significant to study the urban land use, and its effects thereof. According to the estimations urban revolution is going to rise over the coming next decades. The urban populations will expand to be doubled the size of the population in rural areas. One of the negative effects of land use change is overuse of limited water resources, caused by population growth (Pellikka, Clark, Hurskainen, Keskinen, Lanne,

Masalin, Sirviö 2004: 1& Cruz 2004: 20). The possible methods of detecting land cover were then discussed.

Land cover has to be measured at different time intervals in order to determine the changes. The information can be obtained from land users themselves. *"Measuring can also be done by assessing the results of human activity, land cover"*. The land use and land cover for each piece of land can be visually seen directly with the eye or by looking at photographs or by using other remote sensing methods (Zonneveld 1993: 30-31 & CARA 2006: 1). Topographical maps taken over time can be used to determine if the land cover of an area has changed or not (Zonneveld 1993: 30-31). In summary there is a relationship between drought and land use change. The relationship was discussed below.

1.3.7 Meteorological, Hydrological Drought and Land Use

The section looked at the relationship between the occurrence of meteorological, hydrological drought and land use change. The more there are houses built the more energy is consumed during the construction and land use process. Smaller homes consume less energy than large homes (CARA 2006: 1).

The building of new houses increase the amount of Carbon in the atmosphere, since Carbon 'sinks' (vegetation) are decreased (CARA 2006: 1). One of the ways human actions change the frequency of water shortage is through land use change (e.g., deforestation). Hydrological drought occurs even when change in the frequency of meteorological drought has not been experienced (Harwood 1999: s.p.). The problem statement was discussed next.

1.4 Problem Statement/Research Problem

The diverse impacts on water resources had ripped through the Willowfontein communities over the past years. This caused loss of income, and shortages of food staples and the death of livestock, among other hardships. Drought also caused crop failure and water scarcity for domestic purposes (SSA: 2006:1-10 & Chamane 2009: 1).

Moreover the agriculture provided food for project members. What made the situation worse was that the population was increasingly escalating, since the government was developing the area. The exact causes of drought in the area were unknown (Chamane 2009: 1). Evaluating the risks

causing drought in the area would help in determining the causes of drought, in order to prevent, mitigate, and prepare for drought impacts. The significance of the study was discussed below.

1.5 Significance of the Study/ Rationale

The study was of both theoretical and practical importance (Hofstee 2006: 89). Very little research had been conducted to determine if the change in land use had negative effects on water availability (Cosmus 2007:1). Therefore it was necessary to determine whether change in land use had effects on drought occurrence. The study would increase understanding of the drought hazard and how it may be changing in frequency, severity and duration in the area with regards to change in land use.

Improved understanding of the predictability and characteristics of drought and the effects of historical land use change would hopefully better equip scientists, policy makers, and other stakeholders to establish urgently needed policies and plans intended to reduce future vulnerability drought. The goal was to disseminate the findings to the local municipality, the community, and relevant disaster management role players. The objectives of the study were determined.

1.6 Research Objectives

Given the above stated problem statement; the following research objectives were formulated:

1.6.1 General Objective

The general objective of the study was to investigate whether or not land use change contributed to drought occurrence at Willowfontein.

1.6.2 Specific Objectives

The specific objectives of the study were:

- To determine if there was change in land use.
- To investigate factors that influenced drought.
- To analyse the linkage between land use change and drought.

1.7 Research Questions

In the view to achieve the study objectives, key research questions to be addressed in the study were:

- How has the land use change in the area?
- How has the population changed over the past years?

- Has the community water supply demand been the same over the past years?
- How has water runoff been affected over the past years?
- What are the effects of rainfall pattern on water availability?

The hypothesis was then determined.

1.8 Hypothesis

The hypothesis of the study was that Willowfontein had more drought frequency because of change in land use. The delimitations and the limitations were then discussed.

1.9 Delimitations and Limitations of the Study

The delimitations dealt with what was covered in the study. There were no major complications during the study, with regards to limitations.

1.9.1 Delimitations of the Study

The study did not deal with climate change, in order to focus the study. The purpose of the study was to deal with direct primary and secondary causes of drought. The study focused more on the urban or built up land category of land use change. The study also focused on meteorological and hydrological drought.

1.9.2 Major Limitations of the study:

The main challenge was in data collection process. The encountered limitations included:

- Costs: There was no adequate money to conduct the research and buy necessary resources such as video recorder. Some data might not have been captured during the data collection process.
- Privacy: Some documents were private documents, so the public did not have access to them. Important and latest data might not have been used in the research, because it was still not released to the general public. The example was the aerial photographs of Willowfontein, taken by MLM in 2008.
- Lack of information: There was no data for river flow of the Willowfontein River. The Msunduzi River mean annual runoff was used instead. The population growth was determined by using the Msunduzi census data, KZN population statistics because there was only 2001 census data for Willowfontein. Rainfall data covered the whole PMB, was not specific to Willowfontein. The following section presented the preliminary literature review.

1.10 Preliminary Literature Review

Preliminary Literature review was done to find out what other researchers have said in relation to the topic. The credible scholarship in the area of interest was used. The various consulted documents were articles, reports, theses, and chapters in books. Preliminary literature review helped to focus the topic, avoided repeating other researcher's mistakes. Moreover it helped to theorise and conceptualise issues (Mouton 2006: 48, 51, 86). Preliminary literature review also helped to clarify the research objectives, thus focused the research (Mouton 2006: 51, McNeill 1990: 20 & Mouton 2006: 51, 86). The Literature Review was categorized by themes. It looked at the studies on population, rainfall, land use change, water supply, and mean annual runoff.

1.10.1 Research Variables

The variables of the unit of analysis that were used in the study were population, rainfall analysis, water demand, land use change, and water runoff. The first preliminary review discussed was the land use change effects on population, then population growth and water demand. There was also a discussion on land use change and water demand. Human beings were believed to often aggravate the causes of drought by overusing the limited water resources (Drought Management Forum (DMF) 2007: s.p. & Eagleman 1983: s.p).

Previous studies have shown that land use change was commonly high in developing areas which had agriculture based economies and rapidly growing human population (Cruz 2004: 20). Land cover changes resulted from natural and human driving forces. Effects of human activities were immediate and usually direct. From the human factors, human growth was one of the most significant factors (Cruz 2004: 20). Studies further showed that a large number of populations depended on the land for survival. Demands of land were increasing as population increased (Asubonteng 2007: 14, CARA 2006: 1 & Hesmay 2003: 1).

More studies showed that population growth resulted in the degradation of resources which relied on the available land. The high demand of land and food were the result of clearing of the forest for a farming area and urban development (Hesmay 2003: 1). Land cover and land use transformed due to human intervention. It was thus important to understand how land cover change influence the river basin hydrology (CARA 2006: 1 & Harwood 1999: s.p.). Chorpa (2006: 1) noted that there was an increasing pressure on water resources as a result of increasing and shifting population. For instance people migrating from regional and rural to urban areas (Chorpa 2006: 1).

Other studies showed that land cover changes may have immediate and long lasting impacts on hydrology. If land cover was destructed it could affect the hydrological cycle (USGS 2008: 1 & CARA 2006: 1). There was a suggestion that the reductions in evapotranspirations and water recycling due to land cover change initiated a feedback mechanism that caused reduced rainfall (DWAF 2004: 661). It was significant to have knowledge of region's climate, in order to understand meteorological causes of drought, so as to manage hydrological drought (van Lanen 2007: 55). Rainfall data was generally used to calculate drought indices, for they are easily available (Gadisso 2007: 12).

Study of stream flow patterns and rainfall trends over years enabled assessment of land use systems effects (Gadisso 2007: 3, Narendra 2008: 5 & TODMT 1997: 19). The drought events occurrences in the area could be obtained from the observed stream flow/ reservoir hydrograph. The flow situation where the daily discharge was below a certain threshold level was associated with drought period (Erik, Querner & van Lanen 2001: 55).

Land cover and water supply information were used to determine the effects land cover changes on water resource systems. It was appropriate to use satellite Remote Sensing, Geographic Information Systems (GIS) and water demand prediction, respectively (Zonneveld 1993:30-31 & Asubonteng 2007: 15). Information on how water was utilized and the levels of water in reservoirs was available at the municipality database supplies were therefore significant (TODMT 1997: 18).

Preliminary Literature Review gave guidance on how to treat respondents of a study in an ethical manner, by respecting their social values. It also gave guidance on how to design the research, write research questions and use appropriate data collection methods (Neuman 1995: 95, 110 & McNeill 1990: 20). Reviews were done to show familiarity, and establish credibility to some extent (Neuman 1995: 97). Literature Review was discussed in more detail in Chapter 2. The next section discussed research design and methodology, used in the study.

1.11 Research Design and Research Methodology

The section contained methodological procedures carried out in the research. It focused primarily on providing materials, research designs, and research methodology used in the study. The sampling method used, the ethical consideration taken into account were discussed. The section described every step involved in carrying out the study, and the appropriateness of choosing the approach thereof (Phyllis 1995: 2 & Hofstee 2006:109). The section also mentioned the reviewed

literature sources. Furthermore it discussed the field work that was done, and the methodology used. The analysis procedures used were also discussed (Mouton 2006: 123-124).

1.11.1 Data Capturing

Cell phone camera, hard copies were used to capture data (Mouton 2006: 48). A phone camera was used as a helpful supplement to the field collected data. Supplements were useful because they provided a close approximation to what occurred. They were also a permanent record that other people can review. Supplement information helped to recall events and observe non responses by the respondents, which might not have been easily noticed (Neuman 1997: 386). The diagrams drawn aided to organise collected data and to convey information to the readers of the research (Neuman 1997: 386). The drawing technique helped in that large amount of material that was useful in the study was recorded (Neuman 1997: 36). A sample had to be selected to conduct an efficient study.

1.11.2 Sampling

When conducting research it was wise to select a sample in contrast to using the entire population. The sample represented the population being studied. A smaller and focused group was used, rather than large random samples (William 2001: s.p). The major reason to sample was that: it was going to be expensive and impossible to test the entire population. Also involving the whole population would have produced errors, it would be destructive. It was quicker to use a sample then using the whole population (McNeill 1990: 36).

The sampling procedure used was non-random sampling or convenience sampling (Webster. Edu. 2008: s.p.). The specific method used was purposive sampling. Only people who were more knowledgeable about a studied subject and the area were interviewed (Babbie& Mouton 2008: 166, McNeill 1990: 39 & Neuman 1997: 213 &). The ethical consideration used in the study was discussed.

1.11.3 Ethical Consideration

In terms of ethical consideration permission to conduct the research was requested, days before the interview from the individuals who were interviewed (Mouton 2006: 48). People were asked questions in an agreed period (Neuman 1997: 388). It was ensured that the social values of the focus group were respected all the time. The research approach used was discussed next.

1.11.4 Qualitative and Quantitative Research

An integrated approach was used. The study was conducted in both qualitative and quantitative approach to determine the effects of land use change on drought occurrence at Willowfontein, Figure: 1.6 (Hofstee 2006: 112 & Mouton 2006: 76, 107). Qualitative research was discussed first.

1.11.4.1 Qualitative Research Design

Qualitative research design, which provided a broad overview of data, was adopted for analyzing primary data collected at Willowfontein. Basically, qualitative research involved analysis of data such as words (Mouton 2006: 107). Interviews helped to gather reliable information relating to the problem being investigated (Hofstee 2006:109). A qualitative data collection method identified variables relevant to the study (TONRG 2004: 1).

The method also helped in data collection specifically related to population growth, rainfall pattern, characteristics of drought, land use, water supply, and water runoff. The approach allowed for data collected from the officials to be in a form that was easily converted into form of words, pictures or objects (Babbie& Mouton 2008: 278-279& TONRG 2004: 1). In order to avoid subjective results quantitative approach was also used in the study.

1.11.4.2 Quantitative Research Design

Quantitative research involved analysis of numerical data. Quantitative research depended on data collected in the form of numbers and statistical procedures. It looked at the average and totals of the investigated information in an area. Observations and results were presented numerically after associations and trends (Babbie& Mouton 2008: 45& Neuman 1997: 41-42).

A quantitative research methodology was more efficient and could test hypothesis. Moreover, using this method made it possible to remain objective about the subject matter. The limitation of using quantitative method was that it might have missed contextual detail (Neuman 1997: 41-42). A research design chosen for the study was articulated below.

1.11.5 Research Design

Research design indicated the process used in designing the research. A research design was used to structure the research. It showed how major parts of the research worked together to try to answer the research questions (Mouton 2006: 49, 55). The research design used in the study was indicated in Figure: 1.6 (Hofstee 2006: 76).

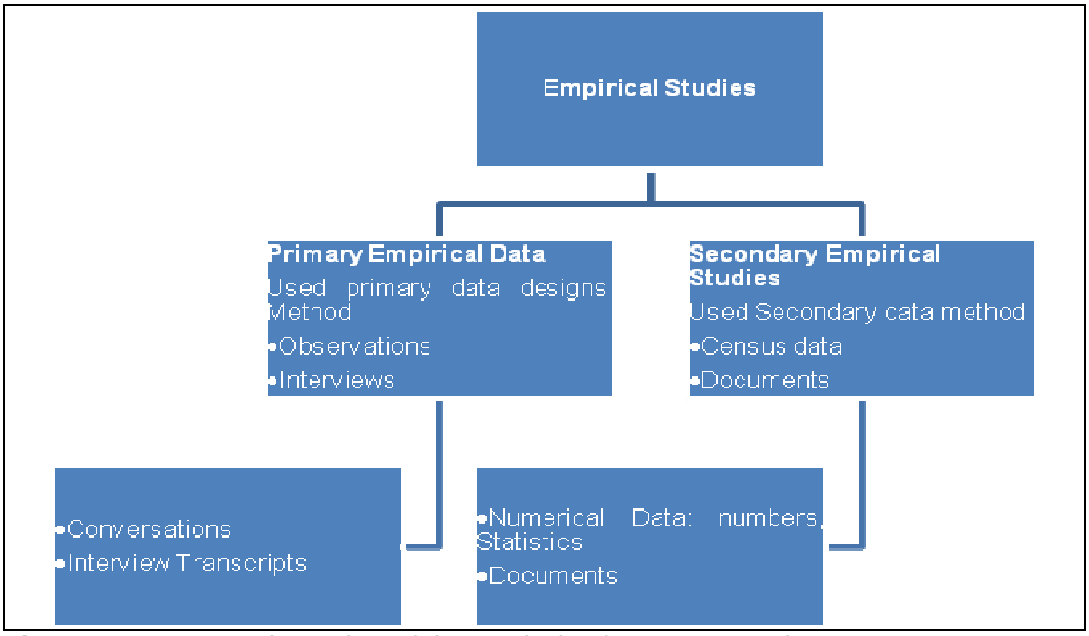


Figure 1.6: Research Design of the study (Hofstee 2006: 76)

The study was an empirical study (Hofsteee 2006: 77). Primary data was collected during the study. Secondary data sources were also reviewed. The questions focused more on how the land cover had changed and the consequences thereof (Hofstee 2006: 133).

1.11.5.1 Primary Data Collection

The methods used when gathering primary data information were: direct observations, transect walk, in depth interviews (Hofstee 2006: 133).

Primary sources such as reports, and personal interviews with the community, authorities from Department of Education (DOE), Department of Water Affairs and Forestry (DWAF), Department of Land Affairs (DLA), South African Weather Service (SAWS), Department of Health (DOH), and the MLM were used in the study to obtain recorded data. Qualitative approach investigated the why and how, not just what, where, and when (William 2001: s.p.).

1.11.5.2 Secondary Data Collection

The secondary data resources used were archive material on census information, rainfall data, characteristics of drought, land use change, and water sources, and water runoff. The documented data was combined with the gathered data and then, incorporated to provide a more

comprehensive study (Mouton 2006: 49). The research design types used in the study were identified and discussed in the following section.

1.11.6 Research Design Types

The major different types of research designs used in the study were simple observation, interviews, survey questionnaires, and a focus group interview (Neuman 1997: 35, Hofstee 2006: 133 & McNeill 1990: 20). Research design types were discussed in detail below.

1.11.6.1 Simple Observation

There was an area analysis through observation. Pictures were taken and the observations were recorded. The observations were summarized, analyzed and the results were reported (Neuman 1997: 35). Interviews were discussed next.

1.11.6.2 Interviews

Interviews were conducted face-to-face, over the phone and through e-mails. The interviews were semi structured, thus enabling the acquisition of answers relevant to the study. Only key informants were used in the study. The questions were open and/ or closed questions (Neuman 1997: 35). One on one interviews were conducted as primary data source from key informants at Willowfontein. Survey questionnaires were also used in the study.

1.11.6.3 Survey Questionnaires

Questionnaires were administered face-to-face to community project members in October 2008. The population was chosen to make sure that the response rate was high (Hofstee 2006: 133). The respondents were chosen based on their knowledge of the study area, as well as the literacy and understanding of English language (McNeill 1990: 20). There was also focus group interview in the study.

1.11.6.4 Focus Group

A focus group composed of homogenous people, representing all segments of people from Willowfontein. The group had a common background, since they had all lived in the area for more than five years. This gave them an equal opportunity to observe changes, if any in the area. The focus group interview lasted for two hours. Another hour was used for a transect walk, where pictures were taken (Lewis 2000: 1). The actual methodology used when collecting data was discussed below.

1.12 Methodology Used

A knowledge and understanding of the area before conducting the research led to the better analysis of results at a later stage. It was not a major problem to conduct research, collect data since there was some degree of familiarity with PMB city (William 2001: s.p.). It was however imperative to be familiar with the study area. Time was taken to ask people about the history, background of the area. There was a thorough review of relevant literature and important historical data, focusing on the international, national, provincial levels. It made it possible then to formulate a research topic and objectives that needed urgent attention in the area (William 2001: s.p.). Some data was collected by observing the area.

1.12.1 Simple Observation

The field work consisted of the staying in PMB from 01 to 14 September 2008, conducting informal interviews with people in the area. This process is known as preparatory investigations and interviews. However reliable conclusions were not drawn from such discussions. The process gave insight about the past and status quo of the area (McNeill 1990: 22-23). In order to gain more details about the study topic and the area a number of interviews were conducted.

1.12.2 Interviews

The participation in the interview process was based on the willingness of people to participate. Informal interviews were conducted, to confirm acquired information (Mouton 2006: 48, McNeill 1990: 41& Hofstee 2006: 132). A total of sixteen semi structured interviews were conducted. Semi structured interviews allowed for a digression from either the questions or the answers. The types of interviews conducted were as follows:

1.12.2.1 Face-to-Face Interviews

The face-to-face conducted interviews were: the one with one Non Government Organisation (NGO) member, one with a community project member, one with the MDM Disaster Management official, and one focus group. Face-to-face interviews took about 45 minutes, were held at the official's offices. The focus group meeting took about three hours, because there was field work involved and there were a lot of issues that were raised in the meeting. It was held at a local school.

A one on one interview was conducted on the 06th of September 2008. The interviewee gave useful information about the history and the current state of Willowfontein. Semi structured focus group meeting was held on the 10th of September 2008, with certain knowledgeable residences

of Willowfontein. The meeting helped to identify the challenges facing the area with the help of the comments made by the residents (Neuman 1997: 35).

1.12.2.2 Telephonic Interviews

Telephonic interviews were as follows: one with a ward 14 councillor, and one with the councillor's personal assistant, one with NGO official (Mouton 2006: 48 & McNeill 1990: 41).

1.12.2.3 Written Interviews

Some interviews were conducted in a written form: e-mails were written, in order to obtain secondary data. The e-mail correspondences were as follows: one with SAWS official, two with SSA official, one with DWAF official, one with DOE official, and one with DOH official, one from MLM official. There were follow up interviews with certain officials when there were clarity seeking questions or when more data was requested. (Mouton 2006: 48). More data was collected through questionnaires.

1.12.3 Survey Questionnaires

A letter of information was given to all people who were given questionnaires. It stated the researcher's name, institution and the purpose of the interview. The letter helped to put many respondents at ease, as they were given assurance that their answers were confidential and that the research was going to benefit them in a way (McNeill 1990: 20). A total of twenty questionnaires were administered to a total of four members in each of the five community project groups in the area.

A total of 24 questions were asked. The reason for using a small number of questions was to minimise respondents' boredom, obtain more carefully thought answers, and probably higher response rate. The questions were grouped from general to specific and from easy to difficult categories (Hofstee 2006: 133). Questionnaires assured confidentiality to respondents. They were also easy to analyse and become quantitative results (Hofstee 2006: 133). However questionnaires did not allow the interaction with the respondents. The method could not probe respondents and digress from the set format (Hofstee 2006: 133).

The questionnaire had multiple choice closed questions and an open ended question. Multiple choice closed questions were asked because they offered a way to reduce the time respondents needed to complete the questionnaire, and hence decreased the time used to analyse questionnaires (Mouton 2006: 48). An open question was used to allow the respondents to

answer in their own words. It also allowed people to express themselves, thus giving them a sense of control. Moreover it permitted for more in-depth answers (Hofstee 2006: 133).

The questionnaires were not collected the same day they were given to the respondents. This helped to get more information and accurate answers, since respondents had more time to read and understand the questionnaires. The researcher's contact details were given to the respondents in order for them to ask questions if they had any queries. The questionnaires were collected when the respondents indicated that they had finished answering the questions (Mouton 2006: 48). When all respondents had returned the questionnaires, the questionnaires were then taken for check up and analyses (McNeill 1990: 40). The last primary data collecting method discussed was the focus group interview.

1.12.4 Focus Group Interview

The focus group members were asked specific questions about a research topic. A focus group helped to investigate the topic further and gather unknown data, which could not have been obtained in other ways. During a focus group interview there was an interaction and the enquiry was in a structured and unstructured manner, since there were probing questions. The focus group participants participated freely and shared their opinions (Lewis 2000: 1). After the focus group interview the key words and answers were grouped together into several phrases. The results were then analyzed (IOWA State University Extension 2001: 2-3). Analysis of secondary data helped in acquiring more information about the study.

1.13 Secondary Data

The information was obtained from Council for Scientific Institution Research (CSIR), DOH, SAWS, DWAF, SSA, Department of Land Affairs (DLA), and UFS as well as DOA. Examples of documents used included: Government and non-governmental reports, South African Acts, magazine articles, newspaper articles, journal articles, books, theses, and media reports. The University of KwaZulu-Natal (UKZN) and University of Pretoria (UP) library facilities were primarily used as sources of documents. Secondary data sources were used because surveys would have been expensive and labour-intensive (William 2001: s.p. & McNeill 1990: 99). At the end of data collection the results were a huge document (grey literature), and had to be analysed.

1.14 Data Processing and Analysis

The processed data was the data that closely answered research questions. Throughout the data analysis research objectives, questions, research theme were constantly revisited. Statistical

analysis and textual analysis were applied (Mouton 2006: 108-110 & Hofstee 2006: 133). Some data was processed while data collection was underway. A computer played a crucial role in data processing. It helped to process a large amount of data (McNeill 1990: 42).

1.14.1 Questionnaires and Interviews

After collecting all the necessary data, completed questionnaires, and interview schedules data were processed. According to Mouton (2006: 49-52), the collected data must be captured, analyzed by compatible computers-aided software's such as Microsoft Excel, arcGIS, Microsoft word, SPSS (Mouton 2006: 49-52). Answers were put into categories and totals were added up. The general pattern of response rate was established and then expressed in statistical terms (McNeill 1990: 42 & Kinnear & Gray 2009: 25-43). Rainfall and runoff data also played a major role in determining the cause of drought.

14.1.2 Trend Analysis and Correlation of Rainfall and Runoff

One way of processing secondary data was the use of trend lines and correlation analysis. Trend line analysis was done to identify whether rainfall had been increasing, constant or decreasing. As for runoff analysis it was done to determine the water amount availability in the river. The correlation was done between rainfall pattern and water runoff. Correlation analysis was done to obtain correlation between drought characterized by rainfall and water runoff deficit.

14.1.3 Land Cover Changes

Computers were used to process data from shape files, taken during data collection process. A total of five maps were produced. The first one was for the wards in MLM. Other two maps showed the land use of MLM in 1996 and 2000 respectively. The forth map and the fifth map showed the Willowfontein land use for 1996 and 2000, respectively. The analysed data was presented in different forms.

1.15 Data Presentation

The processed data was presented in the form of tables, figures, graphs: bar, pie, histograms, line and hydrographs. Other information was presented in a narrative style to determine whether the way the land was used in Willowfontein had effects on drought occurrence (Neuman 1997: 35 & Mouton 2006: 124).

It was likely that the results showed clear link between the developments, and drought. The research was complete when the information could be shared with others. The captured

information could therefore be retrieved and edited when there was a need (Mouton 2006: 124). The last section of Chapter 1, discussed the outline of all research chapters.

1.16 Outline of Research Chapters

The thesis followed the below mentioned sequence, in order to achieve the objectives of the study.

Chapter 1: Introduction and Methodology

The elements that belonged in an Introduction section, Chapter 1 were: Definition of terms, Background to the study, Description of the study area, Problem statement, Research Objectives, Research questions, Hypothesis, Significance of the study, Delineations and limitations of the study, Literature Review, Research methodology, Data Capturing, Data analysis and Presentation, Outline of Research Chapters, and Research Schedule (Mouton 2006: 122 & Hofstee 2006: 83).

Chapter 1 also presented a discussion of the preliminary literature review and specific steps used during data collection in the study. The information regarding methods followed was comprehensive and detailed enough to permit replication of the study by other researchers (Mouton 2006: 123-124).

Chapter 2: Review of Related Literature

Chapter 2 contained the review of related literature and research related to the problem being investigated. This chapter contained theories and models relevant to the problem, a historical overview of the problem, current trends related to the problem, and significant research data published about the problem. The chapter covered research carried out in the drought field, in the area of monitoring, prediction, and risk assessment (Mouton 2006: 123).

Chapter 3: Description of a Study Area

Chapter 3 gave a detailed overview of the study area. It discussed all the important variables of the study.

Chapter 4: Presentation of Results

Chapter 4 provided results of data analyses and findings of the study. This chapter began with an introduction, as all chapters. The questionnaires were discussed first. Information regarding

response rate was reported. The section also covered the discussion of SPSS Cross Tabulation. The focus group interview responses were presented. (Mouton 2006: 124 & Hofstee 2006: 90).

The chapter also covered the description of the relationship established between rainfall and runoff by determining the correlation between these variables. Furthermore results concerning rainfall and water runoff trends and correlation were shown. The obtained land use cover maps were demonstrated

Chapter 5: Analysis of Results

This Chapter covered the analysis of the questionnaires and also analysed cross tabulations of certain variables. The focus group interview results were also analysed. The relationship between runoff and water rainfall trend lines was analysed. Land cover change was analysed as well, through the analyses of the produced maps.

Chapter 6: Summary, Conclusion and Recommendations

Chapter 6 contained the conclusions of the study done. There were recommendations and future studies suggestions, for what could not be handled in the study (Mouton 2006: 126).

1.17 Conclusion

Chapter 1 dealt with an introduction of the study. Introduction presented reasons for selecting the topic. It gave some light on the direction of what other researchers have done on the research area. It also gave a brief description of the significance of the study, as well as specific intention of the study. The second Chapter was Literature Review. It discussed what other scholars have written about the research topic.

CHAPTER 2: A REVIEW OF THE LITERATURE

2.1 Introduction

Researchers agreed that there has been an enormous change in land use over the past years, but they had drawn quite different explanations and conclusions in determining the cause of drought. Current estimates showed the prevalence of change in land use was high in most parts of the world. By 2035 it was estimated that the land cover would look very different from the way it is looking currently (Solcomhouse 2008: 1-3). It was therefore important to determine if the latest developments in the area had caused water shortage.

The main purpose of the section was to provide a review of what was known about the effects of change in land use on drought occurrence. The different land cover patterns were discussed. The population and the consequences of change in land use were investigated. The water demand of the community in different areas was discussed. Water runoff and the effects were also discussed. The causes and effects of rainfall pattern were analyzed. Moreover each variable discussed showed studies done internationally, continentally and nationally. The reviewed various concepts were:

2.2 Land Cover Change Trends

The section discussed the way the land had been changing in different parts of the world.

2.2.1 International Studies

In Europe there was evidence of change in land use when the Europeans settled in the areas. The major land use change was the decrease in the amount of forest cover, and the transition in forest composition. The forest changed from hard wood and conifer types to early successional species such as aspen (Snetsinger& Ventura 1990: 3-4). This was not the first study done in an area, many studies were done before.

Changes in landscape structure were done in the area, where Silbernagel *et al*. (1990: 4) studied past and current vegetation composition and pattern in the Upper Peninsula of Michigan. The challenge was the differences in data sources and resolution (Snetsinger *et al* 1990: 4). The problem was that the writers did not try to relay measures from the two time periods to each other. More studies have been conducted to show that land cover has been changing over the years.

Changes in old forests and vegetation composition for northern Minnesota, Wisconsin, and Michigan were studied by Frelich (Snetsinger *et al* 1990: 4). The downfall of the study was that it did not involve a precise spatial component, thus making it difficult to make conclusions about land use change. The study done by Palik and Pregitzer in northern Lower Michigan analyzed two study areas that were originally not the same in presettlement vegetation. With time they had however converged because of historic land use and management practices. Mladenoff and Howell made observation of changes in upland forest composition and structure in the Gogebic Range of northern Wisconsin, for three time periods ranging from presettlement to the present time the study was conducted. Hall examined spatial pattern and forest cover transition during a more recent and shorter time period, 1973-1983. The satellite imagery, for a 900 sq. km study area in northern Minnesota was used (Snetsinger et *al* 1990: 4).

In order to get common classification and same data resolution, GIS and image processing system were used. Firstly, percent change of overall forest cover, and percent change of individual cover types by ecological unit were calculated. Secondly two general landscape indices were employed. These indices described landscape change in terms of overall degree of land cover change, and diversity and change in diversity, by ecological units. The land cover was based on satellite imagery, which captured only canopy cover (Snetsinger et *al* 1990: 6-9). The following section discussed the studies done in Africa with regards to land use change pattern.

2.2.2 Continental Review

A study done by BBS was in line with the observation that drought can be caused by human activity, through land use change. There was an interesting conclusion that building a dam may help to prevent water, especially for irrigation purposes. The secondary effects of this mitigation activity surprisingly highlighted that there may be drought downstream due to severely reduction of the flow of water. The study also confirmed the previous studies done that deforestation caused drought. This was attributed to the fact that the soil's ability to hold water was significantly reduced, thus triggering desertification, and leading to drought (Voortman 1997: 5). In South Africa the similar study was conducted by Biggs and Scholes.

2.2.3 National Studies

In a detailed article Biggs and Scholes (2002: 420) revealed that in SA the cultivation area had tripled, whereas the plantation area had increased by 10 fold. The land covers had increased to about 12% and 15%, respectively. The major crops planted were maize, wheat, sorghum and

sugar cane. The trend of crop increase demand was observed domestically, internationally. The writers also agreed with other writers that the major cause of change in land use was through human activities. There was also a close link between change in land use and population growth (Biggs & Scholes 2002: 420). Another variable discussed was the relationship between land use change and population growth.

2.3 Relationship between Land Use Change and Population Growth

Some studies determined whether there was a relationship between land use change and population growth.

2.3.1 International Studies

The study in Amazon was the evidence that when people were few in the area there were few land changes, namely shifting cultivation and frequent movement of settlement. The study also showed that by the year 1988 about 15% of the Brazilian Amazon was deforested and seriously fragmented. This could be attributed to a high population growth in an area (Mustard, Defris, Fisher & Moran 2004: 3).

In an influential study Mustard *et al* (2004: 4-5) used past studies in an attempt to determine whether land cover change is linked to common socio-economic drivers, like drought. A study of tropical deforestation aim was to assess common drivers of land use change. The study analyzed the results of 150 case studies. There was a development of a typology of (1) land-cover change (pathways), (2) linking them to broad drivers (both land uses and their ultimate causes – policy, economics, social, environmental), and (3) addressing the major impacts consequences of the land-cover conversions. The typology was obtained from examination of case studies results conducted under the NASA Land Use Land Cover Change (LCLUC) program from 1997, and where appropriate, the results of studies conducted within the broader community of land change science (Mustard *et al* 2004: 3-5).

Limitations of the study were that the case studies from which examples were drawn focused on European colonization of western hemisphere regions, reflecting past orientations of the LCLUC program, and thus do not necessarily capture land-change processes in other parts of the world. The advantages of using western hemisphere emphasis was that the time scale for important changes in many landscapes was compressed relative to other parts of the globe which may

extend over thousands of years (Mustard *et al* 2004: 3-5). The studies done in Africa were discussed next.

2.3.2 Continental Review

The study conducted in Lebanon emphasized the urban expansion was at the expense of agriculture, forestry, and natural resources. The country started to experience urbanization post 1960. The population grew from about 450 000 to about two million in the 20th century. Consequently the increasing population meant more land cover change. The aerial photographs were used to prove this scenario. Consequently high population meant high water demand, due to human interference. The water became unavailable, and more land was degraded (Masri, Khawlie, & Faour sa: 1). The land could be used in various ways.

A study by Lucid showed that people changed the land cover. A different form of land use change, namely rain fed agriculture was observed in the study area. The land cover had changed from being a grazing land to an agricultural, due to the increasing population in the area. The study mentioned that the conversion started as early as in the 1930's and expanded slowly in the 1950's. Land use change had since escalated, after most African counties gained independence. The areas that showed such trend were areas around Mount Kilimanjaro on both the Kenyan and Tanzanian sides, The eastern slopes on Mount Kenya showed a similar trend (Lucid 2006: 1-2).

The expansion led to competition over access to water between and with land use systems. In line with this observation it was discovered that there were also settlements in Kajiado by immigrant farmers. The maps explained different land covers in different years. The study area was Loitokikok area, Jajiado District, Kenya, was shown in Figure: 2.1 (Lucid 2006: 2-3).

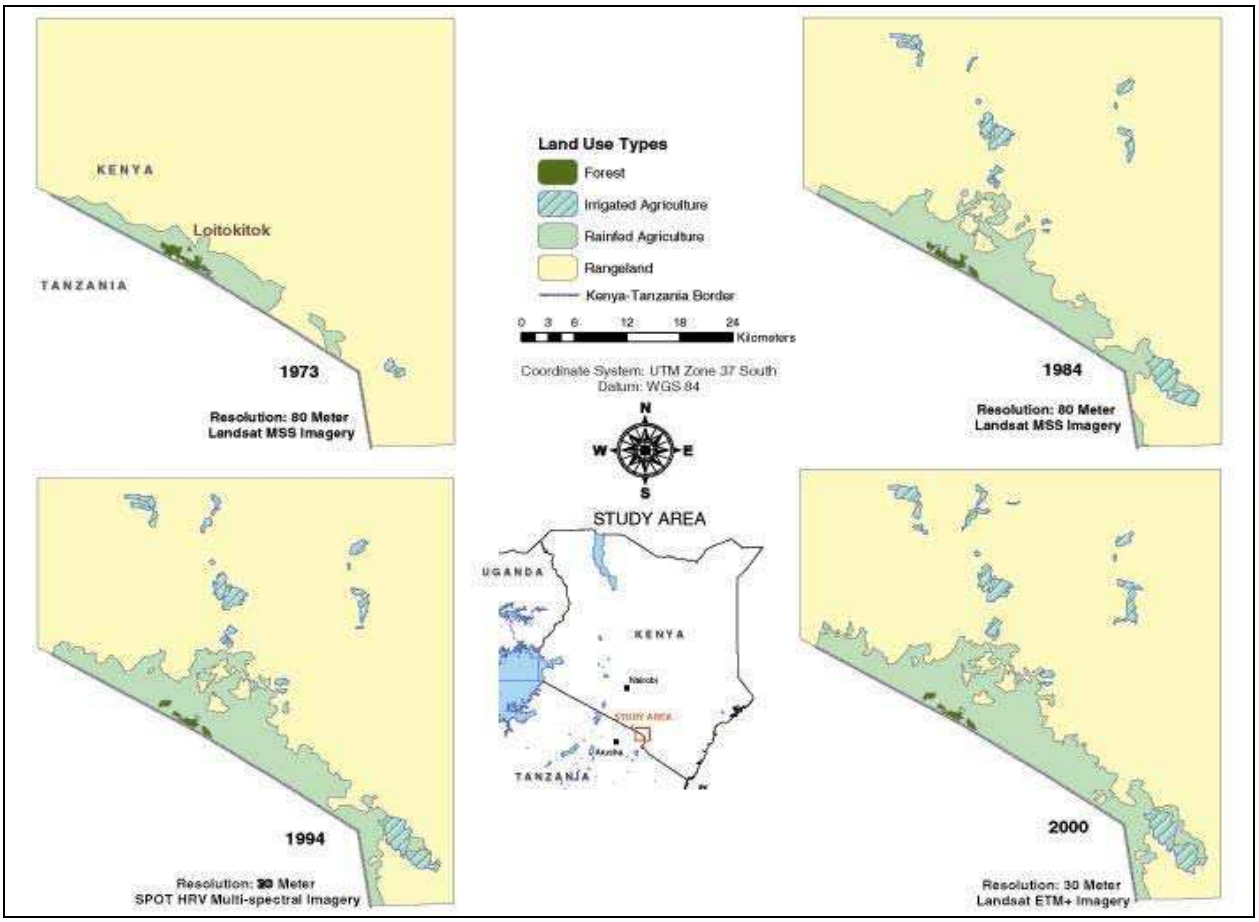


Figure 2.1: Land use in 1773, 1984, 1994 and 2000 in the Loitokikok area (Lucid 2006: 2 3)

Figure 2.1 showed evidence that land cover had been changing over the last years. Some of the studies done in SA were discussed below.

2.3.3 National Studies

What was clear in South Africa was that population growth, which varied between 2.2 and 3.8 led to a high water demand. The water was mostly used for development needs, and the need to grow adequate food to feed the growing population (Abrams sa: 6). The reviewed article by Lambid, Geist (2007:1) pointed out that the increases in local populations had large effects on land use. The demographic changes were believed to be causing the changes in household structure and dynamics. The changes ranged from breaking down of families into multiple nuclear families. Migration was also believed to be the leading cause of rapid land use change (Lambin & Geist 2007: 8).

The developments brought socio-economic and political pressures, which were not there before developments. In the Eastern Cape, specifically Ndlabe Municipality the coastal area was used for personal wealth, holiday homes and resorts, leisure and outdoor activities. The high amounts of developments led to land use and land cover change, in response to human needs and wants. The consequences of change in land use were environmental impacts within the coastal system (Palmer 2008: 2). Coastal developments along the coast and the negative impacts were mostly observed in KZN and the WC (Palmer 2008: 2).

In KZN, the study was carried by Watson (1995:1-4) in a sub arid riverine and interior lowland area of the Mfolozi catchment. The area had no one living in it from early 19th century until 1958. The data to investigate the change in land use was through using aerial photographs taken between 1937 and 1983. The photographs were used to determine the temporal and spatial variation in eroded surfaces, lightly vegetated surfaces vulnerable to erosion, and active gullies (Watson 1995:1-4).

Prior to settlements in 1958 the erosion was not bad and there was light vegetation. The woody communities covered over seventy percent of the area. However immediately after settlement erosion and loss of vegetation increased dramatically. The area became overpopulated, deforested, since people cleared plots for cultivation and used wood for dwelling and fence construction. Subsequently the woody communities decreased to fifty percent, within two years of settlement. The dry season and overgrazing further decreased the coverage to about forty percent (Watson 1995:1-4).

The trend continued for over two decades. It was noted that during wet conditions, by the mid 1960, the situation was reversed. Immediately when the dry spell started in the early 80's the situation reverted back. These conditions were attributed to the deforestation, establishment and linkage of homesteads and arable land. The findings of the study suggested that change in land use caused soil erosion, which led to drought (Watson 1995:1-4). The following section determined the studies showing water demand by the communities over the past years.

2.4 The Quantity of Water Used By the Community

Other studies were conducted to assess the amount of water used in different years.

2.4.1 International Studies

According to Hesmay (2003: 1), many lakes have reduced their water levels because of the increased water use in their catchments (Hesmay 2003: 1). For example: In 1960, the Aral Siea which used to be the largest inland sea in the world had shrunk. It had left its saline shores exposed to the wind; because of high population, hence the water had dramatically decreased (Hesmay 2003: 1). There were other studies showing a similar trend.

The study done by Forest Science Services showed that water yield was above water demand by more than 100 times during an average precipitation year in the area. The study also found that water shortages occurred because of high population density, water demand, and/ or period drought. It was predicted that in 20 years to come, the water shortages would increase (US Climate Change Science Program Final Report (USCCSPLR) 2004: 1).

Like in many areas studied in Europe the demand of water demand had increased by 5 fold (from 100 km^3 per annum in 1950 to 550 km^3 per annum in 1990). There were estimates that these figures would increase to 660 km^3 by the end of the 19th Century. It was predicted that due to this situation there would be drought, which would result in future conflict between human demands (commercial, social & political) and ecological needs. The study eluded that it was important to develop techniques to assess the frequency of droughts in European rivers and how these may change in the 21st Century (Albert-Ludwigs-Universitaet Freiburg 2004: 1). The studies done in Africa showed related results.

2.4.2 Continental Review

A study conducted by Solcomhouse (2008: 1-3) showed that the increase in population in the 20^{th} population had increased the number of people who used renewable water resource by six fold. Basically when there were many people there was high urbanization and industrialization. This would in turn lead to drying up of water resources, hence caused drought (Solcomhouse, 2008: 1-3). The study further continued to reveal that by 2025 a total of 1.8 billion would have water shortage in their countries or regions. Currently many countries in the Middle East and North Africa were experiencing hydrological drought. By 2025 Pakistan, South Africa and parts of India would experience absolute water scarcity. Generally if there were no water resources for irrigation, industrial, environmental, and domestic uses there would be drought (Solcomhouse, 2008: 1-3). The water demand was rising, as seen in Table 2.1 (Abrams sa: 2).

Table 2.1: Past and projected water demand (cu km/yr) in Southern Africa (Abrams sa: 3)

Country	**1993 Demand**	**1993 Irrigation**	**2020 Demand**	**2020 Irrigation**	**Total Available**
Angola	1.335	0.350	2.757	0.750	78.000
Botswana	0.129	0.020	**0.336**	0.047	**0.230**
Lesotho	0.118	0.070	0.268	0.160	2.490
Malawi	1.135	0.795	2.578	1.820	4.240
Mozambique	1.967	1.308	3.210	3.000	132.000
Namibia	0.265	0.108	0.538	0.248	0.740
South Africa	19.295	9.615	**30.168**	12.674	**28.470**
Swaziland	0.454	0.310	0.511	0.331	1.160
Tanzania	5.374	4.560	12.220	10.450	44.000
Zambia	0.994	0.690	2.192	1.580	60.000
Zimbabwe	2.524	2.175	5.737	4.980	7.860
TOTAL	33.590	19.981	60.515	36.120	359.190

Table 2.2, showed that the total amount of water in various countries used was estimated to increase in future. In some countries such as Botswana and SA the water demand in 2020 would surpass the total available (Abrams sa: 3). The studies done in South Africa showed the water demand trend.

2.4.3 National Studies

One of the studies revealed that one of the challenges facing South African government was the provision of water for its citizens. The rapidly growing population had resulted in the spread of settlements. This made it difficult for the government to fulfill its promise to the people of water provision to the nation. The consequences were detrimental; since South Africa was reliant on uncertain supply of surface water to fulfill the agricultural and citizen needs (Showalter, Silberbauer, Moolman & Howman sa: 1).

A document compiled for the Ministry of Agriculture, showed that the areas with high levels of water consumption, due to high population might experience water scarcity faster than areas with low water consumption (Abrams sa: 2-5).

A study done to highlight water related aspects of drought concluded that water was the significant factor related to drought occurrence. The study further showed that there were many factors which exacerbated and intensified water shortage. On average the country's rainfall was 500mm per annum. As a result of high population, it became lesser feasible for wetter regions to transfer water to drier regions. The dry land farming was mostly affected by the situation. The study predicted that the water demand in SA would be above the available water resources. The situation had already started to affect several water basins. The predicted water demand by sector in the country was indicated below, Table 2.2. (Abrams sa: 3-4).

Table 2.2: Past and projected demand in South Africa by sector (Abrams sa: 3-4)

Sector		**Demand (x 10^6 m^3)**
	1993	**2010**
Domestic	1516	3000
Industry	1031	2500
Municipal use	90	200
Urban use	280	500
Power generation	224	400
Mining	466	600
Irrigation	8254	11500
Stock watering	264	350
Forestry	1284	1700
Nature conservation	2994	5000

The water demand increased in all sectors with time. The situation in 1993 would be totally different from the situation that would be observed in 2010, as the prediction showed that more water will be used then (Abrams sa: 3-4).

Similar to other studies in the study conducted in Rietspruit, the satellite imaginary showed that the land cover had been changing over years. Different years were used to compare land lover change. In the four time periods examined showed that there had been an increase in the extent of settlements. Since 1991, there was a significant increase in the extent of settlements. Indeed, the urban/residential area's average growth rate of 1.87 square kilometres per year from 1972-1982. The growth nearly doubled after nine years (1982-1991) to 2.67, almost doubled again

after seven years (1991-1998) to 4.79 square km/year. Figure 2.2 demonstrated the observed trend (Showalter *et al* sa: 3).

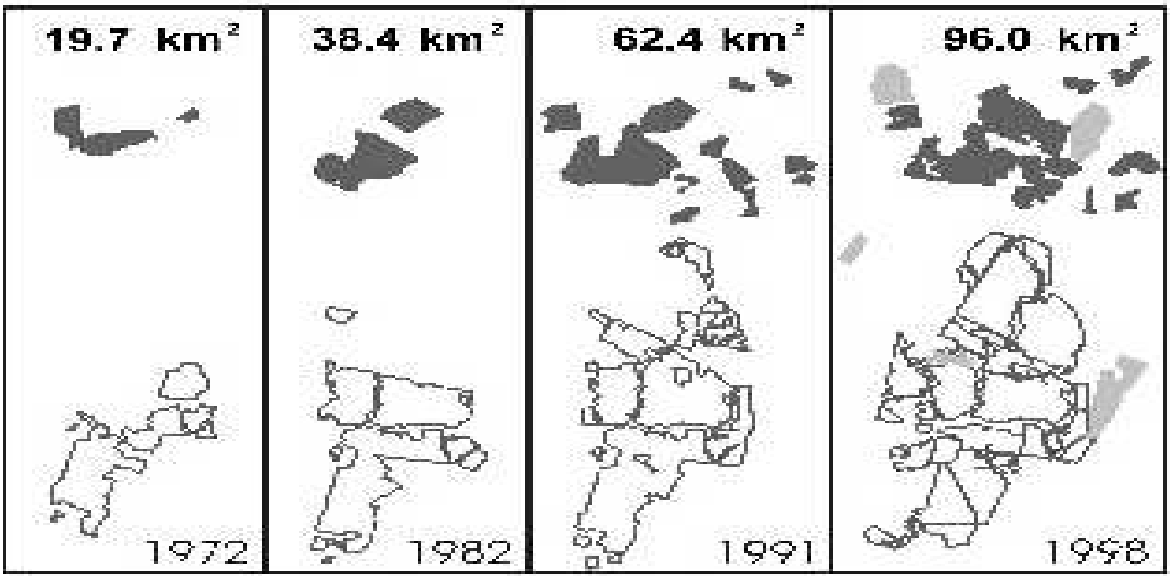


Figure 2.2: Increase in Residential Area in the eastern part on the Rietspruit Catchent (Showalter et al sa: 3)

The implications of the extensive development of formal, low cost housing developments vis-à-vis water demand were substantial, as there was high competition of water. This might lead to water scarcity, which could result in conflict, within the community (Showalter *et al* sa: 3). The land use change could also affect the water runoff.

2.5 The Land Use Change Effects on the Hydrologic Regime

Various studies were conducted in different areas to detect the land use change effects on the hydrological regime.

2.5.1 International Studies

The USGS study revealed that the surface runoff was affected by the meteorological factors, physical geology of an area and topography of the land (USGS 2008: 1-2). In reality only a third of the precipitation ran off into the rivers and streams. The two thirds of precipitation were evaporated into ground water. Surface water could be averted and used by humans (USGS 2008: 1-3). In Greece urbanization and construction of tourists' complexes, particularly along the Mediterranean coast had environmental impacts. Change in land use also increased vulnerability of the area to drought hazard (Isendahl, Schmidt 2006: 7-8).

Greece had changed the land use by planting cotton. Despite the fact that pressure on water resources was moderate, the cotton production consumed about 87% of total fresh water. Land was also used for maize, oilseeds and cereals. The study showed that due to decrease in forest cover and increase of agriculture land, the runoff increased. However the base flow was decreased, because the new land cover, the cropland was not effective at maintaining high infiltration rates (Isendahl *et al* 2006: 7-8). A study done in Africa proved this theory.

2.5.2 Continental Review

When there was rainfall, 31% of the rainfall returned to the sea through rivers in Africa. In SA the situation was different as only 9% of water returned to the sea. One of the major contributing factors was evaporation rate (DWAF 2004: 661). More studies done were discussed below.

2.5.3 National Studies

On average the annual runoff in SA Rivers was about 50 billion m^3. Water shortage in SA was exacerbated by the fact that it is situated in a drought belt. Another cause of drought was that the country's rainfall was seasonal and was influenced by topography (DWAF 2004: 661). The perennial rivers were also very limited in the country. They were over one quarter of South Africa surface area. Rivers on the western interior of the country are episodic: They only flow when major rainfall events have occurred. Other than that they remained dry for the rest of the year (DWAF 2004: 661).

Another South African study showed that ground water only contributed 13% of bulk water supply. However, since SA was a water scarce country, ground water was significant. Actually two-thirds of South African public was dependent on ground water for different purposes. Water was mostly used for irrigation purposes. To respond to water shortage in the country ground water and underground water was used as the water source. Underground water sources also supplied the river (DWAF 2004: 661).

To emphasize the land use change negative effects on water runoff, the study prepared for DOA showed that land use change reduced water infiltration and the storage capacity of water resource through siltation. The situation was even worse for downstream users, because when the runoff was reduced the water did not reach certain areas (Abrams sa: 7). The next section reviewed studies related to rainfall causes and the effects of the lack of rainfall.

2.6 Rainfall Indicator

Other studies were conducted to show whether or not the rainfall trend of the area affected drought occurrence.

2.6.1 International Studies

Ranjan (2007: 1) and Laurance, Williamson (2008: 1) agreed that when people change the way the land is used, for instance change of forests to agricultural land increased ground water recharge. Deforestation resulted in reduced evapotranspiration, even though deforestation favored runoff (Ranjan 2007:1). Rapid forest lost and fragmentation on Amazon made the area more prone to droughts. When plant evapotranspiration was reduced due to deforestation, regional rainfall was constrained (Laurance, Williamson 2008: 1). The studies emphasized the importance of vegetation. The lack of vegetation may lead to rainfall shortage. The following study discussed the rainfall effects.

Another study showed that the 1996 drought in southwestern United States was caused by the rainfall shortage in winter and spring of 1995-1996. Many stations reported less than 2" of precipitation and temperatures 2 to 6 degrees F above normal. The similar occurrences were observed in northern Mexico in 1995 (Eakin & Liverman 2003:1). The next study looked at the rainfall trend analysis to determine drought occurrence.

In the study conducted in Gesing sub watershed, in Java rainfall analysis was done annually and monthly. The study emphasized that when analyzing rainfall data information concerning precipitation amount trends, the beginning of the dry season, number of dry months and the beginning of rainy seasons should be discussed. To determine whether the rainfall season had been high or low, its rainfall amount was compared with that of the country (Narendra 2009: 28).

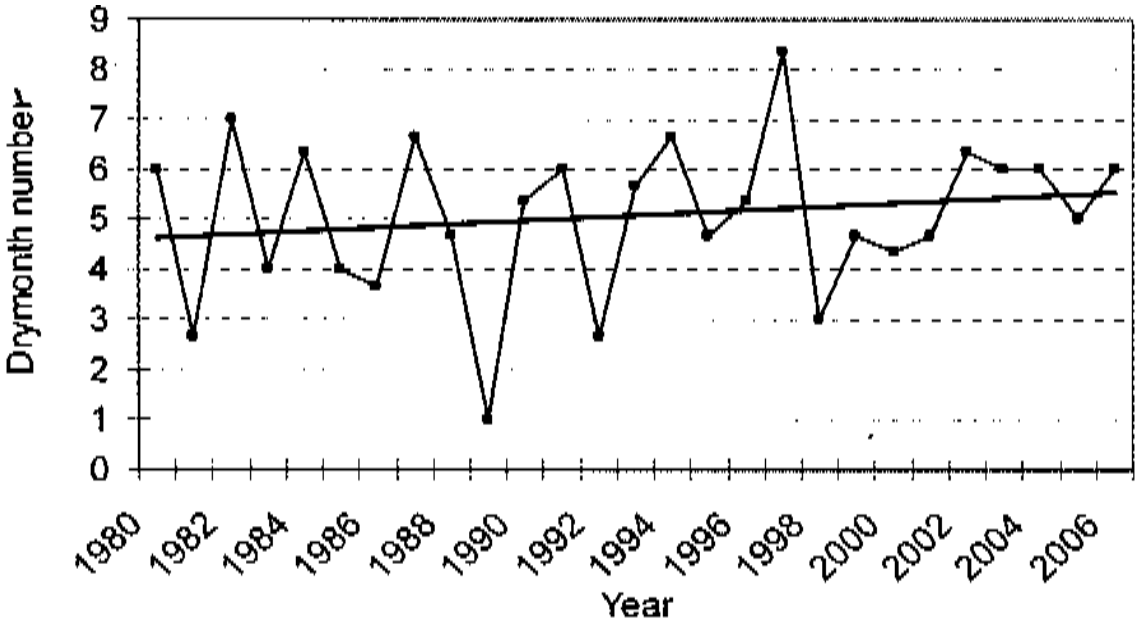


Figure 2.3: Trend line of dry month number averaged from 3 stations (Narendra 2009: 28)

Drought was caused by the above average number of dry months. The trend line of dry month number indicated that the number of dry months throughout the years had been increasing in the area, Figure 2.3 The correlation was however insignificant (Narendra 2009: 27-28).

Furthermore the study analyzed the rainfall trend to determine whether the precipitation amount had been increasing or decreasing in the past 27 years, studied.

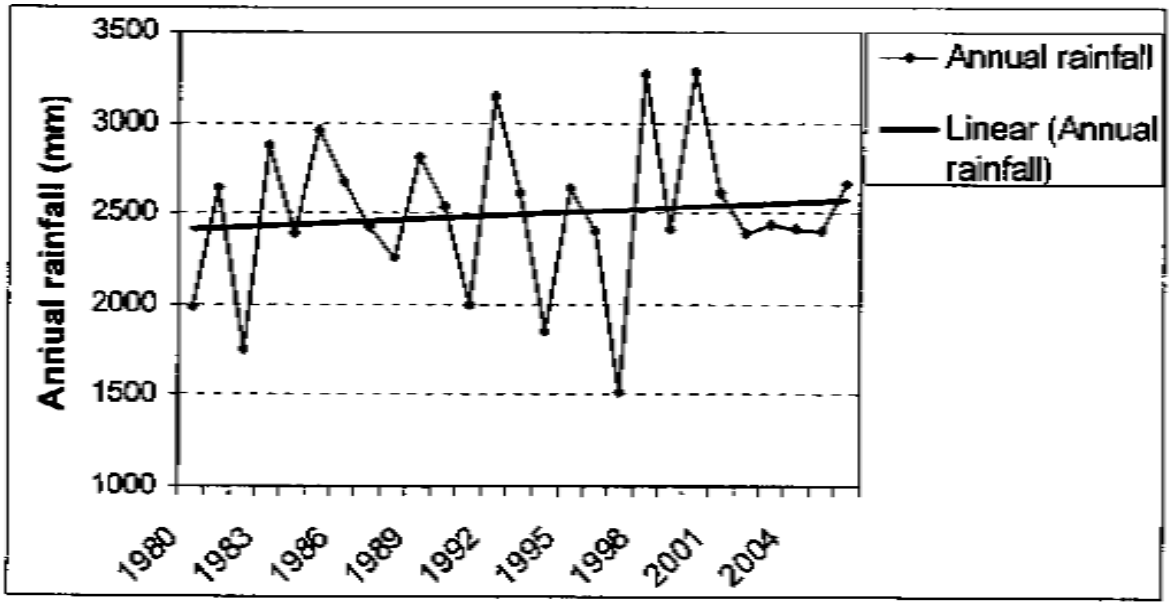


Figure 2.4: Trend line of Annual Rainfall (Narendra 2009: 24)

Surprisingly the results showed that the annual rainfall had been increasing, Figure 2.4. A threshold amount was used to determine drought years (Narendra 2009: 24).

There were studies that introduced a new dimension, by showing that the occurrence of rainfall is reliant on the vegetation availability. There was a general ideology that the destruction of rainforests caused drought. When the rainforests were cut down it was believed that the amount of rain, that clouds formed and caused rain were reduced. As a result there won't be rain. This trend was seen in both South America and Central Africa (Yahoo Answers 2009: 1).

2.6.2 Continental Review

In West Africa, a study showed that low rainfall and drought have been more prevalent. The simple method used to detect the rainfall pattern was the analysis of time series on rainfall, for the period of 1950 to 1992. What was unexpected in the results was that change in rainfall was not the gradual one. There were trend breaks. Consequences of reduced rainfall were shortened length of growing period, hence less crop yield. The study also highlighted the possibility that change in land use might have minimized the rainfall occurrence (Voortman 1997: 385).

In order to illustrate rainfall trend in West Africa, annual rainfall totals for Sokoto from 1907 to 1991 were analyzed. The trend showed that the rainfall amount was above average in 1968 and below average thereafter (Voortman 1997: 385). However the evaluation of root causes showed that land cover change, high population growth had made the area more vulnerable to drought occurrence (Voortman 1997: 387). Another study was conducted in Sahel.

Sahel, which had been suffering from drought since the 1980's did a study to determine the primary cause of drought. The primary, direct cause was found to be rainfall shortage. There were however secondary factors such as marginal land and human activities in the area (BBC 2009: 5). The 2008 study conducted in Kenya after post election violence found that drought was one of the challenges the country was faced with. Drought was thought to be caused by poor November rains. The risk assessment showed that a total of 74.6mm average rainfall was received. Consequently there was no improvement in the quality and quantity of forage in the study area due to water unavailability (International Federation 2009: 1-2). The following section reviewed what has been seen in South Africa in terms of rainfall occurrence trend.

2.6.3 National Studies

In Southern Africa the reduced annual rainfall was deemed as a primary cause of desertification. What intensified the situation was that the sub region was one of the water stressed regions. The long term effects were decrease in stream flow and the inability of ground water to recharge. The shocking statistics revealed that by 2025 Southern Africa would be amongst the absolute water scarce regions. This was believed to lead to minimal levels of food production, since there won't be adequate water to irrigate crops (United Nations Economic Commission for Africa 2007:10).

Examination of past drought is South Africa's arid and semi-arid rangelands showed that rainfall pattern had changed. Models predicted that the mean annual rainfall had decreased. The study also emphasized that there were links between drought, and land use. The identified dynamic pressures leading to drought in the rangeland systems were human population, rising food and fuel prices, political changes and uncertainties around land reform (Vetter 2009: 29).

2.7 Summary/ Conclusion

The section had reviewed the scientific literature available about the effects of change in land use. Chapter 2 evaluated the reviewed literature review, which provided the authoritative scholarship on the research problem. Drought was an event that was caused by different circumstances.

Although the effects of change in land use studies continue to generate controversy, researchers have shown over the past years that there was a relationship between the change in land use and drought occurrence. There was also evidence that the other contributing factor in water shortage was the lack of rainfall. Some studies have shown that the change of rainfall was actually caused by land use change. The next Chapter that was discussed was Chapter 3, ift focused on the study area.

CHAPTER 3: DESCRIPTION OF A STUDY AREA

3.1 Introduction

Chapter 3 looked the research variables in details. Firstly the land use change and effects in the area were looked at. Secondly the population in the area, MLM were evaluated. Thirdly water resources and the amount of water supplied in the area by the local municipality were discussed. Fourthly the historical annual runoff was discussed. Fifthly the monthly and annual rainfall data was examined. The sub conclusions were drawn from the presented information.

3.2 Land Use Cover Change

Land use change was examined using quantitative, qualitative survey techniques. There was a transect walk taken in the area in 2008, the river and the status quo of the area were captured, using a phone camera. The pictures of the type of houses in the area were obtained from the internet. Furthermore the household size data was taken from the SSA census data (SSA 2001: 1-10). Schools and health facilities found in Willowfontein were determined (Mfeka 2009: 1, Stuart 2009: 1 & Hofstee 2006: 132).

3.2.1 Land Use Zones

The section determined whether there had been major change in land use, which might have affected the water availability in the area. The trend in land cover change was established.
Willowfontein could be broadly classified to the following land use zones:

3.2.1.1 Vegetation zone

There was different vegetation in an area, Figure 3.1. The preliminary investigation indicated that the predominant vegetation type within Willowfontein were gum trees. The land slope in the area could be regarded as disturbed, and the causing factors are mainly settlement and agricultural activities. The increasing population in the area made the situation worse (Ndawonde 2008:1).

Figure 3.1: Willowfontein vegetation (Blogspot 2008: 1)

The indigenous plants helped to absorb a lot of water. Consequently the water was released slowly to the water resources, over a long period of time. The current trees were no longer able to absorb and store water. This situation made it difficult for water resources to get water every time of the year. With rates of change in land use being high, the drought characteristics were changing (Koohafkan 2008:1).

3.2.1.2 Residential (Settlement) zone

Housing was one of the key developments in Willowfontein. This was evident from the relatively high representation (3182) of households which were of different types of dwellings within the area, Table 3.1 (SSA 2001: 1-10). There were also pictures to support the way houses looked in the area, Figure: 3.3.

Table 3.1: Number of Rooms (SSA 2001: 1-10)

Number of Rooms	1	2	3	4	5	6	7	8	9	Over 10	Not Applied
Total	179	354	392	628	582	431	231	162	86	127	10

The number of rooms per houses ranged from one to over ten. There were small houses and big houses, Table 3.1, Figure: 3.2 (SSA 201: 1-10).

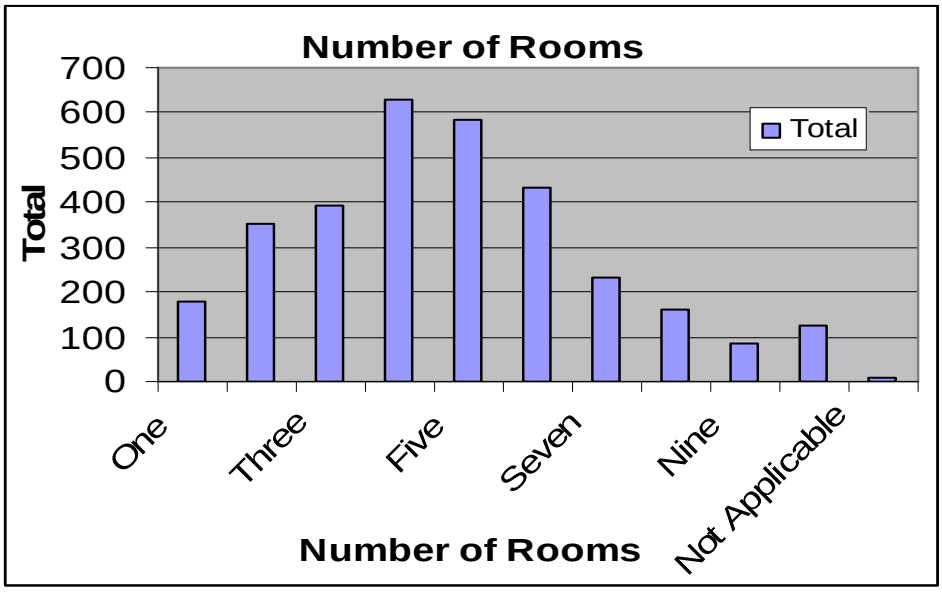


Figure 3.2: Number of Rooms

Very few houses were one roomed house (179). The average number of rooms was five. This meant that more space was used to build houses. Basically more water resources were used and more land was used to build a house. In essence more trees had been destroyed (SSA 201: 1-10).

Table 3.2: Number of Houses in the area (Pillay 2009: 1)

Area	**Year**						
	1999	2000	2001	2002	2003	2004	2005
Terminus	350	359	389	377	389	396	406
Mhlongo	570	584	599	614	629	645	661
Kwa Khuwayo	360	369	378	388	397	407	417
Phupha	800	820	841	862	883	905	928
Total	**2080**	**2132**	**2185**	**2240**	**2296**	**2352**	**2412**

Assuming a 2.5%, per annum growth rate.

The house count was taken from 1999 planners in Willowfontein (Pillay 2009: 1). The quantity of houses varied significantly depending on the economic status of each household, Table 3.2 (Pillay 2009: 1). There were big and small houses. As the population increased, it was assumed that more houses were built (Koohafkan 2008:1).

Figure 3.3: Houses in Willowfontein (Blogspot 2008: 1)

From Figure 3.3, one can be able to determine that a lot of vegetation had been replaced by different types of houses. The construction of tar roads made the situation worse, because more trees were destroyed. The change in land use effects could be a major contributing factor to the frequent drought reported events. In the past drought events were significantly lower due to the fewer developments that had taken place (Koohafkan 2008:1).

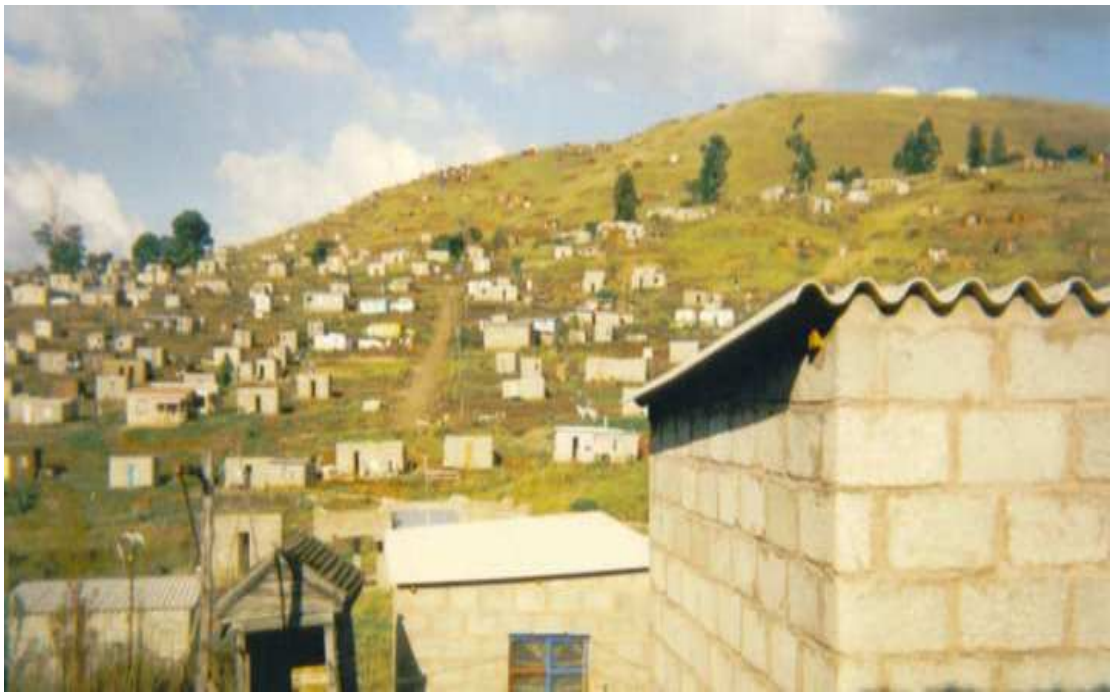


Figure 3.4: RDP Houses in Willowfontein (Blogspot 2008: 1)

The large number of RDP houses showed that there had been change in land use in the past few years, Figure 3.4 (Blogspot 2008: 1) . RDP houses were built after 1994. One could say that the space that was occupied by RDP houses used to be a vegetation of some sort. Today, due to a large amount of developments the risk of the areas to be impacted by drought was high (Koohafkan 2008:1).

3.2.1.3 Agricultural zone

Agriculture was the dominant form of practice in Willowfontein. People planted different vegetables and there were different community projects (Chamane 2008: 1). The most planted vegetables were potatoes. Some of the vegetables were sold to supermarkets. Agricultural sector needed a lot of water to be sustained. Most water in the area was therefore used for irrigation purposes. Some people even had livestock. They really needed water in the river, and other natural water resources for their animals to drink (Chamane 2008:1 & Smith sa. 249).

3.2.1.4 Public institution zone

The urbanization of the area had led to commercial and public buildings being built (Chamane 2008:1 & CARA 2006: 1). Public institutions included all service centers such as schools, clinics, churches, garages, shops. Some people had tuck shops. Some of these buildings were new. There were schools built in Willowfontein. The schools were built in different years (Mfeka 2009: 1). There were also health facilities built in Willowfontein (Stuart 2009: 1). The land cover change had resulted in the net loss of vegetation (Asuboneng 2007: 15).

3.2.2 Aerial photographs

There was evidence that since 1973 there had been a significant increase in the amount of settlements. The aerial photographs showed that urban land changed from being a low density residential to be a high density residential. From the images the land in Willowfontein was used mainly for houses, between 1973 and 1995. It was apparent that the most significant change had been the extensive building of formal RDP housing development (Marais 2009: 1). Trees soaked in water like sponge, releasing it slowly. If trees were removed, and houses were built water would not be absorbed (Walker 2002: 24& CARA 2006: 1).

3.2.3 Sub Conclusion

The significance of houses types showed that even though 787 people had taps in their houses, they still used other water resources (SSA 2001: 1-10). There was a continuation of building RDP houses in the area (Chamane 2008: 1). This meant that the population had increased because

people came from other areas and occupied the new houses. (SSA 2001: 1-10). The next section covered the population growth in the area.

3.3 Population

The population in the area was determined by using 2001 Census official statistics. The most recent, and only census done in ward 14 was in 2001. The household size of Willowfontein in 2001 was used to determine the number of individuals living in each household. The next national census would be in 2011 (Motsima 2009: 1). To determine the population growth of the local municipality, the population statistics for 3 years was used. The only available statistics data for Msunduzi Municipality was in 1996, 2001 census, and 2006 household survey data (Chatindiara 2009:1).

3.3.1 Willowfontein Household size

The section determined the population change in Willowfontein and MLM. The census data showed that, the household size ranged from one to ten. The smallest number of household size was the household with 9 members.

Table 3.3: Household size (SSA 2001: 1-10)

Household size	**Total**
One	335
Two	410
Three	363
Four	438
Five	400
Six	361
Seven	284
Eight	217
Nine	134
Ten and over	241

Table 3.3 showed that there were 134 households which consisted of 9 members. The largest number of households had 4 family members per household. There were 438 members with a household number of 4 (SSA 2008: 1-10).

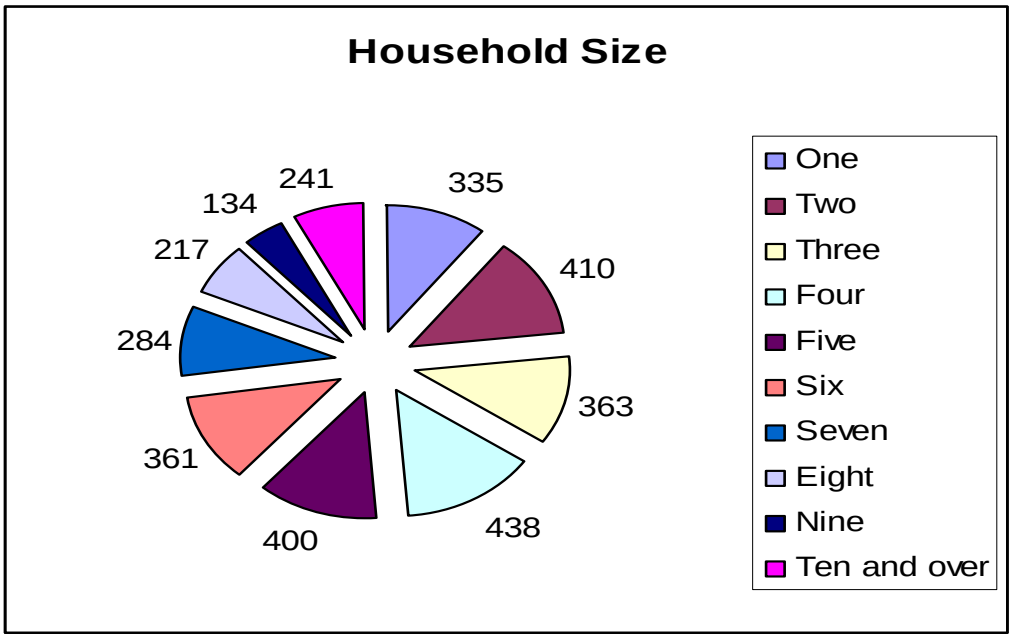


Figure 3.5: Household size

The average households had 6 family members (SSA 2008). The local municipal's population was determined to analyze the population growth in the municipality, thus getting the growth rate in the study area, Figure 3.5.

3.3.2 Msunduzi Local Municipality Population

Generally the local municipality's population growth is 0.89%.

Table 3.4: Msunduzi Municipality Population Growth from 1996 to 2001 (SSA 2008:1)

Year	**Population**
1996	524 937
2001	553 223
2006	616 729

The population was 524 937, 553 223, 616 729 in 1996, 2001 and 2006 correspondingly, Table: 3.4 (SSA 2008:1). The population in Msunduzi Local Municipality increased from 1996 to 2006. Due to the increase of population, drought often has devastating effects on the lives of vulnerable people (Koohafkan 2008:1).

3.3.3 Sub conclusion

As the time has progressed, people who were between the ages of 20-24 in 2001 were now old enough to have babies. The population in Willowfontein has thus increased. Subsequently, as the population had increased more people are using water in the area. The water resources had been affected; the water level had decreased (Hesmay 2003: 1). As the population increased the water demand, hence water storage also escalated with the number of years (USCCPLR 2004: sp). The next variable discussed was the water supply demand.

3.4 Water Supply Demand

The availability of water to people in the area was determined by monitoring the water sources used in the area. The data used was from the 2001 census data in Willowfontein. The sources were named and the number of people using a particular source was determined. This helped to determine the main source of water for people in the area (SSA 2001: 1-10). In order to determine the water supplied by the municipality, the statistical data originally used to design the pump stations was used. During the design of pump stations the area was divided into four sections, namely: Terminus, Mhlongo, Kwa Khuwayo, Phupha (Pillay 2009: 1).

3.4.1 Water Resources

The section mentioned the available water resources in the area. The number of households using each resource was determined. This estimated quantity of water used by the community on an annual basis. There was a relatively good water infrastructure which delivered pipe water on-site and off-site to about 5755 households (SSA 2001: 1-10).

Table 3.5: Water Services (SSA 2001: 1-10)

Water Source	Number of Households
No Access to Pipe	233
Pipe water(dwell)	131
Pipe water(yrd)	787
Pipe water<200m	937
Pipe water>200m	1096
Regional Local School	2804
Borehole	21
Spring	255
Rain-water tank	13
Dam/pool/stagnant	72
River/stream	2
Water vendor	12
Other	4

Water was directly delivered to the dwelling unit of 131 households and within a close range of 5624 households, a large number of households (375) derived water from natural sources, such as a spring. A total of 233 household did not have access to pipe water Refer to Table 3.5, Figure 3.5 (SSA 2001: 1-10).

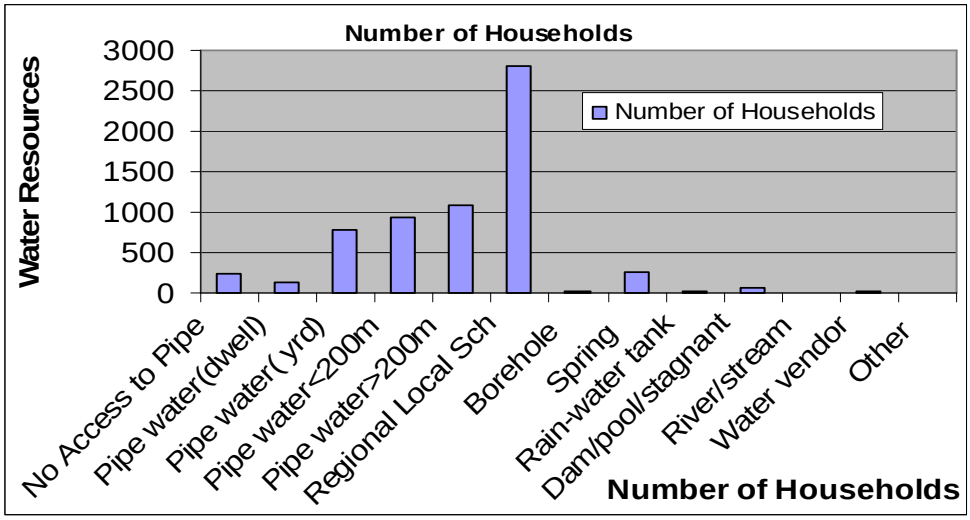


Figure 3.6: Access to water

Figure 3.6 showed that most people got their water from the local school (SSA 2001: 1-10). The following section discussed the water supplied by the municipality

3.4.2 Water Supply by the Municipality

The section determined the amount of water utilized by the community. It estimated quantity of water used by the community on an annual basis. The water supply was not gravity fed, but water was pumped to this area. Water was supplied to Willowfontein via a pump station into two reservoirs namely: Mhlongo and Khuzwayo. These reservoirs supplied water to the Willowfontein area. The area was divided into four sections, namely Terminus, Mhlongo, Kwa Khuwayo, Phupha. Water supply problems were detected by only pump status via telemetry, Tables 3.6-3.8 (Pillay 2009: 1).

Table 3.6: Demand for communal connections (standpipes)

Area	**Year**						
	1999	2000	2001	2002	2003	2004	2005
Terminus	70 000	71 750	73 544	75 328	77 267	79 199	81 129
Mhlongo	114 000	116 850	119 771	122 766	125 835	128 981	132 205
Kwa Khuwayo	72 000	73 800	75 645	77 536	79 475	81 416	83 498
Phupha	160 000	164 000	168 100	122 303	126 610	181 025	185 551
Total	**416 000**	**426 400**	**437 060**	**447 987**	**459 186**	**470 666**	**482 432**

Assuming, 8 persons per house, 25 litres per person per day.

Table 3.7: Demand for household connections

Area	**Year**						
	1999	2000	2001	2002	2003	2004	2005
Terminus	224 000	229 600	235 340	241 224	247 254	253 435	259 771
Mhlongo	364 800	373 920	383 268	392 850	402 671	412 738	423 056
Kwa Khuwayo	230 400	236160	242 064	248 116	254 318	260 676	267 193
Phupha	512 000	524 800	537 920	551 368	565 152	579 281	593 763
Total	**1331200**	**1384480**	**1398592**	**1433557**	**1479396**	**1506131**	**1543784**

Assuming: 8 persons per house, 80 litres per person per day

From the calculations there was a predicted increase in the water demand from 1999 to 2005, as seen in Tables 3.8 and 3.9 (Pillay 2009: 1).

3.4.2.1 Design Demands

Table 3.8: Pump Station to handle year 2005 demands

Area	Communal (Standpipes)	Household
Terminus	81 200	259 800
Mhlongo	132 250	423 100
Kwa Khuwayo	83 500	267 200
Phupha	185 600	593 800

Figures were rounded to upper 50.

The following sections determined the amount of water demand expected in different reservoirs. Phase 1 pump stations were stand pipes. The reservoirs were grouped into two reservoirs.

PHASE 1 Communal (Standpipes)

Demand to Terminus and Mhlongo Reservoirs

= (81 200 + 132 250) + 10% losses + 15% summer factor)

= 213 450 + 25%

= 266 812l/day

$$= \frac{266\ 812}{24 \times 3\ 600}$$

=3.088 l/sec

Design 5 l/sec = 0.005m^3/sec

Demand to Kwa Kkuzwayo and Phupha Reservoirs

= (83 500 + 185 600) + 10% losses + 15% summer factor

= 269 100 + 25%

= 336 325 l/day

$=\frac{336\ 325}{24 \times 3\ 600}$ l/s

=3.893 l/sec

Design 5l/sec = 0.005m^3/sec

Please note:

A peak factor is not included as phase 1 is for a standpipe system.

The next calculations showed the water demand expected in households; phase two.

PHASE 2 Household connections

Demand to Terminus and Mhlongo Reservoirs

= (259 800 + 423 100) + 10% losses + 15% summer factor+1.5 peak factor

= (682 900 + 25%) + (682 900 x 0.5)

=853 625 + 341 450

= 1195 075 l/day

$=\frac{1195\ 075}{24 \times 3\ 600}$

=13. 832 l/sec

Design 14 l/sec = 0.014m^3/sec

Demand to Kwa Khuzwayo and Phupha Reservoirs

= (267 200 + 593 800) + 10% losses + 15% summer factor+1.5 peak factor

= (861 000 + 25%) + (861 000 x 0.5)

=1076 250 + 430 500

= 1506 750 l/day

$=\frac{1506\ 750}{24 \times 3\ 600}$

=12. 439 l/sec

Design 18 l/sec = 0.018m^3/sec

3.4.3 Sub conclusion

People paid for using tap water in their homes. That is why there was a high number of people using natural resources, thus placing high demand on water resources. The water source in the section with RDP houses was communal taps, since houses did not have tap waters in the yard (SSA 2001: 1-10). The next section discussed the annual runoff in the area.

3.5 Mean Annual Runoff

The information used was that of Henley Dam gauging station. It had the highest number of recorded days, when comparing it with other stations it had only 1625 number of days missing in 52 years, making it only 9% of the missing data. Basically 91% of water runoff was recorded. The information was presented in a table and a hydrograph (Mogaswa 2009: 1).

Table 3.9: Runoff data from different gauging stations (Mogaswa 2009: 1)

	Henley Dam	**Inanda Loc.**	**Hamstead Park**	**Slang Spruit**
Minimum	0.142	0.934	2.262	0.074
Maximum	2.595	9.651	5.354	0.795
Mean	1.020	3.827	3.571	0.290
Median	0.943	3.101	3.643	0.209
Total of missing days	1625	1667	700	1102
Number of years: total days	52: 18993	26: 9497	13: 4749	14: 5113
Percentage of days not Rerecorded (%)	9	18	15	22

Mean annual runoff data showed that there had been a dramatic fluctuation in the water level over the past years, Table 3.9.

Table 3.10: Annual Runoff from 1957/8 to 2008/09

Year Starting October	**Mean Annual (Cubic Metres/Second)**	**Year Staring October**	**Mean Annual (Cubic Metres/Second)**
1957/58	0.820	**1983/84**	0.842
1958/59	1.014	**1984/85**	0.815
1959/60	0.635	**1985/86**	0.870

1960/61	0.943	**1986/87**	1.917
1961/62	0.714	**1987/88**	2.344
1962/63	0.996	**1988/89**	1.366
1963/64	0.641	**1989/90**	1.497
196465	0.706	**1990/91**	1.356
1965/66	0.748	**1991/92**	0.601
1966/67	1.469	**1992/93**	0.252
1967/68	0.523	**1993/94**	0.787
1968/69	0.548	**1994/95**	0.378
1969/70	0.813	**1995/96**	2.324
1970/71	1.077	**1996/97**	1.634
1971/72	1.251	**1997/98**	1.088
1972/73	0.793	**1998/99**	0.428
1973/74	1.874	**1999/00**	1.284
1974/75	1.077	**2000/01**	1.108
1975/76	2.474	**2001/02**	1.568
1976/77	0.798	**2002/03**	0.376
1977/78	1.195	**2003/04**	0.217
1978/79	1.362	**2004/05**	1.058
1979/80	0.304	**2005/06**	0.827
1980/81	0.350	**2006/07**	0.502
1981/82	0.000	**2007/08**	1.021
1982/83	0.099	**2008/09**	0.000

Total = 49.683

Minimum = 0.00

Maximum=2.474

Average = 0.974

It may also be noted that conditions at the Msunduzi River showed that the years 1986 to 1996 were characterized by very wet conditions. The pressures on land might result in the falling of the groundwater water levels and low, or even zero stream flow (Koohafkan 2008:1).

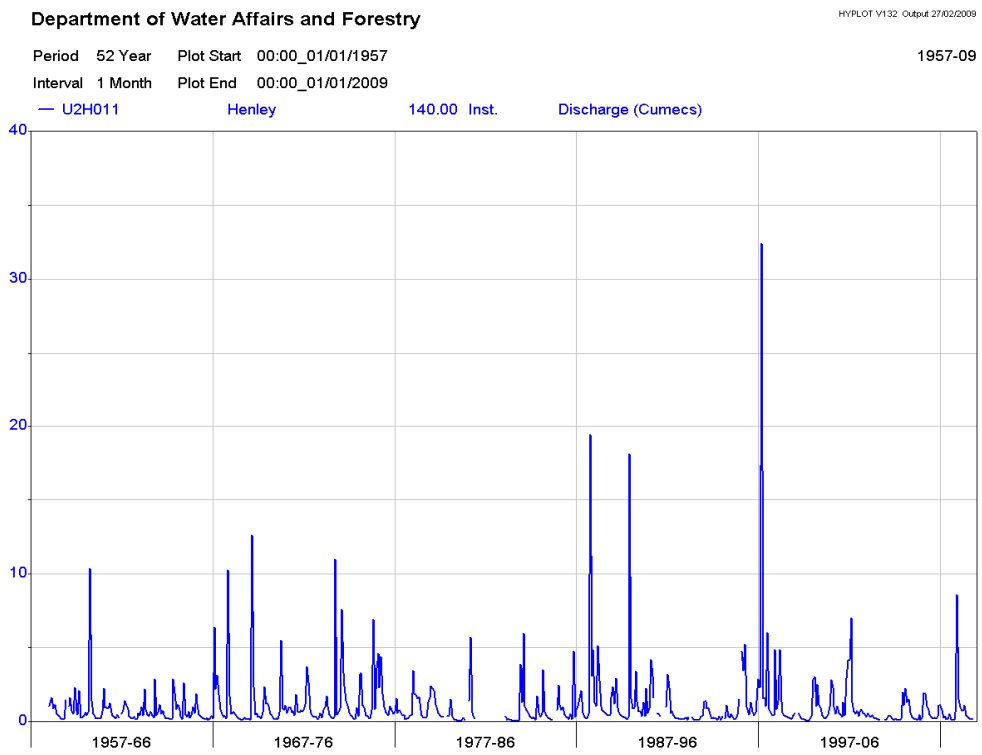


Figure 3.7: Mean annual runoff from 1957 to 2006 (Mogaswa 2009: 1)

The hydrograph showed that the extremes of water shortage appear to have been worse between 1977 and 1986. In the early 20th century as well there were very low levels of water in the river. For example values of less than 0.4 Cubic Metres/Second were recorded in 1979/1980, 2002/2004, Figure 3.7 (Mogaswa 2009: 1).

3.5.1 Sub conclusion

The hydrographs taken on different gauging stations showed evidence that a river that people used as one of their main sources of water had declined water availability. Table 3.10, Figure 3.7 (Mogaswa 2009: 1). This might be due to the fact that one of the inlets of the river was Msunduzi River had become dry (Harwood 1999: sp & Erik, *et al* 2001: 55). The next that was discussed was the rainfall variable.

3.6 Rainfall

To determine drought years and months rainfall data was used. Rainfall data was used to calculate drought indices because it was easily available (Gadisso 2007: 3). Recorded annual rainfall data was obtained from SAWS. Rainfall data used began from 1904 and ended in 2008.

This was a total of 105 years. The data consisted of monthly rainfall from 11 stations located in areas around Pietermaritzburg. In these stations rainfall data was collected using manual rain gauge. The total of the daily rainfall (in mm) by month was measured at 08:00. From annual rainfall, the data was tabulated into monthly data (deVilliers 2009:1).

Out of the eleven rainfall data stations, given by SAWS only three stations had complete rainfall data for 50 years (1958 to 2008). The rainfall stations were [0239482 0]-Cedara, [0239585 4]-Baynesfield Estate, and [0239756 5]-Pietermaritzburg-Darville. However the rainfall station data used in the research was Cedara Station, because there was complete recorded data of 60 consecutive years. In some months the rainfall data was not recorded (de Villiers 2009: sp). The rainfall data provided by the station was reliable and accurate (Zondi 2009: 1).

3.6.1. Monthly rainfall (1904-2008)

The section evaluated drought season and years, by analysing rainfall data of 105 years. The sum of monthly rainfall increased from October (8194.4), to 11145.2 mm in November, to 13092.1 mm in December. The rainfall was still above 6000 mm in January (13140.5 mm), which is the maximum and was 12180.9 mm in February. In March the rainfall decreased to 10976.2 mm, Figure 3.8 (deVilliers 2009:1).

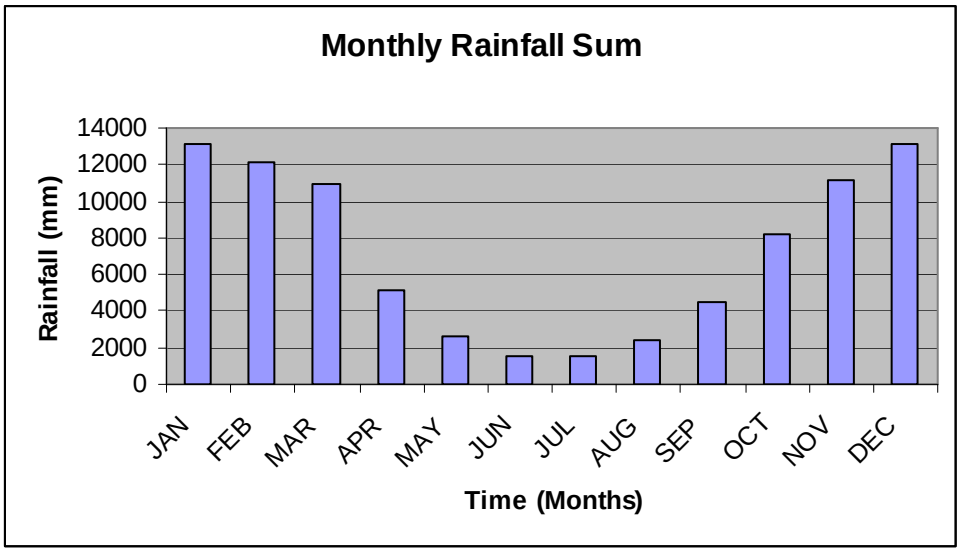


Figure 3.8: Monthly Average Rainfall from 1904-2008 (deVilliers 2009:1)

The Cedara Rainfall station showed that the rain deficient season was between April and September, Figure: 3.8. A dry period was when precipitation had decreased by more than 25% from normal (Chorpa 2006: 2). In the case of PMB dry month was a month which had the monthly

rainfall of less than 800 mm (Wikepedia 2009: sp). Dry months occurred in dry season, winter. In PMB dry months occurred in April to September, Figure 3.9 (deVilliers 2009: 1). The next section looked at the annual rainfall.

3.6.2. Yearly rainfall (Mean Annual Precipitation)

Table 3.11 showed that the recorded annual sum of the rainfall of 105 years was 85735.78 mm. On average in a year the rainfall was 840.55mm. The highest recorded rainfall was 1495.7 mm, recorded in 1958. A year that received the least amount of rainfall was in 1957, it had only 72.2 mm.

Table 3.11: Annual Rain from 1904 to 2008 (deVilliers 2009:1)

Year	Rainfall Amount	Year	Rainfall Amount	Year	Rainfall Amount
1904	249.8	**1941**	603.3	**1975**	74.675
1905	927.8	**1942**	1166.4	**1976**	1132.6
1906	727.4	**1943**	1434.6	**1977**	759.8
1907	889.7	**1944**	640.3	**1978**	904.2
1910		**1945**	666.8	**1979**	771.9
1911	138	**1946**	847.5	**1980**	567.2
1912	287.7	**1947**	1185.5	**1981**	697.2
1913	881.4	**1948**	935	**1982**	711.4
1914	798	**1949**	785.1	**1983**	738.6
1915	726.2	**1950**	719.2	**1984**	768.4
1916	689.2	**1951**	715.5	**1985**	1005.7
1917	1473.1	**1952**	875.4	**1986**	662.5
1918	687.3	**1953**	751.3	**1987**	1461.8
1919	699.2	**1954**	872.9	**1988**	1051.8
1920	1182.9	**1955**	1013.8	**1989**	884
1921	1014	**1956**	939.9	**1990**	763.1
1922	823.3	**1957**	72.2	**1991**	1157.6
1923	728.1	**1958**	1495.7	**1992**	591.3
1924	1011	**1959**	955.3	**1993**	733.7
1925	1242.7	**1960**	757.8	**1994**	788.1

1926	777	**1961**	847.5	**1995**	865.7
1927	850.9	**1962**	760.6	**1996**	1014.5
1928	664.8	**1963**	917.4	**1997**	954.4
1929	1023.7	**1964**	911.4	**1998**	802.9
1930	890.2	**1965**	757.5	**1999**	1115.2
1931	630.7	**1966**	783.1	**2000**	797
1932	711.2	**1967**	978.4	**2001**	1005.5
1933	696.3	**1968**	737	**2002**	789.5
1934	1043.1	**1969**	927.8	**2003**	631.5
1935	697.1	**1970**	948.5	**2004**	836.9
1936	876.5	**1971**	816.8	**2005**	878.2
1937	795	**1972**	790	**2006**	944.3
1938	966.8	**1973**	927	**2007**	722.7
1939	1052.6	**1974**	1093.8	**2008**	597.6
1940	1034.3				

Table 3.11 showed that there was constant change of rainfall amount in each year. Not even once had the rainfall amount been the same in 2 consecutive years.

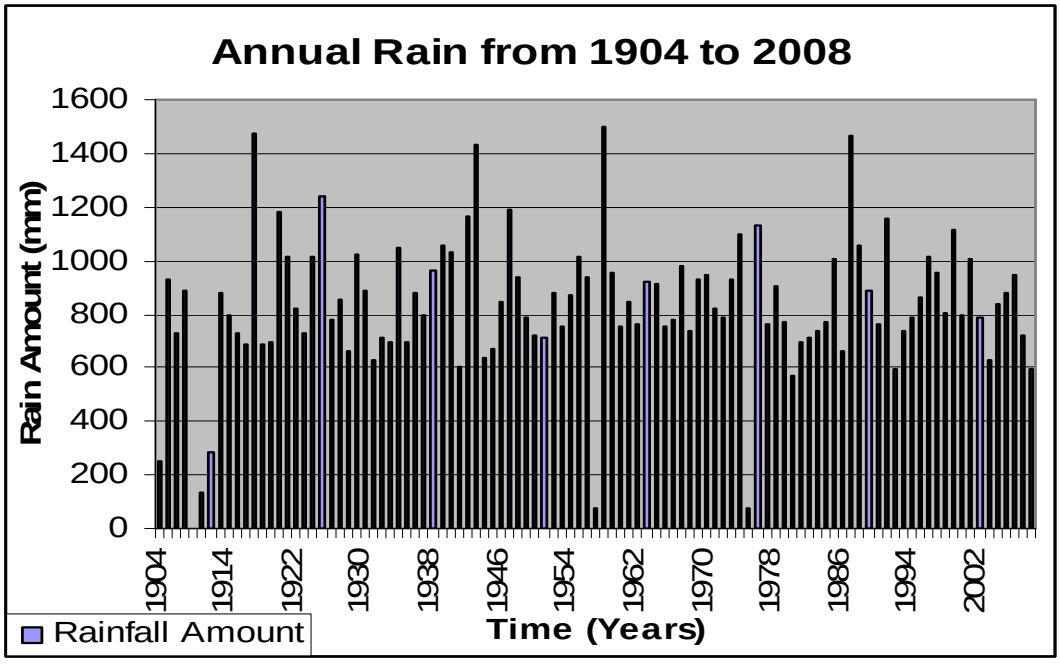


Figure 3.9: Annual Rainfall from 1904 to 2008 (deVilliers 2009:1)

The intensity of rainfall varied considerably. In total there were 46 years, out of 105 years which had a rainfall of less than 900 mm. The annual rainfall amount above 900 mm was between 1938-1940 and 1982-1985. Analysis of Table 3.11 and Figure 3.9 showed that the drought years were: 1906-1916, 1926-1928, 1931-1933, 1935-1937, 1944-1946, 1949-1954, 1960-1962, 1979-1981, 1992-1995, and 2002-2008 (deVilliers 2009:1). Trees added moisture to the air, as water passes out through their leaves, in a process called transpiration. If trees were removed, rainfall occurrence would be disturbed (Walker 2002: 24).

3.6.3 Sub conclusion

In the past 105 years drought events had occurred 10 times. The rainfall amount had to be less than 900 mm, for 3 consecutive years for drought occurrence. The normal annual rainfall was when the rainfall was 9000-1100 mm. The rainfall amount had to be less than 900 mm, for 3 consecutive years for drought occurrence. The normal annual rainfall was when the rainfall amount was 900-1100 mm. Environmental degradation, especially the loss of green cover fields cover affected rainfall received in the area, increasing the possibility of water scarcity (Sekenyo 2008: 1 & Savenije 1996: 1). The next Chapter that was discussed was Chapter 4. It presented the results of the study.

CHAPTER 4: RESULTS PRESENTATION AND DISCUSSION

4.1 Introduction

The section gave results obtained during data collection process. Firstly research questionnaires results were illustrated. Secondly the focus group discussions were presented. Thirdly the annual rainfall data was examined, and a trend line was drawn. Fourthly the historical annual runoff was discussed, and the water runoff was presented. Fifthly the relationship between the rainfall and land use change was discussed. Sixthly the SPSS results were presented. Lastly the land use change maps were presented.

4.2 Questionnaires

After questionnaires analysis, by Excel the results were presented in bar, pie charts and histograms. The obtained results were discussed. The response rate was determined first.

4.2.1 Response rate

Out of the 20 people who got the questionnaires, all people returned them. They were fully and correctly answered. This was 100 % response rate of the selected sample. The analyses results therefore represented the majority views of the sample (Hofstee: 2006: 133). The following section discussed how the analyzed data was presented.

4.2.2 Data Presentation

The number of people who represented each choice in a question was determined. Furthermore the answer chosen by each respondent, in a question was shown. Data collected by questionnaires was incorporated in a spreadsheet and graphs were drawn. The data was analyzed using Microsoft Excel Program, because there were only 20 questionnaires to be analyzed (Mouton 2006: 124). Different types of graphs drawn from various responses were shown below.

A: BACKGROUND INFORMATION

Question 1

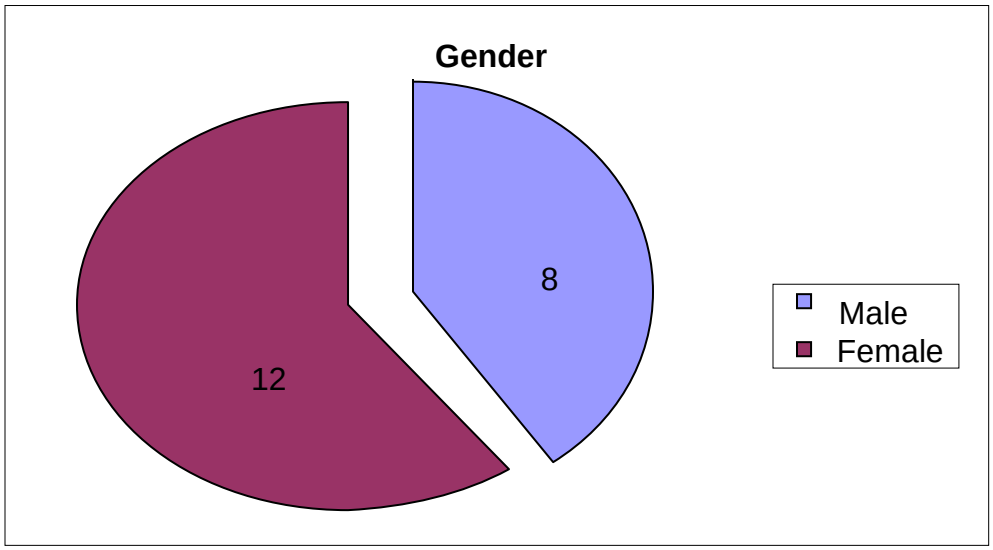


Figure 4.1: Gender of Respondents

According to Figure 4.1 the sample group consisted of 40% males and 60% females.

Question 2

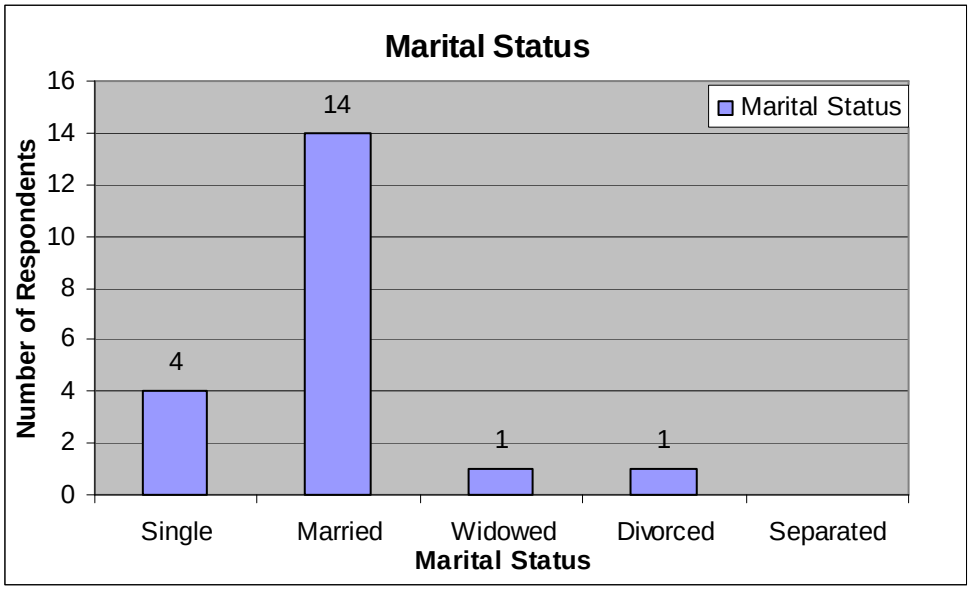


Figure 4.2: Marital Status

Figure 4.2 showed that 20% of the samples were single, 70% were married, only 5% were widowed, and also 5% were divorced.

Question 3

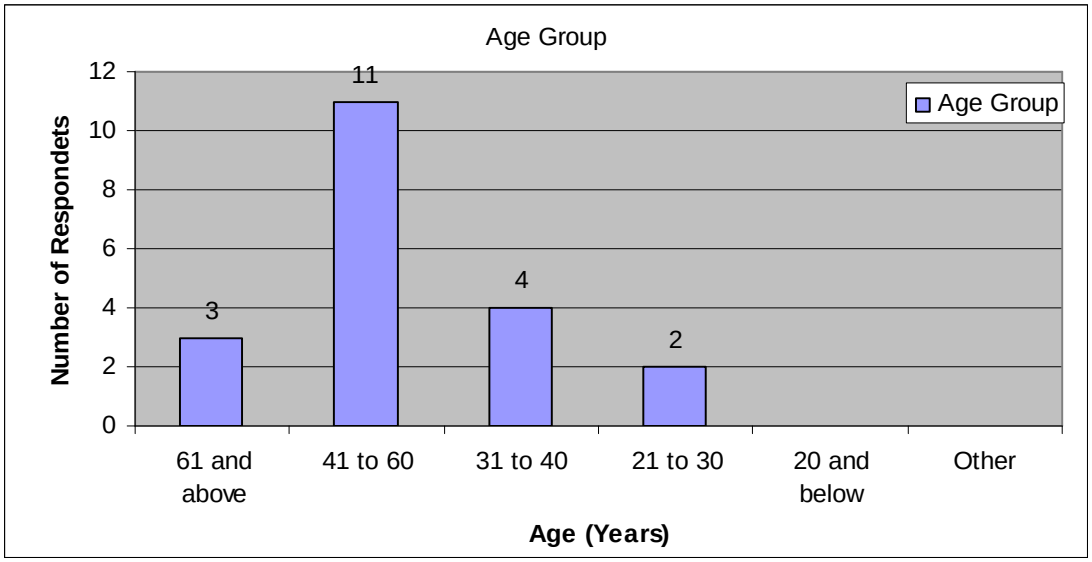


Figure 4.3: Age Group

The age group of respondents ranged from 21 to above 61 years. Figure 4.3 showed that 15% were 61 and above years old, 55% were aged between 41 and 60, 20% were aged between 31 and 40. Only 10% had between 21 to 31 years.

Question 4

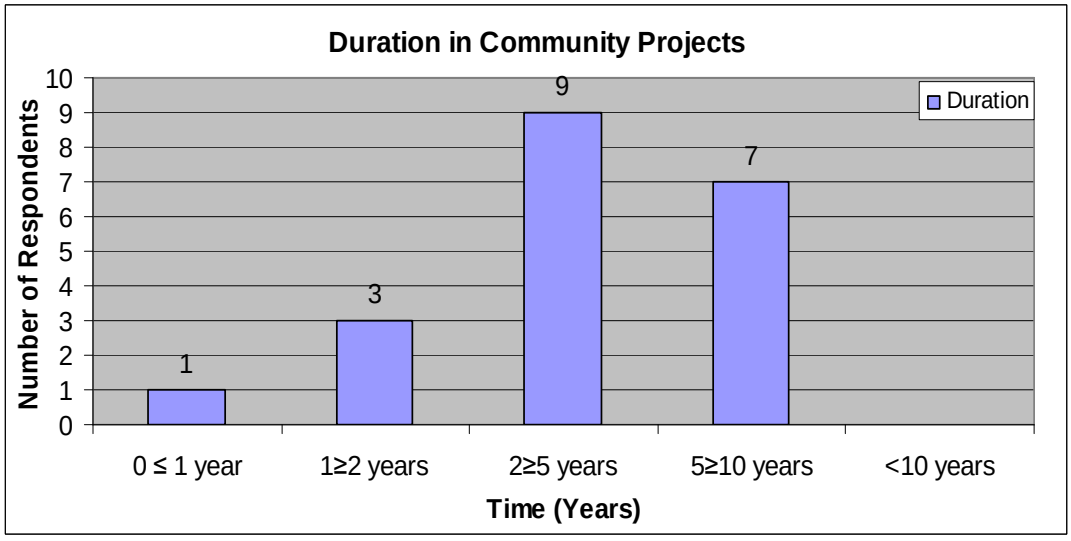


Figure 4.4: Duration in community projects

Legend:**≥:** Less than but equal to, ≤: More than or equal to, <: More than, >: Less than.

As shown in Figure 4.4, only 5% had been involved in community projects for 0 to less than a year. 15% said more than 1 year to less than 2 years, 45% said more than 5 years to 10 years, 35% said more than 10 years.

Question 5

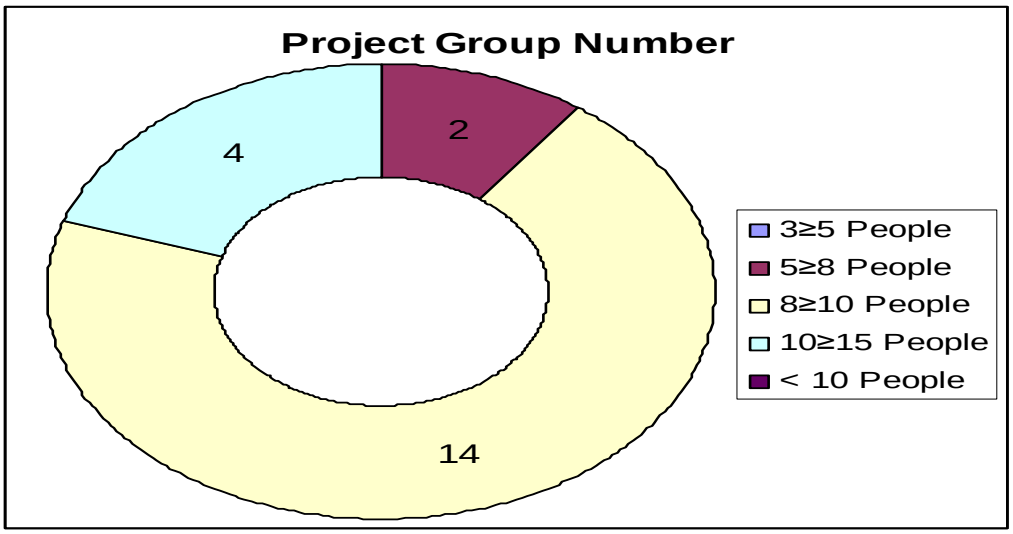


Figure 4.5: Project Group Number

As reflected in Figure 4.5; a small fraction of the respondents; 10% said they were more than 5 but less than 8 in their group, whereas 70% said more than 8 but less than 10, 20% said more than 10 but less than 15.

Question 6

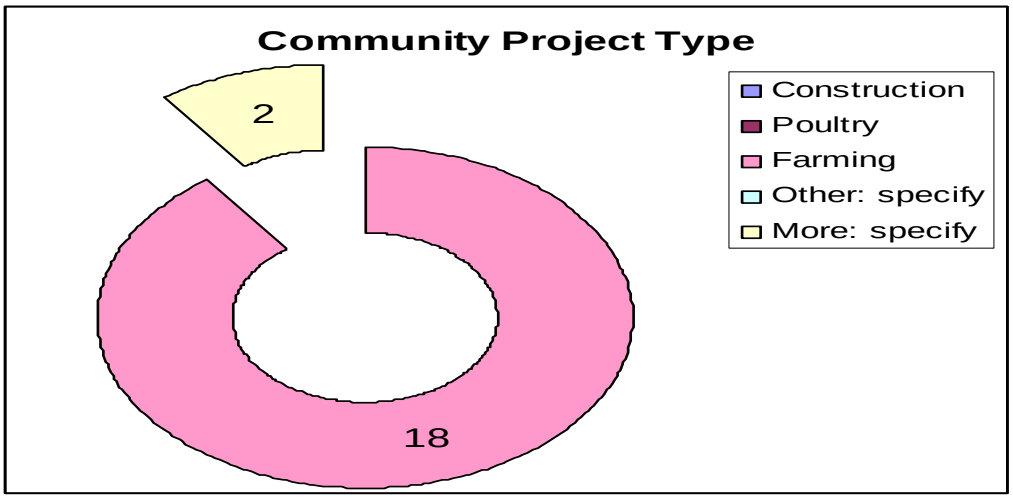


Figure 4.6: Community Project Type

The results in Figure 4.6 showed that the majority of the population; 90% were involved in farming projects. Only 10% said farming and other projects.

Question 7

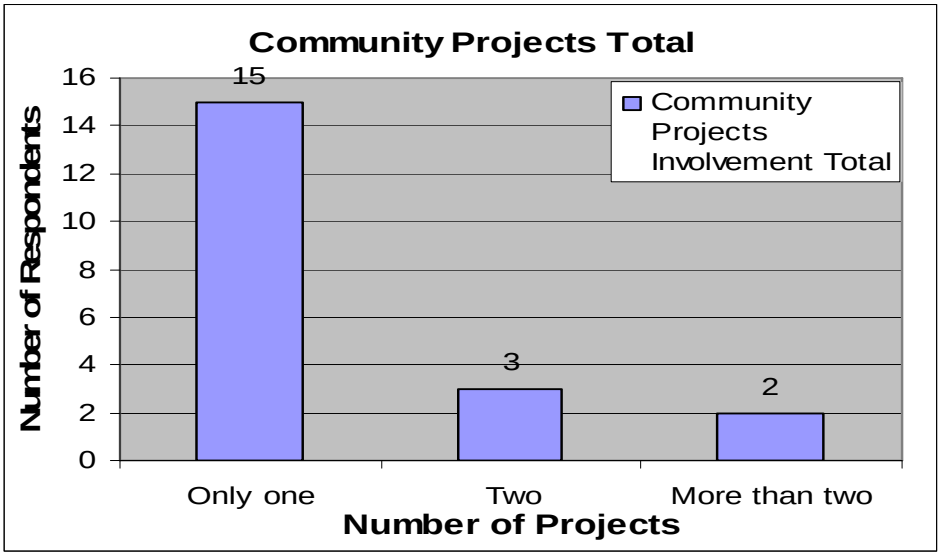


Figure 4.7: Community Project Involvement Total

The analyses in Figure 4.7 showed that the respondents' involvement in community projects was as follows: 75% said one, 15% said two, 10% said more than two.

Question 8

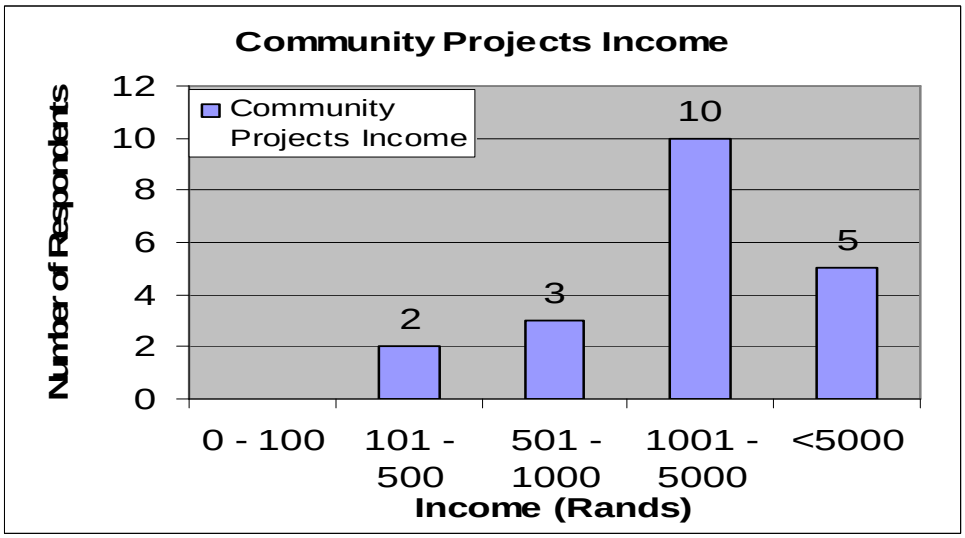


Figure 4.8: Community Projects Income

As seen in Figure 4.8, the income from community projects was as follows: 10% said R 101 – 500, 15% said R 501 – 1000,50% said R 1001 – 5000, and 25% said more than R 5000.

Question 9

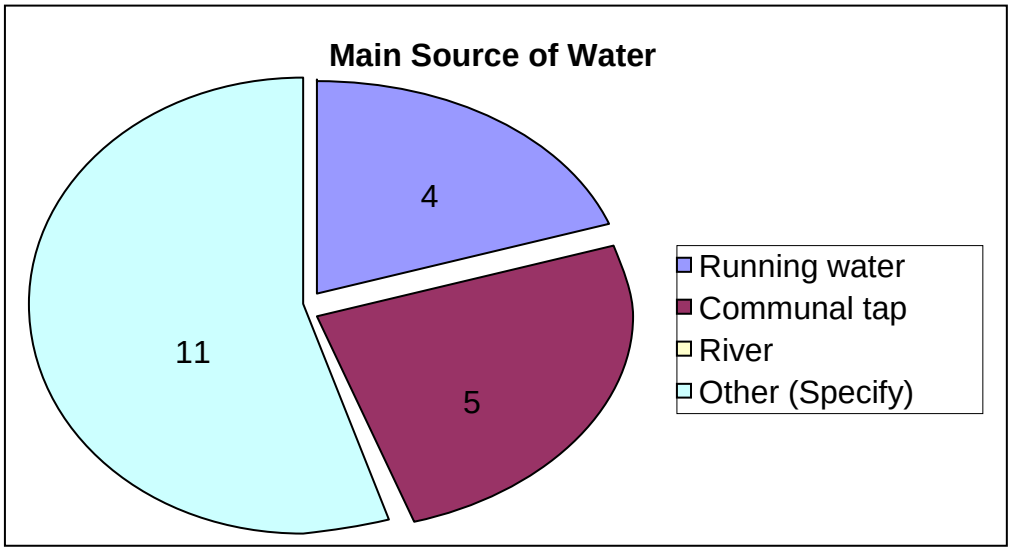


Figure 4.9: Graphical representation of the main source of water

When asked about water source, as seen in Figure 4.9; 20% said running water in the house, 25% said communal tap, and 55% said other.

B: INFORMATION

Question 10

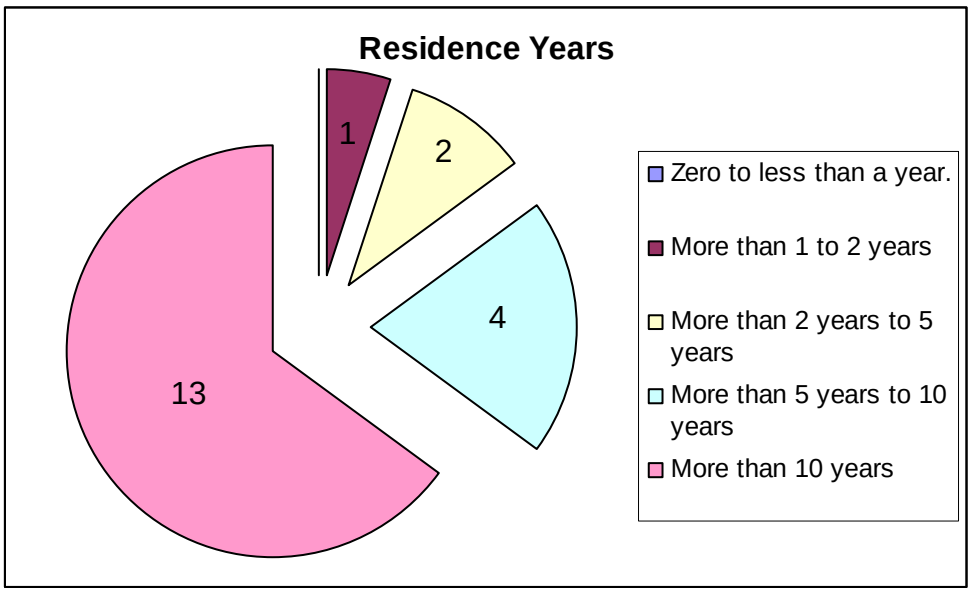


Figure 4.10: Residence Years in Willowfontein

According to Figure 4.10, no one had been living in the area for less than one year. 5% said more than 1 to 2 years, 10% said more than 2 years to 5 years, 20% said more than 5 years to 10 years 65% said more than 10 years.

Question 11

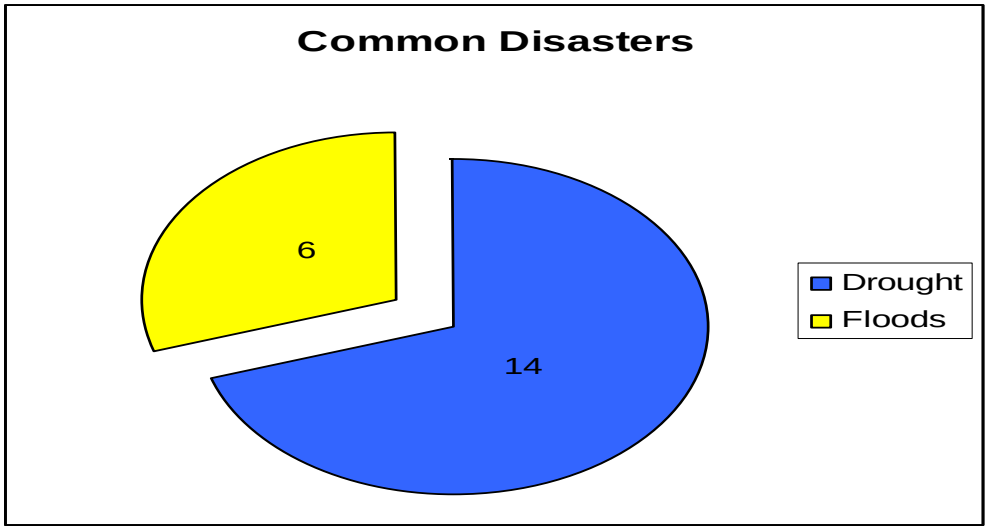


Figure 4.11: Common Disaster in Willowfontein

According to Figure 4.11; 70% said drought, 30% said floods were the common disasters in the area.

Question 12

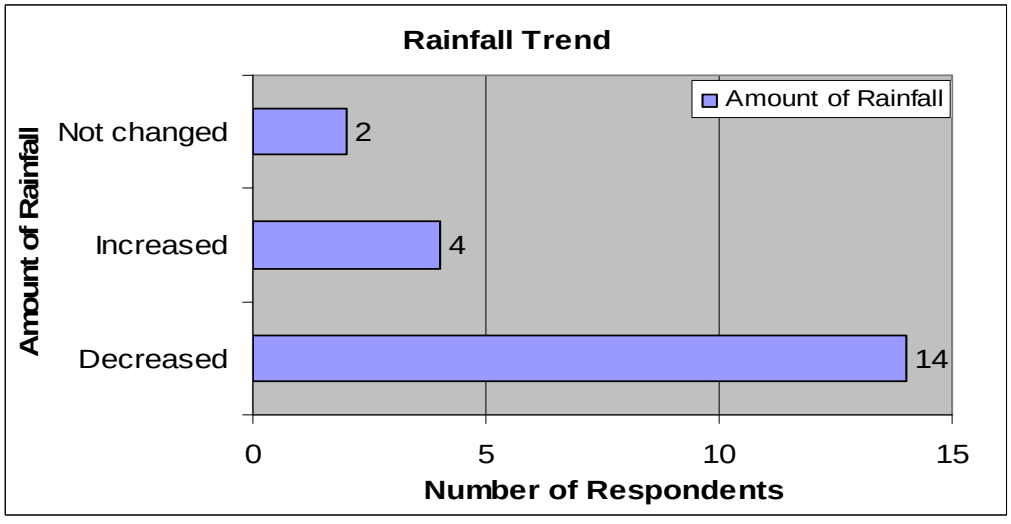


Figure 4.12: Rainfall Trend

Figure 4.12 showed that people had different opinions about the rainfall pattern over the past 5 years. 70% felt it had decreased, 20% felt it had increased, 10% felt there was no change.

Question 13

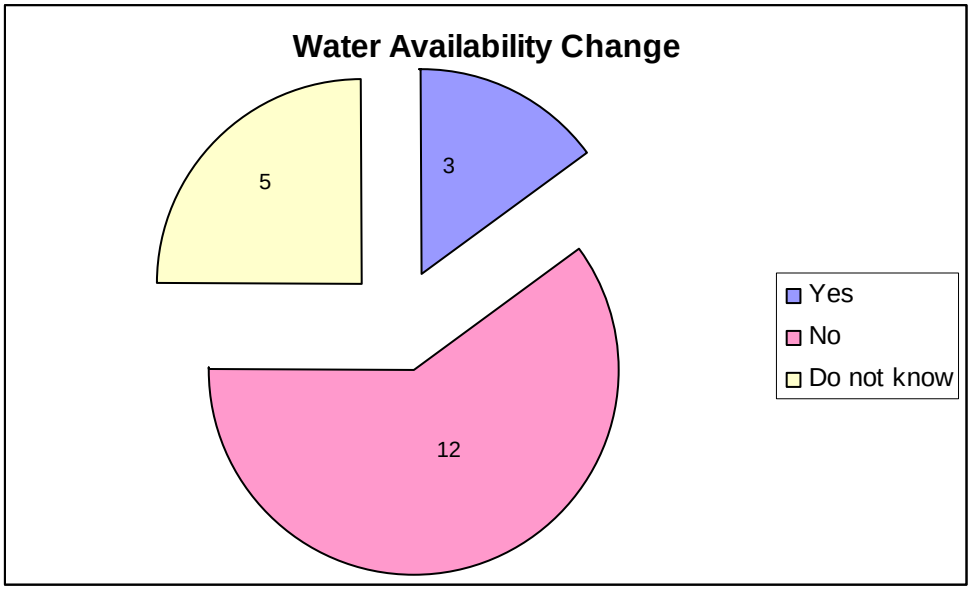


Figure 4.13: Water availability change

As shown in Figure 4.13 people had different views about whether the water availability had been the same in the past ten years. 15% said yes, 60% said no, 25% said they do not know.

Question 14

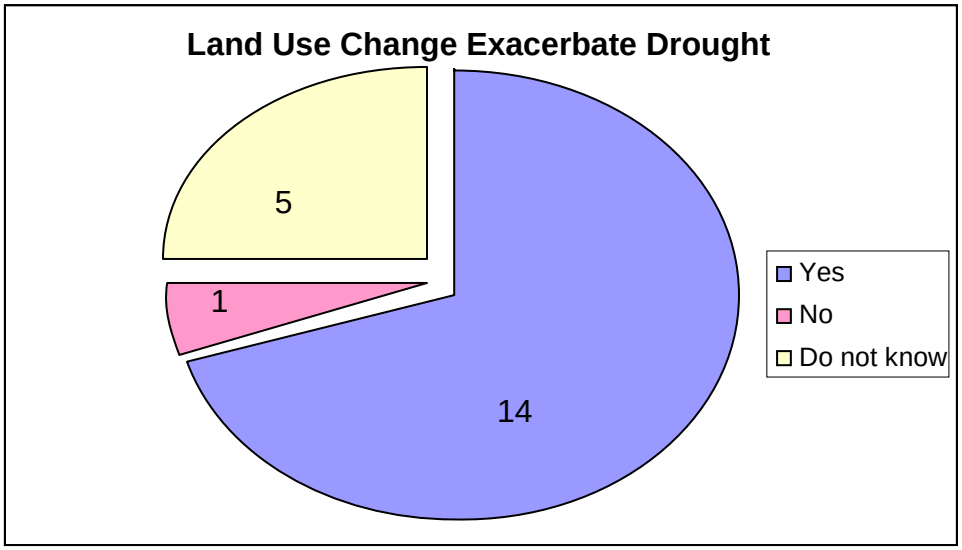


Figure 4.14: Relationship between land use change and drought

As reflected in Figure 4.14, 70% said yes land use change exacerbate drought, 5% said no, 25% said they did not know.

Question 15

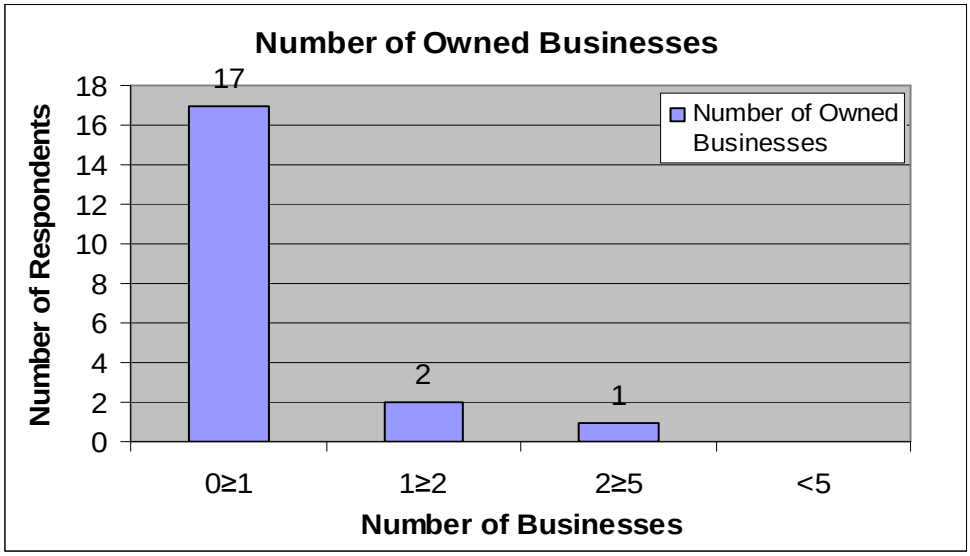


Figure 4.15: Number of owned businesses

Some people had one business, and others had more than one business. Figure 4.15 showed that 85% said zero to one, 10% said more than 1 to less than 2, 5% said more than 2 to 5.

Question 16

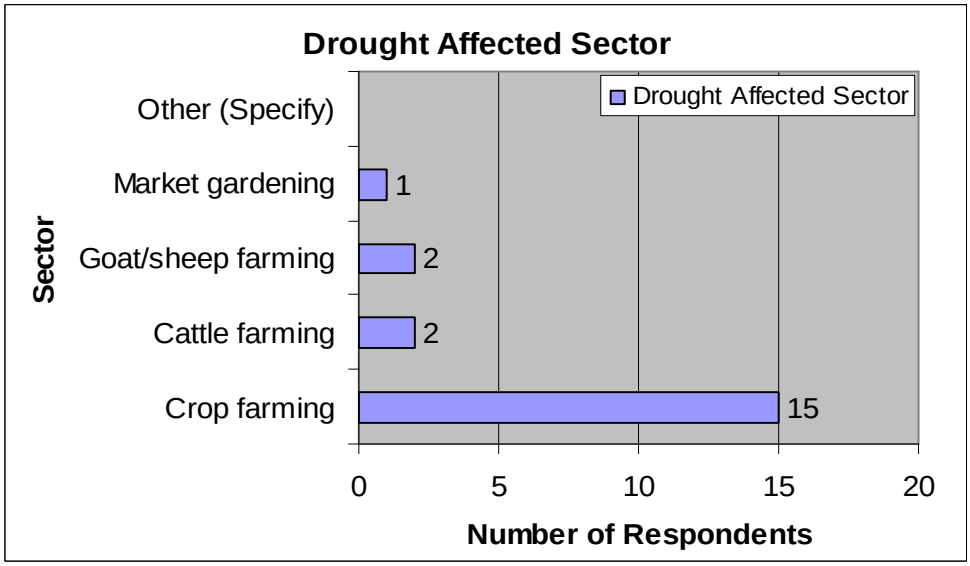


Figure 4.16: Most drought affected sector

As shown in Figure 4.16; 75% said crop farming, 10% said cattle farming, 10% said goat/sheep farming, 5% said market gardening are the sectors that are affected when there is drought.

Question 17

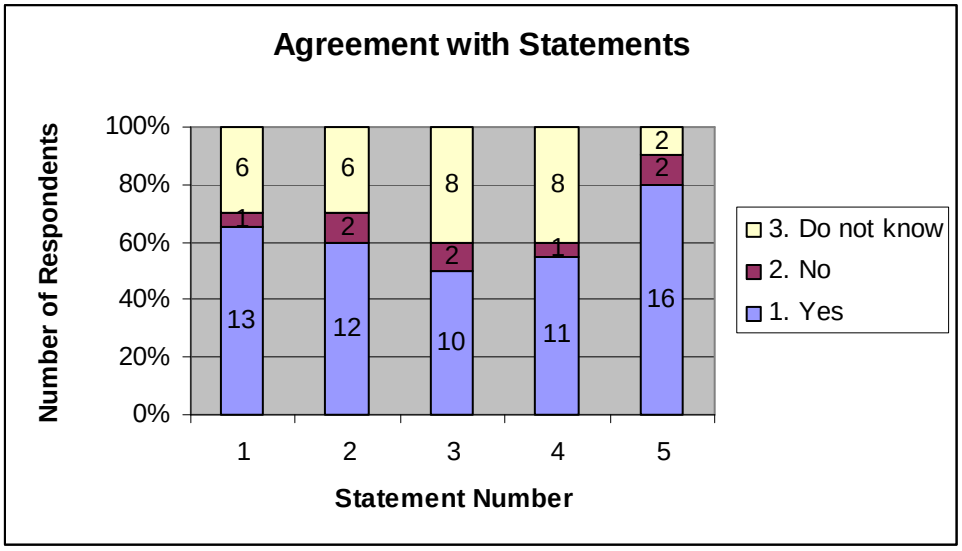


Figure 4.17: Causes drought assumptions

Figure 4.17, reflected answers of the respondents when asked whether:

- The increase of houses in the area has minimized the water availability: 65% said yes, 5% said no, and 30% said they do not know.
- There has been a shortage of rainfall in the past ten years: 60% said yes, 10% said no, and 30% said they do not know.
- The water resources have been destroyed since developments took place in an area: 50% said yes, 5% said no, and 45% said they do not know.
- Water resources have been destroyed by the change in land use in the past few years: 55% said yes, 5% said no, and 40% said they do not know.
- The developments are the cause of overpopulation in the area: 80% said yes, 10% said no, and10% said they do not know

Question 18

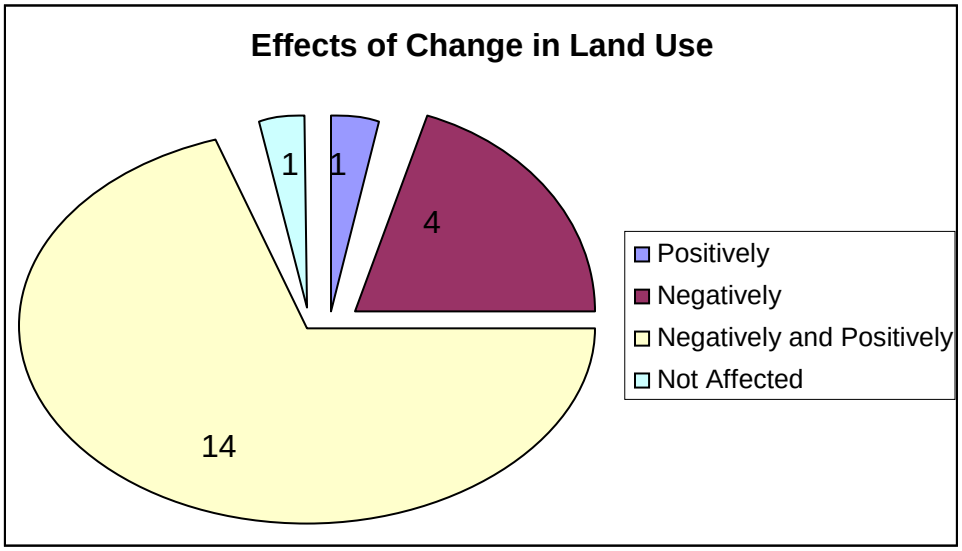


Figure 4.18: Effects of change in land use

Results in Figure 4.18 showed that people had been affected by land use change in different ways. 5% said positively, 20% said negatively, 70% said negatively and positively, 5% said not affected.

Question 19

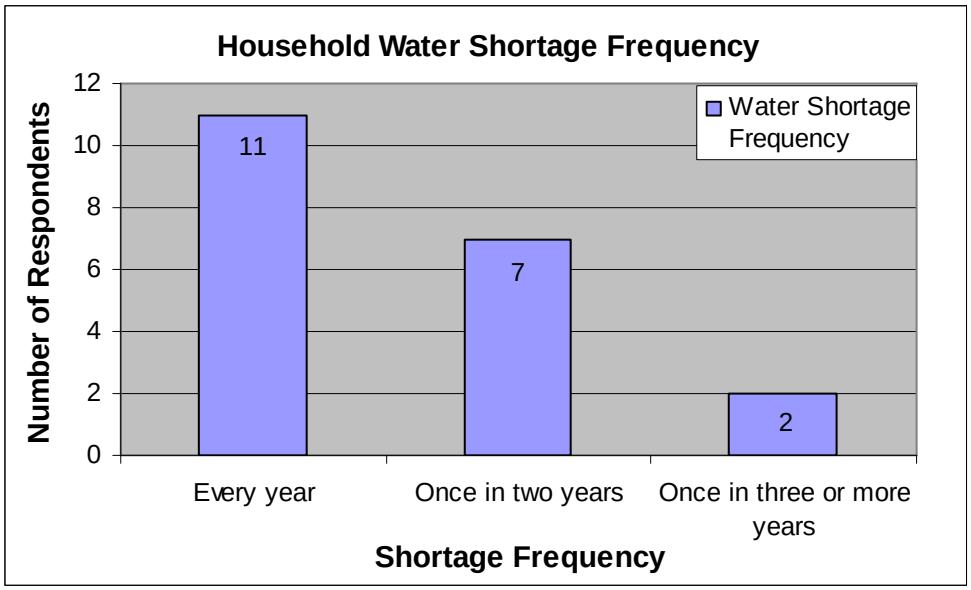


Figure 4.19: Household Water Shortage Frequency

The graph, seen in Figure 4.19 showed that household water shortage frequency experience differed per household 55% said yearly, 35% said once in 2 years, 10% said once in 3 years.

Question 20

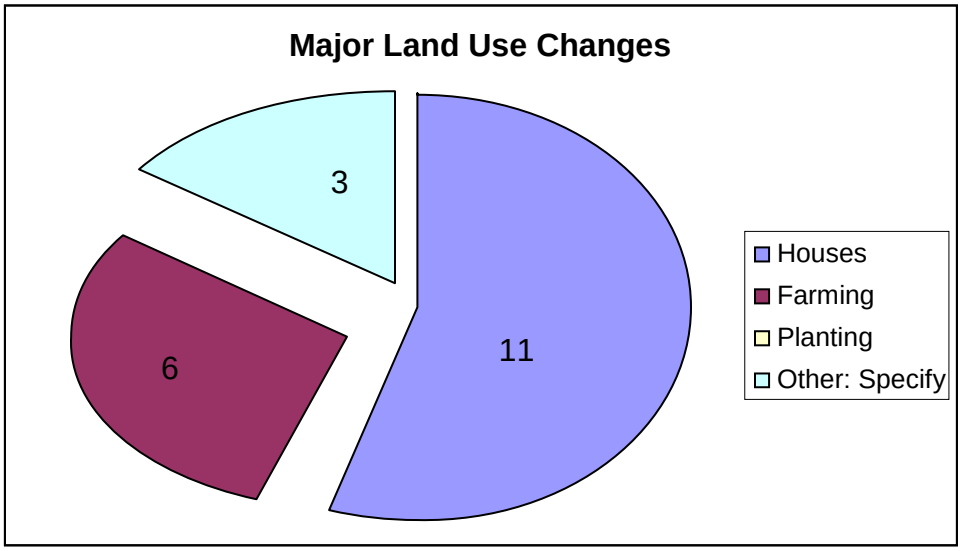


Figure 4.20: Major land use change

As seen in Figure 4.20 people felt there were different land use changes causes. 55% said houses, 30% said farming, and 15% said other.

Question 21

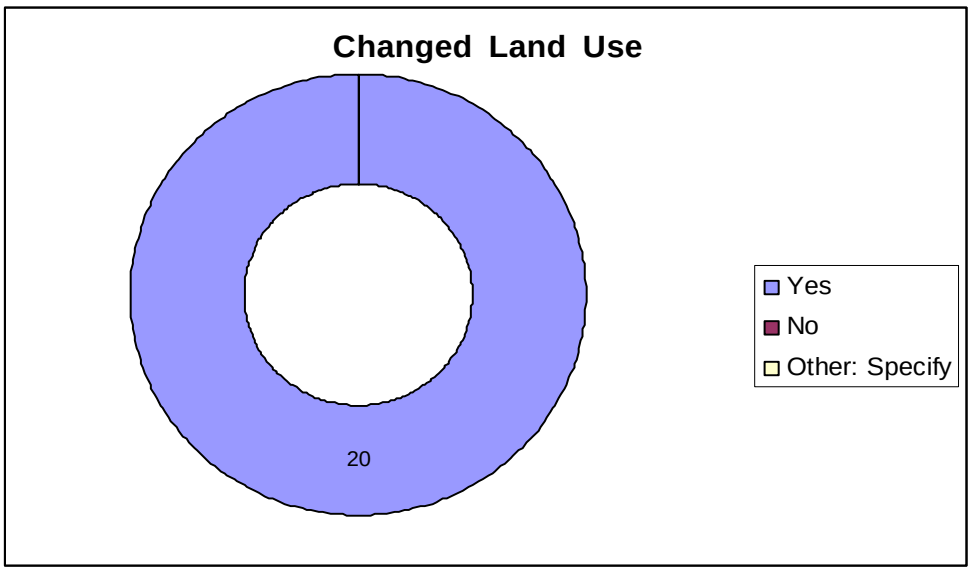


Figure 4.21: Number of People who changed land use

According to Figure 4.21; 100% of the interviewed had changed the way there were using the land in the past years.

Question 22

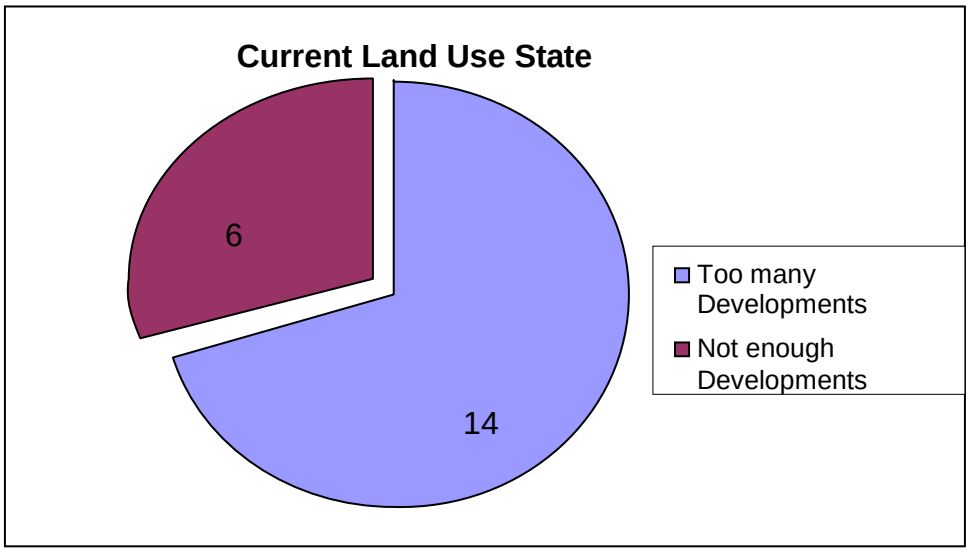


Figure 4.22: Current Land Use State

As shown in Figure 4.22, people felt differently about the way the land is used. 70% said there were too many developments, 30% said there were not enough developments.

Question 23

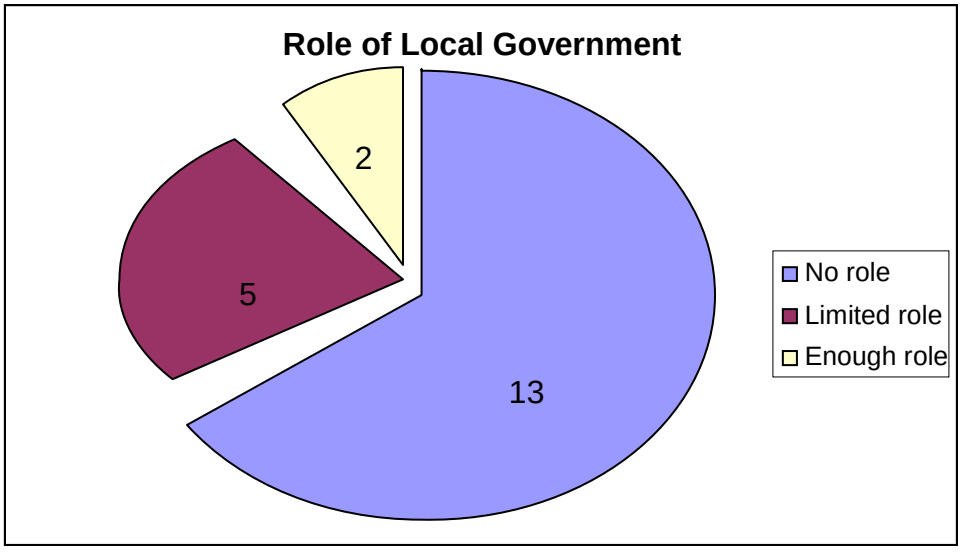


Figure 4.23: Role played by the local government

As reflected in Figure 4.23 respondents said different things about the role of the government in preventing land use change. 65% said no role, 25% said limited role, and 10% said enough role.

Question 24

Table 4.1: Proposed drought mitigation and prevention measures

Respondent Number	**Proposed mitigation and prevention measure**
1	There should be more water tanks in the area, to increase water availability.
2	More water storing plants should be planted.
3	The cost of water shouldn't be high, so that many people can access water.
4	The Department of Agriculture should encourage planting of trees.
5	The community should be taught about drought reducing techniques.
6	People must not waste water.
7	Children and adults should be educated about causes of drought.
8	People should be prevented from cutting plants
9	People should pay a fine, if they remove plants.
10	People should be encouraged to reuse water.
11	More water storage tanks should be bought.
12	School awareness programmes should be developed.
13	People should stop air pollution, because it affects rain occurrence.
14	The community should be taught about the importance of plants.
15	There should be drainage system: channeling water going to the river.
16	School children should be taught the importance of saving water.
17	People should be consulted about developments in the area.
18	People should have self control on how to use water.
19	Animals should be provided for, since they die when there is water shortage.
20	Water charges should be lowered.

The respondents' answers were grouped into 5 categories, Figure 4.24.

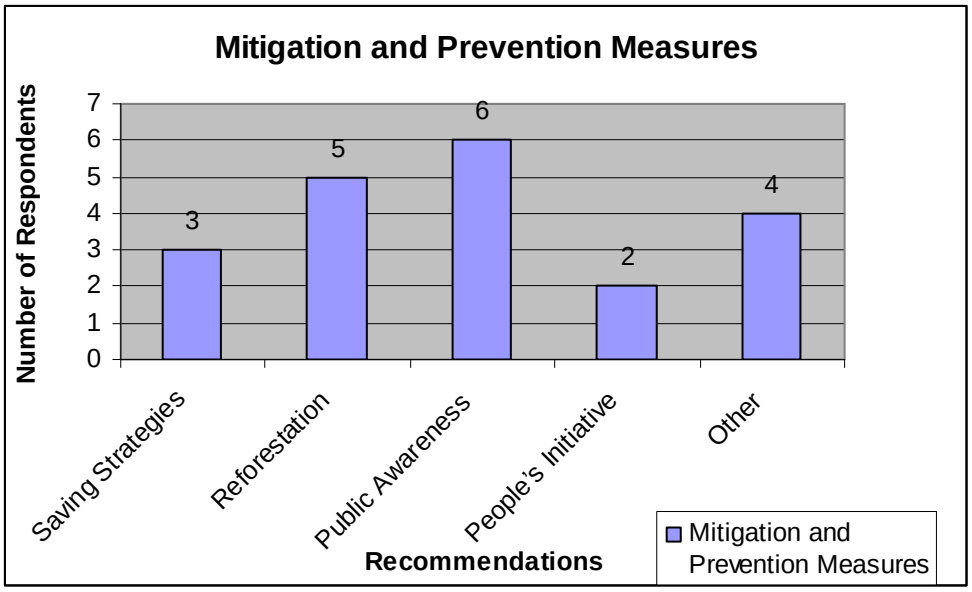


Figure 4.24: Drought Mitigation and Prevention Measures

The recommendations by the respondents were as follows: 15% suggested different water saving strategies, 25% recommended that there should be reforestation, 30% indicated that public awareness campaigns could help minimize drought occurrence, 10% said people should take initiative to mitigate drought, the remaining 20% raised different strategies. The following section presented the analyzed results obtained from SPSS Analysis.

4.3 SPSS Cross Tabulations Results

Firstly the cross tabulation was done for two variables. Secondly it was done for three variables. Due to the high volume of SPSS results, only tables and graphs that directly answered the research questions were shown. The SPSS cross tabulation of 3 variables, showed the following results.

Table: 4.2: Residence Years * Common Disaster * Current Land Cover State Cross Tabulation

Current Land Cover State				Common Disaster		Total
				Drought	Floods	
Too many Developments	Residence Years	More than 2 years to 5 years	Count	1	0	1
			% of Total	7.1%	.0%	7.1%
		More than 5 years to 10 years	Count	1	1	2
			% of Total	7.1%	7.1%	14.3%
		More than 10 years	Count	7	4	11
			% of Total	50.0%	28.6%	78.6%
	Total		Count	9	5	14
			% of Total	64.3%	35.7%	100.0%
Not Enough Developments	Residence Years	More than 1 to 2 years	Count	1	0	1
			% of Total	16.7%	.0%	16.7%
		More than 2 years to 5 years	Count	0	1	1
			% of Total	.0%	16.7%	16.7%
		More than 5 years to 10 years	Count	2	0	2
			% of Total	33.3%	.0%	33.3%
		More than 10 years	Count	2	0	2
			% of Total	33.3%	.0%	33.3%
	Total		Count	5	1	6
			% of Total	83.3%	16.7%	100.0%

Results in Table 4.2 showed that people felt differently about the land cover state. A total of 14 said there were many developments, 6 said there were not enough developments.

Table: 4.3: Residence Years * Common Disaster * Overpopulation Effects Cross Tabulation

Overpopulation Effects				Common Disaster		Total
				Drought	Floods	
Yes	Residence Years	More than 2 years to 5 years	Count	0	1	1
			% of Total	.0%	6.3%	6.3%
		More than 5 years to 10 years	Count	1	1	2
			% of Total	6.3%	6.3%	12.5%
		More than 10 years	Count	9	4	13
			% of Total	56.3%	25.0%	81.3%
	Total		Count	10	6	16
			% of Total	62.5%	37.5%	100.0%
No	Residence Years	More than 5 years to 10 years	Count	2		2
			% of Total	100.0%		100.0%
	Total		Count	2		2
			% of Total	100.0%		100.0%
Do not know	Residence Years	More than 1 to 2 years	Count	1		1
			% of Total	50.0%		50.0%
		More than 2 years to 5 years	Count	1		1
			% of Total	50.0%		50.0%
	Total		Count	2		2
			% of Total	100.0%		100.0%

According to Table 4.3, 16 people said there were overpopulation effects due to change in land use, 4 said there were no effects and 2 said they did not know.

Table: 4.4: Residence Years * Common Disaster * Water Availability Change Cross Tabulation

Water Availability Change				Common Disaster		Total
				Drought	Floods	
Yes	Residence Years	More than 5 years to 10 years	Count	2	0	2
			% of Total	66.7%	.0%	66.7%
		More than 10 years	Count	0	1	1
			% of Total	.0%	33.3%	33.3%
	Total		Count	2	1	3
			% of Total	66.7%	33.3%	100.0%
No	Residence Years	More than 5 years to 10 years	Count	0	1	1
			% of Total	.0%	8.3%	8.3%
		More than 10 years	Count	8	3	11
			% of Total	66.7%	25.0%	91.7%
	Total		Count	8	4	12
			% of Total	66.7%	33.3%	100.0%
Do not know	Residence Years	More than 1 to 2 years	Count	1	0	1
			% of Total	20.0%	.0%	20.0%
		More than 2 years to 5 years	Count	1	1	2
			% of Total	20.0%	20.0%	40.0%
		More than 5 years to 10 years	Count	1	0	1
			% of Total	20.0%	.0%	20.0%
		More than 10 years	Count	1	0	1
			% of Total	20.0%	.0%	20.0%
	Total		Count	4	1	5
			of Total	80.0%	20.0%	100.0%

The analysis in Figure 4.4 showed that 3 people said the water availability had changed, 12 said it had not and 5 said they dig not know.

Table: 4.5: Residence Years * Common Disaster * Main Source of Water Cross Tabulation

Main Source of Water				Common Disaster		Total
				Drought	Floods	
Running Water in the house	Residence Years	More than 5 years to 10 years	Count	1		1
			% of Total	25.0%		25.0%
		More than 10 years	Count	3		3
			% of Total	75.0%		75.0%
	Total		Count	4		4
			% of Total	100.0%		100.0%
Communal Tap	Residence Years	More than 1 to 2 years	Count	1	0	1
			% of Total	20.0%	.0%	20.0%
		More than 5 years to 10 years	Count	1	0	1
			% of Total	20.0%	.0%	20.0%
		More than 10 years	Count	1	2	3
			% of Total	20.0%	40.0%	60.0%
	Total		Count	3	2	5
			% of Total	60.0%	40.0%	100.0%
Other	Residence Years	More than 2 years to 5 years	Count	1	1	2
			% of Total	9.1%	9.1%	18.2%
		More than 5 years to 10 years	Count	1	1	2
			% of Total	9.1%	9.1%	18.2%
		More than 10 years	Count	5	2	7
			% of Total	45.5%	18.2%	63.6%
	Total		Count	7	4	11
			% of Total	63.6%	36.4%	100.0%

The water resource types were different in the area, 4 people had running water taps in house, 5 used communal taps and 9 used other natural resources.

Table: 4.6: Residence Years * Common Disaster * Rainfall Trend Cross Tabulation

Rainfall Trend				Common Disaster		Total
				Drought	Floods	
Decreased	Residence Years	More than 2 years to 5 years	Count	0	1	1
			% of Total	.0%	7.1%	7.1%
		More than 5 years to 10 years	Count	3	1	4
			% of Total	21.4%	7.1%	28.6%
		More than 10 years	Count	5	4	9
			% of Total	35.7%	28.6%	64.3%
	Total		Count	8	6	14
			% of Total	57.1%	42.9%	100.0%
Increased	Residence Years	More than 1 to 2 years	Count	1		1
			% of Total	25.0%		25.0%
		More than 2 years to 5 years	Count	1		1
			% of Total	25.0%		25.0%
		More than 10 years	Count	2		2
			% of Total	50.0%		50.0%
	Total		Count	4		4
			% of Total	100.0%		100.0%
Not Changed	Residence Years	More than 10 years	Count	2		2
			% of Total	100.0%		100.0%
	Total		Count	2		2
			% of Total	100.0%		100.0%

As reflected in Table 4.6, 4 people felt that the rainfall amount had decreased, 4 felt it had increased and 2 felt it had not changed. The next section discussed the answers obtained from the focus group interview.

4.4 Focus Group Interview

During the focus group interviews, the representatives at Willowfontein people had different opinions about the effects of change in land use in the area. The responses created a vivid picture of the participants' feelings and moods. The results were divided into three categories, namely: the central theme, the general sentiment and the recommendations.

4.4.1 Central Theme

A total of 6 people felt that the area was affected by the drought because of urbanization. To them the mostly affected sector was agriculture. This was because they felt that when there was drought the crops did not get water for irrigation and the animals died because of water shortage for drinking and grassland for grazing. When asked about other causes of drought, 7 people said that the rainfall amount had been depreciating over the past years.

All group members said that some water resources they were using in the past had become totally dry. They made a reference to the Willowfontein River. The group also mentioned that sometimes there was water shortage in the taps, especially communal taps. They attributed this to the fact that the water from the taps was not from the area's water resource. The water was exported from the city's river, likely to be Msunduzi River. Moreover one pipe water was used by more than 100 people.

4.4.2 General Sentiments

All respondents felt that hydrologic disasters occurring in the area had changed. They said that before urbanization the floods were mostly affecting the area. They even mentioned the damage caused by the 1988, and the 1995 flood disasters. They felt that the area had become dry and there was water shortage in an area.

Those who had gardens said they could not sell their potatoes to big markets in and around the area, because the produce was of low quality and quantity. The total of 33% that had livestock expressed their concerns, with regards to the inefficient growth of grass. They said this situated affected food availability for their animals. They even mentioned that some livestock have died due to drought in an area.

4.4.3 Recommendations

The whole group agreed that they needed more water provided, so that they would be able to irrigate their crops. They also said that they would love the government to provide them with water tanks, so that they could be able to store water, during rainy seasons. One person said "We should build inkasi to block water". Three more people agreed that this would be a cheaper water saving strategy. All people felt that reforestation was the necessary strategy to prevent water runoff at the high speed. One person even said "There is little vegetation in the area, and water is not saved during the wet season, and there is also soil erosion". The next section dealt with the relationship between rainfall and runoff.

4.5 Relationship between Rainfall and Water Runoff Trends

The rainfall and runoff were ranked in order to determine the discharged water. The runoff was divided by the rainfall of the same year. The results yielded very small values, which were then multiplied by one million. This thus made them comparable with the rainfall values. All data was presented in a table.

Table 4.7: Rainfall and Runoff Ranking

Year Number	Year	Rainfall	Rainfall Ranking	Water Runoff	Runoff Ranking	Runoff Rainfall	Runoff/ Rainfall X 1000000
1	1960	757.8	**16**	0.635	**14**	0.000838	837.952
2	1961	847.5	**29**	0.943	**27**	0.001113	1112.684
3	1962	760.6	**18**	0.714	**17**	0.000939	938.5813
4	1963	917.4	**36**	0.996	**28**	0.001086	1085.677
5	1964	911.4	**35**	0.641	**15**	0.000703	703.3136
5	1965	757.5	**15**	0.706	**16**	0.000932	932.0132
7	1966	783.1	**22**	0.748	**18**	0.000955	955.1781
8	1967	978.4	**41**	1.469	**41**	0.001501	1501.431
9	1968	737.0	**12**	0.523	**11**	0.00071	709.6336
10	1969	927.8	**38**	0.548	**12**	0.000591	590.6445
11	1970	948.5	**39**	0.813	**22**	0.000857	857.1429
12	1971	816.8	**28**	1.077	**31**	0.001319	1318.56
13	1972	790.0	**26**	1.251	**38**	0.001584	1583.544
14	1973	927.0	**37**	0.793	**20**	0.000856	855.823
15	1974	1093.8	**46**	1.874	**45**	0.001713	1713.293

16	1975	896.1	**33**	1.077	**32**	0.001202	1201.875
17	1976	1132.6	**47**	2.474	**49**	0.002184	2184.476
18	1977	759.8	**17**	0.798	**21**	0.00105	1050.276
19	1978	904.2	**34**	1.195	**35**	0.001322	1321.61
20	1979	771.9	**21**	1.362	**39**	0.001764	1764.101
21	1980	567.2	**1**	0.304	**5**	0.000536	535.5797
22	1981	697.2	**8**	0.350	**6**	0.000501	501.3203
23	1982	711.4	**9**	0.000	**1**	0.0005	500
24	1983	738.6	**12**	0.099	**2**	0.000134	133.7888
25	1984	768.4	**20**	0.842	**25**	0.001096	1095.783
26	1985	1005.7	**43**	0.815	**23**	0.00081	810.1248
27	1986	662.5	**5**	0.870	**26**	0.001313	1312.968
28	1987	1461.8	**49**	1.917	**46**	0.001311	1311.397
29	1988	1051.8	**45**	2.344	**47**	0.002229	2228.561
30	1989	884.0	**32**	1.366	**40**	0.001545	1545.249
31	1990	763.1	**19**	1.497	**42**	0.001962	1961.538
32	1991	1157.6	**48**	1.356	**37**	0.001171	1171.02
33	1992	591.3	**3**	0.601	**13**	0.001017	1016.627
34	1993	733.7	**11**	0.252	**4**	0.000344	343.5318
35	1994	788.1	**24**	0.787	**19**	0.000999	998.6042
36	1995	865.7	**30**	0.378	**8**	0.000437	437.0143
37	1996	1014.5	**44**	2.324	**48**	0.002291	2290.892
38	1997	959.4	**40**	1.634	**44**	0.001703	1703.119
39	1998	802.9	**27**	1.088	**33**	0.001355	1355.388
40	1999	753.1	**13**	0.428	**9**	0.000568	568.3904
41	2000	582.0	**2**	1.284	**36**	0.002206	2206.186
42	2001	1005.5	**42**	1.108	**34**	0.001102	1101.939
43	2002	789.5	**25**	1.568	**43**	0.001986	1986.067
44	2003	631.5	**4**	0.376	**7**	0.000595	595.4078
45	2004	697.0	**7**	0.217	**3**	0.000312	311.6645
46	2005	878.2	**31**	1.058	**30**	0.001205	1204.737
47	2006	787.0	**23**	0.827	**24**	0.001051	1050.826

48	2007	722.7	**10**	0.502	**10**	0.000695	694.6174
49	2008	670.0	**6**	1.021	**29**	0.001524	1523.881

Table, 4.7 indicated that the average rainfall amount was 840.0mm. The lowest recorded rainfall amount was 567 mm, in 1980, vis-à-vis the lowest runoff amount, which was 0.099, in 1983. Equally so, the year with the highest rainfall amount was in 1987, where the rainfall amount was 1461.8. The highest runoff amount observed was in 1976, where the runoff amount of 2.474. The rainfall and runoff trends were determined.

4.6 Rainfall and Water Runoff Trend Line and Correlation

4.6.1 Trend Line

For the rainfall a trend line was drawn to determine the rainfall pattern of the studied 49 years.

4.6.1.1 Rainfall trend line analysis

Trend analysis of precipitations showed fluctuation precipitation amounts in 49 years. Figure 4.25 showed an increase of annual rainfall with regression equation:

$y=-0.189x^2+7.7612x+801.89$ and $R^2=0.0632$.

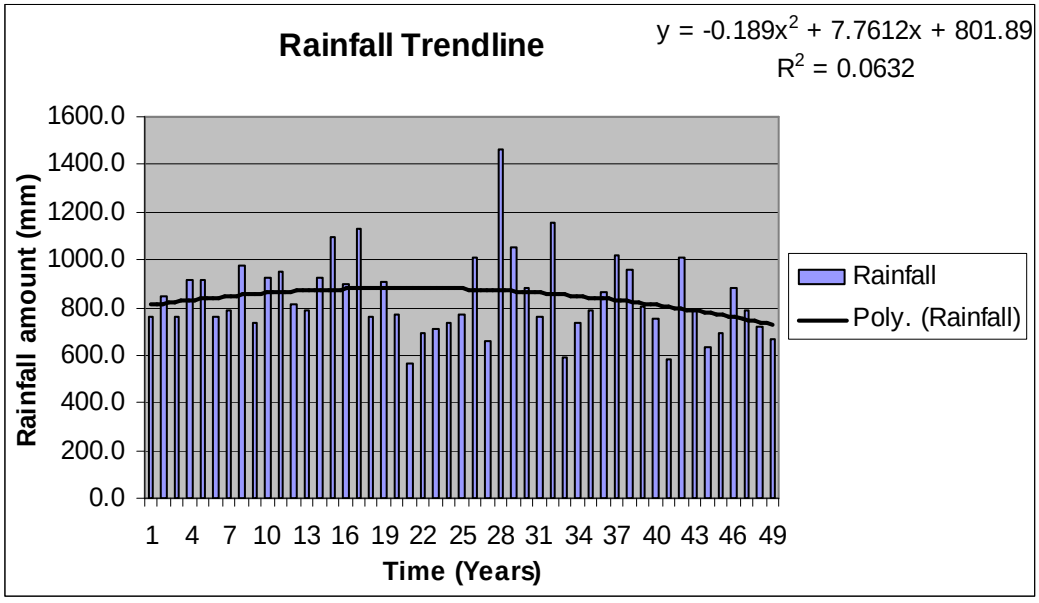


Figure 4.25: Trend line of Annual Rainfall

There was a positive trend however, it was not significant. The runoff trend was then analyzed to determine whether the water runoff was increasing or decreasing in the area.

4.6.1.2 Runoff trend line analysis

A trend line of water runoff indicated that generally water runoff slightly increased year to year, at the beginning and then decreased, Figure 4.26. The regression equation was: $y=-0.348x^2+21.452x + 887.84$ and $R^2=0.0025$.

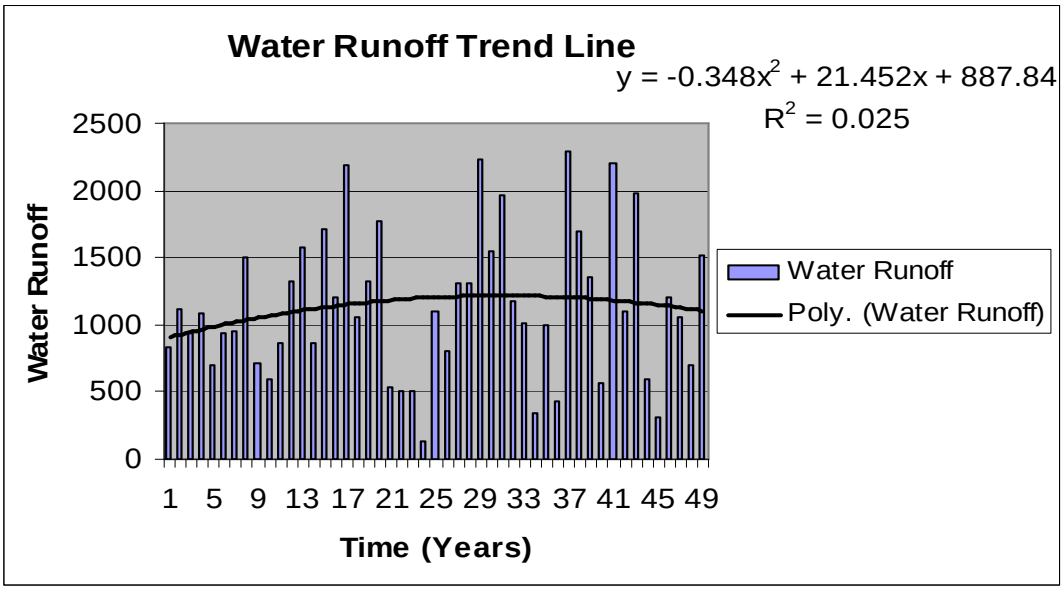


Figure 4.26: Trend line of Annual Runoff

Similar to the rainfall trend, this trend was insignificant. The trend line had been decreasing. The rainfall and runoff were correlated. The results were discussed in the next section.

4.6.2 Correlation

In this study, meteorological drought was defined as drought caused by rainfall amount. The rainfall and runoff graphs were drawn in one graph, Figure 4.27. The relationship between these two variables was determined.

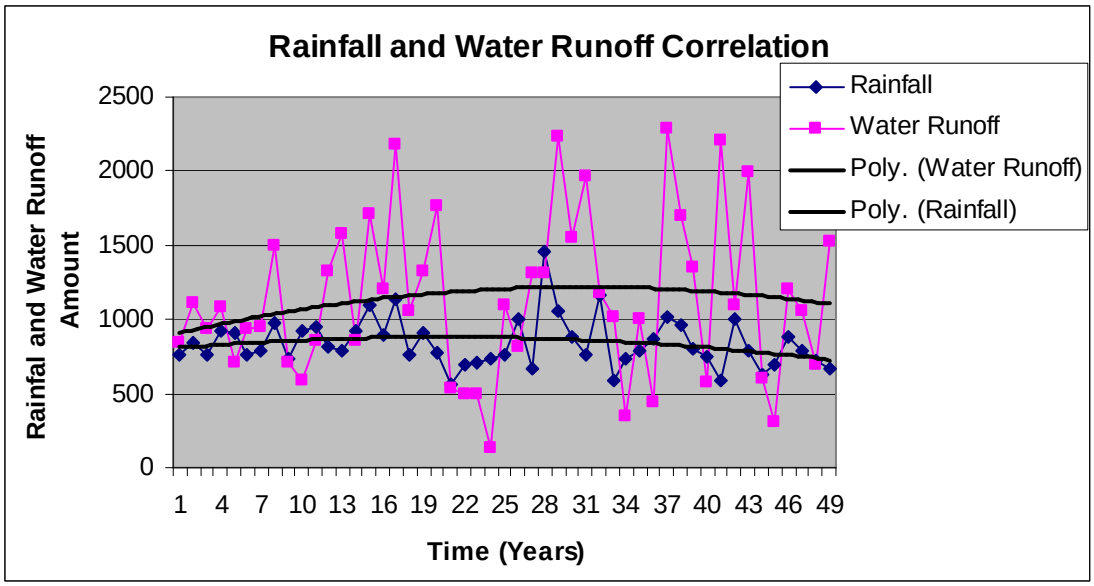


Figure 4.27: Rainfall and Water Runoff Correlation

The correlation between rainfall and water runoff was 0.646699147. This was a positive correlation. The correlation test showed that there was no significant correlation between rainfall and water runoff. The following section presented the two land use maps that were prepared.

4.7 Land Use Cover Maps

Two land use maps were produced using available shape files. The maps were for 1996 and 2000, respectively.

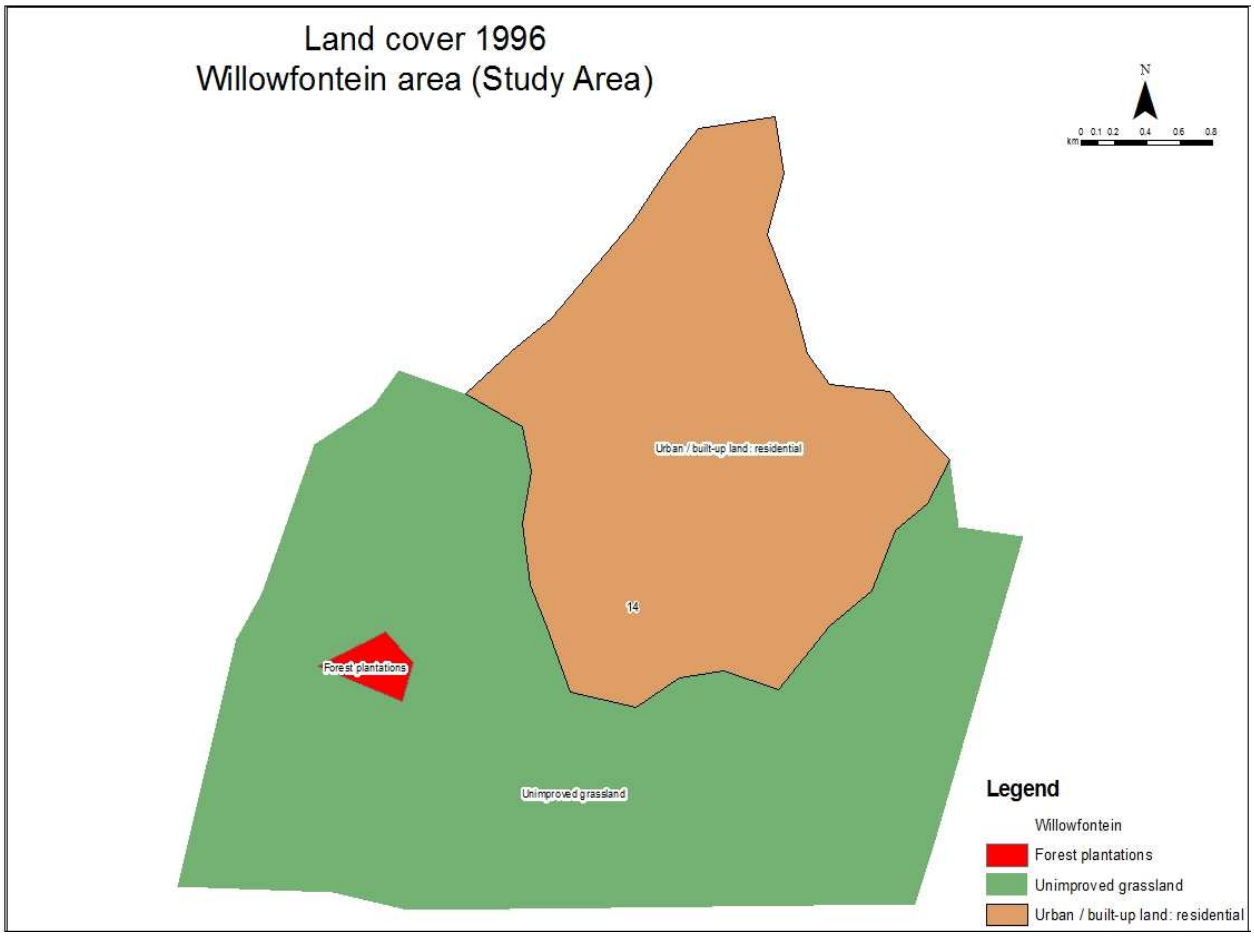


Figure 4.28: Land cover map of Willowfontein in 1996 (UFS 2009: 1)

The map showed that there was more vegetation in 1996, and few houses. The three distinguished different types of land cover were Forest plantations, Unimproved grasslands, Urban or built up land: residential, Figure 4.28. The next map showed the 2000 land cover.

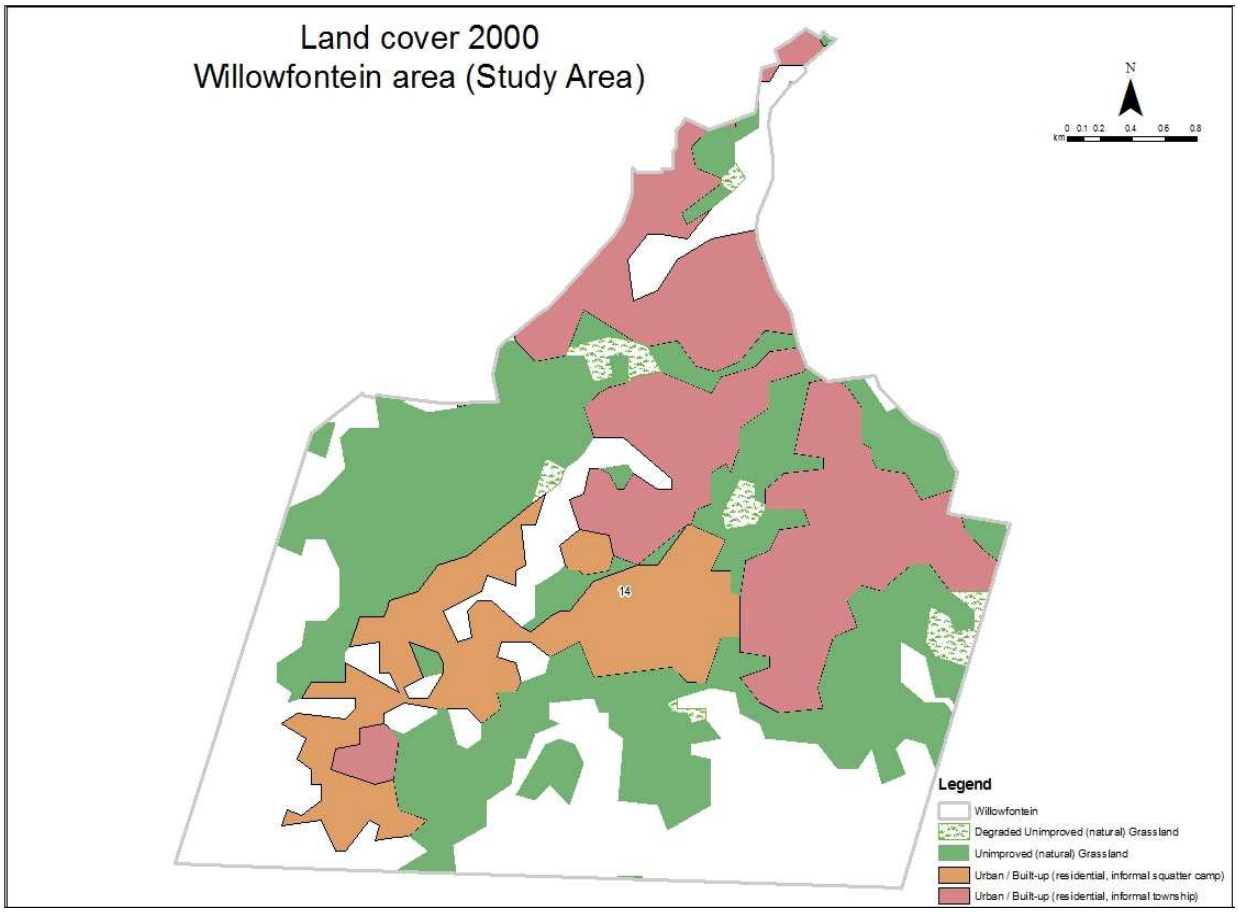


Figure 4.29: Land cover map of Willowfontein in 2000 (UFS 2009: 1)

In 2000 the land use cover had changed. There was more built up land and little vegetation, as seen in Figure 4.29. The land cover types were Degraded Unimproved (natural) grassland, Unimproved (natural) Grassland, Urban/ Build up (residential informal squatter camp), and Urban/ Build up (residential informal township). The next section concluded the chapter.

4.8 Conclusion

There were different factors accounting to drought occurrence in an area, such as decreasing rainfall, runoff and increasing change in land cover. This was based on interviews with the local community in the area, as well as experts from Land Affairs office and use of secondary data. The next Chapter that was discussed was Chapter 5, where the results were analyzed.

CHAPTER 5: ANALYSIS OF RESULTS

5.1 Introduction

The results obtained in the study were analyzed. The analyzed results included questionnaires, SPSS Cross Tabulations, focus group interview, trend lines analysis, correlation and land cover maps.

5.2 Questionnaires

The questionnaire results showed that married people were many in a group. This was attributed to the fact that married people were believed to be people who had families. They then needed money to support their children, wives and extended family members. Looking at the age of the respondents the majority of them were supposed to be working, hence they were dominant participants. Moreover they did not have adequate qualifications to get jobs; they relied on the income they got from community projects. The majority of the participants were involved in agriculture projects. It was their livelihood.

Water availability was thus a crucial factor because farmers needed water for irrigation purposes. The lack thereof would cause problems. Only 20% used household tap water, about 80% relied on other water resources, such as stand pipes and boreholes. This situation thus put a lot of strain on water resources, because of high water demand. It was then not surprising to learn than a total of 70% of the population believed that drought was the common disaster in the area. The respondents suggested different mitigation strategies for drought. The following section showed the link between certain questionnaire variables, through the use of cross tabulations.

5.3 SPSS Cross Tabulations

The cross tabulation focused on the 5 variables, which had been discussed throughout the study. These variables were cross tabulated against the number of years people had been living in the area and what people believed was the common disaster in the area.

5.3.1 Background Information

It was interesting to focus on the views of people who had been living in the area for more than five years, because they were more knowledgeable about the area. This helped to understand different trends in the studied variables. People who had been residing in an area for more than five years believed that the common disaster was drought. Further more people who were involved in farming felt that the common disaster was drought; this was because they needed more water to irrigate crops. From the answers, it showed that people experienced drought

almost every year. The land cover had changed in the area. The land cover change and the effects were therefore discussed below.

5.3.2 Land Cover Trend

The common land use change in the area had been housing and agriculture. The area had changed from forest, grass land to residential and agricultural land respectively. The area's land use change maps supported this view. People who had been living in the area for more than five years, who were believed to be observing the land cover change trend felt that land use change caused drought.

As much as everyone in the area had changed the land cover in one way or another some people felt that the land cover changes were not good, because they caused drought. The lack of vegetation made it difficult for the area to hold water and release it during the dry season. More than half of the respondents felt that land use change and decreasing rainfall led to drought. Despite the negative effects of land cover change, the majority of people benefited from the land use change. The changing land cover had led to high population growth. The possible effects were discussed in a section below.

5.3.3 Effects of Population Growth

Most people believed that the change in land use caused an increase in population. Here again this sentiment was supported by people who had been staying in an area for a long time. There was a strong relationship between population growth and drought. People said the higher the population growth the higher were the chances of drought occurrence. The studies have shown that the higher the population, the higher was the water demand.

People who were solely using communal taps and other sources of water felt that the increase in the water availability was caused by the increased population in the area. The general feeling was that the high population in the area meant less water reserved in water resources. The water demand variable was discussed in the following section.

5.3.4 Water Demand

People who believed that the water availability had been decreasing were those who had been residing in the area for more than five years. These people also believed that the consequences of the water availability change had led to drought. From the respondents' answers it was deduced that the non improvement in water availability caused drought. It was significant to note that it was people that were into farming that felt that the water availability had not improved.

Interestingly though some respondents said there was an improvement in the water availability in the area. They also believed that the common disaster was flood. However these were people who had not been in the area for long, it must have been that they had not experienced drought years and were those who had running tap water, hence did not rely on other resources for domestic purposes. When the water demand was high, it meant that very little water was stored in the resources. The water runoff variable was discussed next.

5.3.5 Water Runoff

People who were using natural sources to access water experienced water shortage more often than people who also had a privilege of accessing water from the taps. Respondents felt that not enough water was going into the resources and stored for a dry season. It meant that when the dry season came, there would not be adequate amount of water for people to use.

Most people using communal taps and other resources said that water had been decreasing in water resources. For the resources that dependant on rainfall for water, it implied that the water runoff had also decreased. An interesting result showed that the respondents felt that land use change exacerbated drought, for it destroyed water resources. This was a judgment among the majority of the respondents. It was therefore concluded, as stated in previous studies that the type of land cover affected water runoff. Rainfall, which was discussed next, was also believed to have effects on water availability in natural resources.

People who had been staying in an area for a long time believed that the amount of rainfall had decreased. They perceived drought to be caused by a rainfall shortage. These people had been observing rainfall trend in the past years, as opposed to the people who had been in the area for 2 years. It was also amazing to establish that 10% of the people who had been in an area for more than 10 years actually felt that the rainfall had been increasing. These were people who were not in farming industry.

Those who had been living in an area for less than 10 years felt that there had not been change in the rainfall occurrence. These people were not familiar with the rainfall pattern of the area. In fact some even thought that the rainfall had actually increased. This information could be attributed to the fact that people needed water for different purposes. It was more people who were into farming that felt that the rainfall amount had decreased.

This feeling was contradicted by only four people who felt that the rainfall amount had been increasing. Even people who said rainfall had not changed said that there had been drought in an area. From these results it was concluded that there were other factors that caused drought in the area other that rainfall shortage. The following next analyzed the focus group results.

5.4 Focus Group Discussion

A focus group yielded diversified array of responses. The trends and patterns that reappeared in the group answers were determined. Moreover the emphasized and repeated respondents' comments were considered. There was an observation of information clash. Information between the interviewees clashed with regards to the rainfall pattern.

Some people felt that the rain was adequate and some said there would have liked more rain to irrigate their agricultural crops. Some respondents during the focus group meeting felt that there were no adequate means to alleviate water shortage others said they were not affected by what others perceived as water shortage in the area. From the group's responses it was concluded that drought in an area was caused by multiple factors, not only rainfall shortage.

Since land use change was mentioned by more than 50% of the respondents, it might be a primary cause of drought in an area. As for the rainfall amount, which the majority of the respondents felt it had decreased was also grouped as the direct, primary cause of drought. The secondary causes of drought were overpopulation, which was believed to lead to high water demand. The following section analysed the secondary data in order to prove or disprove the respondents' sentiments.

5.5 Rainfall and Water Runoff Trend Lines and Correlation Analysis

Runoff was the most significant variable in reviewing the hydrologic response of the river to determine the rainfall and land use changes effects. Only data from 1960 for the rainfall and runoff were used for analyzing the rainfall pattern and runoff trend, due to missing rainfall data in

some years before 1960. Moreover the runoff available data was only from 1960. The section started by analyzing three observed periods in the obtained data. The correlation between rainfall and runoff were then analyzed.

5.5.1 Dry and Wet Period Analysis

Investigation of the trends of annual rainfall and runoff in the 1960-2008 periods showed the existence of three different periods. The three observed periods were:

i. 1960-1976 Period: This period was a relatively wet period. The annual average rainfall and runoff were 881mm and 1.017m^3/sec, respectively.

ii. 1977-1992 Period: This period was again the wet period. However the average rainfall and runoff were lower than the 1960-1976 period. The average annual rainfall and runoff were 843mm and 0.982m^3/sec, respectively.

iii. The 1993-2008 Period: This period was a combination of a wet and dry period. It was wet with regards to the rainfall, since the average was 792mm. When comparing the rainfall of the 1993 to 2008 period it was relatively lower that the previous two periods. It was dry because the mean annual runoff had a decreasing trend. The average runoff it this period was 0.928 m^3/sec.

There was a significant change of the runoff, as opposed to the non significant decreasing shift of the rainfall. The downward shift of the flow duration curve reflected an overall high decrease in discharge in the last period, 1993-2008. The observed changes in the rainfall trends and discharge rates were an indication of hydrological changes, in the Msunduzi River.

The results also showed that the rainfall was somehow constant. However the runoff decreased. This was a clear indication that the decrease of annual runoff was not only due to change in rainfall. The correlation coefficient between the rainfall and runoff was determined.

5.5.2 Correlation

There was a correlation between the runoff and the annual average rainfall for 49 years analyzed. The correlation of runoff and rainfall was 0,646699. This correlation coefficient meant that there was indeed some positive relation between variables. A value of 0,646699 was near 0; hence it indicated little correlation between rainfall and runoff. The relationship between rainfall and runoff was considerably a weak correlation. This meant that the rainfall amount did not have

the major impact on the runoff amount. The land cover change was determined through land use maps as shown, below.

5.6 Land Use Maps Analysis

In 1996 about 60% of Willowfontein was still covered with grassland. The forest covered approximately 5%. The extent of the residential area was 45%. In comparison with the 1996 map, land use map of 2000 showed a severe reduction of grassland. In this year the extent of forest was zero. Furthermore the unimproved grassland was reduced. There was an observation of an increase of urban: built up lands. Change in land use subsequently meant less water runoff because the vegetation was reduced. When water runoff was reduced there was water shortage, thus resulting in drought. The last section gave the conclusion for Chapter 5.

5.7 Conclusion

The rainfall trend did not change much in the three observed periods. There was no empirical evidence that the rainfall amount had been dropping at a rate that could cause drought. It was thus people's perception that the rainfall amount had been decreasing. The rainfall trend analysis clearly showed the linear trend, which was insignificant to cause drought.

What was observed was that the runoff was at an increasing rate over the previous years and it decreased later. Cleary there were other explanations for the observed trend. Therefore the downward runoff trend could be attributed to changes in land use. Land use changes in Willowfontein were likely to have had an impact on a flow decline. The last Chapter of the research discussed was Chapter 6. It dealt with the conclusion and recommendations.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

Chapter 6 completed the report with the conclusion, recommendations, and finally included suggestions for future studies.

6.2 Conclusion

In the study primary and secondary data were used to answer research questions. Rainfall data and runoff data were analyzed and correlated to evaluate the impact of land use change on water resources. Land cover maps produced from shape files were found to be a helpful tool to detect land cover dynamics in an area in different years. The analysis of the results led to the conclusions; stated below.

Even though drought was believed to be caused by rainfall change, anthropogenic actions were proven to be the primary and direct cause. People caused drought by removing vegetation, mainly for houses. This action reduced the area's capacity of storing water for dry periods. It should also be noted that when the number of people increased, it meant more houses in an area were built. This did not only reduce vegetation it also increased the population. High population thus resulted in high water demand, consequently low water amount in water resources. The study concluded that change in land use had an impact on water resources. There were three recommendations based on the lessons learnt throughout the study. They were listed below.

6.3 Recommendations

The following recommendations were made:

- .After interviewing the community it became apparent that there was a great need to conduct public awareness campaigns in the area. The community clearly needed more education about the causes of drought. It seemed as if people did not know the extent of effects land use change had on drought occurrence. They strongly believed that drought was caused by change in rainfall.

- Besides education people would need assistance in water saving strategies, as clearly stated out by some of the interviewees during the focus group interview and the interviews. It was recommended that the community should be provided with water tanks. This strategy was believed to be able to help mitigate drought, since water would be saved during the rainy season.

Consequently there will be adequate water for irrigation and domestic purposes during dry season, especially when the water resources would be dry.

- Another valuable option would be deforestation. It would help more water to be retained and slowly released to the river over a long period of time. Moreover deforestation would minimize water runoff and store water for a long time. Another alternative could be to reuse water in an attempt to save it.

After the study it was realized that more research was needed to be conducted in the area. The suggested future studies were discussed below.

6.4 Future studies

The proposed studies were:

- The study focused on the primary and direct causes of drought. For future research a detailed study of causes of drought should look at indirect primary and secondary causes of drought. The focus should be on social issues like poverty, as most people were unemployed in the area.

- The most common livelihood in an area was agriculture. Therefore further work could be done to predict the occurrence of drought. There should be a study that would be able to give guidance on how to predict drought occurrence in an area. Drought prediction could even prevent drought from occurring.

- Anthropogenic water availability changes derived in the study focused on negative effects of land use change. The study could be continued by looking at land use changes that would save water in the area. Examples of new strategies might include new farming strategies that would be promoted in an area.

References

Abrams, L. s. a. Drought policy – Water issues. South Africa.

Albert-Ludwigs-Universitaet Freiburg. 2004. Assessment of the regional impact of droughts in Europe. [Online] Retrieved from: http://cordis.europa.eu/data/PROJ_EESD_KA1/ACTIONeqDndSESSIONeq17303200595ndDOCeq1ndTBLeqEN_PROJ.htm [Accessed 08 December 2008].

Asubonteng, K. O. 2007. (Published Masters Thesis). Identification of land use/ cover transfer hotspots in the Ejisu-Juabeng District. Ghana. International Institute for Geo – Information Science and Earth Observation Enschende. Nertherlands. Kwame Nkrumah University of Science and Technology. Ghana.

Babbie, E. & Mouton, J. 2008. Practice of Social Research. South Africa: Oxford University Press.

BBC News. 2008. Drought in England. [Online]. Retrieved from: http://news.bbc.co.uk/1/shared/spl/hi/guides/456900/456972/html/nn1page1.stm [Accessed 05 December 2008].

Biggs, R., Scholes, R.J. 2002. Land cover changes in South Africa 1911-1993. South African Journal of Science. 98: 420-424.

Blogspot. 2008. Nomzamo's Future. [Online]. Retrieved from: http://nomzamosfuture.blogspot.com/ [Accessed 30 March 2008].

Chamane, E. 2008. Community Farming Member. Phuthumani Farming Cooperation. Semi Structured Interview: 10 September 2009.

Chatindiara, K. (KennethC@statssa.gov.za). 05 March 2009. *Census data 1996, 2001, 2007.* E-mail to Sindisiwe Nyide. (nyides@dwaf.gov.za).

Cheianu-Andrei, D. & Černík, J. 2008. RESEARCH REPORT Identification of secondary victims of drought in Moldova 2007. [Online]. Retrieved from: http://www.un.md/drought/Identification2007(2).pdf [Accessed 28 November 2009].

Chorpa, P. 2006. (Published Master's Thesis). Drought risk assessment using remote sensing and GIS: A case study of Gujarath. International Institute for Geo – Information Science and Earth Observation Enschende. Nertherlands.

CIESIN Columbia University. 2007. Natural Hazards: Drought and Flooding. [Online]. Retrieved from http://sedac.ciesin.columbia.edu/tg/guide_glue.jsp?rd=lu&ds=6.4 [Accessed 02 June 2008].

Consortium for Atlantic Regional Assessment (a). 2006. Land Use Primer: How do scientists measure Land Use and Land Cover and what are some sources of information? [Online]. Retrieved from: http://www.cara.psu.edu/land/lu-primer/luprimer05.asp [Accessed 19 February 2009].

Consortium for Atlantic Regional Assessment (b). 2006. Land Use Primer: How do we categorize Land Cover? [Online]. Retrieved from: http://www.cara.psu.edu/land/lu-primer/luprimer04.asp [Accessed 19 February 2009].

Consortium for Atlantic Regional Assessment (c). 2006. Land Use Primer: How Does Land Use/Land Cover Affect Global Climate? [Online]. Retrieved from: http://www.cara.psu.edu/land/lu-primer/luprimer14.asp [Accessed 19 February 2009].

Consortium for Atlantic Regional Assessment (d). 2006. Land Use Primer: What are the main factors driving Land Use/Land Cover change? [Online]. Retrieved from: http://www.cara.psu.edu/land/lu-primer/luprimer07.asp [Accessed 19 February 2009].

Consortium for Atlantic Regional Assessment (e). 2006. Land Use Primer: What is the difference between Land use and Land Cover. [Online]. Retrieved from: http://www.cara.psu.edu/land/lu-primer/luprimer01.asp [Accessed 19 February 2009].

Consortium for Atlantic Regional Assessment (f). 2006. Land Use Primer: Why are we concerned about changes in Land Use and Land Cover? [Online]. Retrieved from: http://www.cara.psu.edu/land/lu-primer/luprimer02.asp [Accessed 19 February 2009].

Consortium for Atlantic Regional Assessment (g). 2006. Land Use Primer: How does land use/land cover affect local climate? [Online]. Retrieved from: http://www.cara.psu.edu/land/lu-primer/luprimer13.asp [Accessed 19 February 2009].

Cruz, R. B. 2004. (Published Masters Thesis). Developing a land use information system for Local Government: The case of Naga City, Philippines. International Institute for Geo – Information Science and Earth Observation Enschende. Nertherlands.

Department of Water Affairs and Forestry. 2004. South African Year Book 2003/2004. South Africa. Pretoria.

deVilliers, C (a). (Coleen.deVilliers@weathersa.co.za). 23 September 2008. *Pietermaritzburg rainfall.xls.* E-mail to Sindisiwe Nyide. (nyides@dwaf.gov.za).

deVilliers, C (b). (Coleen.deVilliers@weathersa.co.za). 26 January 2009. *Rainfall PMB area xls.* E-mail to Sindisiwe Nyide. (nyides@dwaf.gov.za).

Dolph Rotfeld Engineering. 2009. DMA 2000 Hazard Mitigation Plan SECTION 5: Risk Assessment - Drought Town/ Village of Harrison, New York. [Online]. Retrieved from: http://www.town.harrison.ny.us/HHMP/draftdocs/H%20pdh%20drought.pdf
[Accessed 10 November 2009]

Drought Management Forum. 2007. Drought Management. [Online]. Retrieved from: http://www.waterencyclopedia.com/Da-En/Drought-Management.html. [Accessed 26 March 2008].

Eagleman, G. R. 1983. Severe and Unusual Weather: Floods and Drought. New York: van Nostrand Keinhold Company.

Eakin,H., Liverman, D. 2003. Drought and Ranching in Arizona: A Case of Vulnerability. [Online]. Retrieved from: http://geochange.er.usgs.gov/sw/impacts/society/ranching/ [Accessed 08 December 2008].

Erik P. Querner, E., P., van Lanen, H,A.. J., 31 October 2001. Journal of Hydrology. Volume 252. Issues 1-4. Pages 51-64. Impact assessment of drought mitigation measures in two adjacent Dutch basins using simulation modeling. [Online]. Retrieved from: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V6C-43RJY6J-D&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=2c9c5c5a676e7325475e581de860b79a. [Accessed 23 August 2008].

FEMA/EMI. n.d. Flood Risk Assessment. [Online]. Retrieved from: http://training.fema.gov/EMIWeb/edu/docs/fmc/Chapter%204%20%20Flood%20Risk%20Assessment.pdf. [Accessed 03 April 2008].

Gadisso, B.E. 2007. Drought assessment for the Nile Basin using Meteostat Second generation data with special emphasis on the Upper Blue Nile River. International Institute for Geo – Information Science and Earth Observation Enschende. Nertherlands.

Gcabhashe, M. 2008. DM Practitioner: Umgungundlovu District Municipality. Semi Structured Interview: 11 September 2008.

Harwood, J. 1999. Local Government, Community, and Business Working Group Draft Report. [Online]. Retrieved from: http://govinfo.library.unt.edu/drought/finalreport/fileb/draftlgc3_MASTER.htm. [Accessed 23 August 2008].

Hesmay, A. 2003. (Published Masters Thesis). Modelling impact of change in irrigatet land on rivers discharge and recharge. International Institute for Geo – Information Science and Earth Observation Enschende. Nertherlands.

Hofstee, E. 2006. Constructing a Good Dissertation. A Practical Guide to Finish a Master's, MBA or PHD on Schedule. South Africa. EPE.

Institute of Water Research, 1997. Watershed Approach: Land Use Effects on Water Quality and Quantity. [Online]. Retrieved from: http://www.iwr.msu.edu/edmodule/water/wtrfrm1.htm. [Accessed 03 June 2008].

Institutions for rural development. 2007. Climate Variability and change: Adaptation to drought in Bangladesh. Rome.

International Federation. 2008. Kenya: Drought. Kenya.

IOWA State University Extension. 2001. Focus Group Approach. [Online]. Retrieved from: http://www.extension.iastate.edu/communities/tools/assess/focus.html [Accessed 25 November 2009].

Isendahl, N., Schmidt, G. 2006. Drought in the Mediterranean: A WWF Report. [Online]. Retrieved from: http://assets.panda.org/downloads/wwf_drought_med_report_2006.pdf [Accessed 05 December 2008]

Jaca, V. 2009. Ward 22 Councilor. Msunduzi Local Municipality. Semi Structured Interview: 15 January 2009. 2009.

Kinnear, P.R. & Gray, C.D. 2009. SPSS 16 Made Simple. New York: Psychology Press.

Koohafkan, A.P. 2008. Features of desertification and drought. [Online]. Retrieved from: http://www.fao.org/sd/EPdirect/EPan0005.htm [Accessed 05 December 2008].

Lambin, E. & Geist, H.J. 2007. Causes of land-use and land-cover change. [Online]. Retrieved From: http://www.eoearth.org/article/Causes_of_land-use_and_land-cover_change [Accessed 21 November 2009].

Lewis, M. 2000. Focus Group Interviews in Qualitative Research: A Review of the Literature. [Online]. Retrieved From: http://www2.fhs.usyd.edu.au/arow/arer/002.htm [Accessed 25 November 2009].

Lucid. 2006. ARID AND SEMI-ARID AGRO-PASTORAL SYSTEMS IN TRANSITION. Kenya.

Malima, N. 2009. Ward 22 Councilor Personal Assistant. Msunduzi Local Municipality. Semi Structured Interview: 16 January 2009.

Marais, E. 2009. Land Surveyor: Department of Land Affairs. Semi Structured Interview: 03 June 2009.

Masri, T., Khawlie, M., & Faour, G. s.a. LAND-USE/COVER CHANGE, WATER RESOURCES AND DRIVING FORCES DURING 40 YEARS IN LEBANON. [Online]. Retrieved From: http://mediasfrance.org/Reseau/Lettre/13bis/en/10.LIBAN.PDF [Accessed 19 November 2009].

McNeill, P. 1990. Research Methods. 2nd Edition. London and New York. Routledge.

Mfeka, X. (Xolo.Mfeka@kzndoe.gov.za). 28 January 2009. *uMgungundlovu Schools.* E-mail to Sindisiwe Nyide. (nyides@dwaf.gov.za).

Michigan State University Board of Trustees. 2003. Land Use Change Modeling. [Online]. Retrieved from: http://clip.msu.edu/landuse.htm [Accessed 08 December 2008].

Mkhize, S. 2009. Ward 14 Councilor. Msunduzi Local Municipality. Semi Structured Interview: 15 January 2009.

Mlokoti,V. 2005. DELIMITATION OF MUNICIPAL WARDS IN TERMS OF THE LOCAL GOVERNMENT. [Online]. Retrieved from: http://www.demarcation.org.za/ward_delimitation/FINAL/gz1/kzn/KZ225.htm [Accessed 06 February 2009].

Mogaswa, J. (SGT@dwaf.gov.za). 27 February 2009. *Water Supply and Mean Annual runoff.* E-mail to Sindisiwe Nyide. (nyides@dwaf.gov.za).

Motsima, T. (TshaudiM@statssa.gov.za). 23 January 2009. *Willowfontein Data.* E-mail to Sindisiwe Nyide. (nyides@dwaf.gov.za).

Mouton, J. 2006. How to Succeed in Your Master's & Doctoral Studies: A South African Guide and Resource Book. 10th Edition. Pretoria: Van Schaik Publishers.

MTP Programme. 2004. Drought Concepts, Characteristics, and Definitions. [Online]. Retrieved from http://www.case.ibimet.cnr.it/MTPprogramme/data/doc/4ClimateAnalysisTools/DroughtConceptsCharacteristicsDefinitions.pdf. [Accessed 01 April 2008].

Mustard, J.F., Defries, R.S., Fisher, T., Moran, E., 2004, Representative land-cover and land-use histories: TROPICAL DEFORESTATION: THE AMAZON. [Online] Retrieved from: http://www.planetary.brown.edu/pdfs/3391.pdf [Accessed 05 December 2008].

Narendra. B.H. 2008. (Published Masters Thesis). Drought monitoring using rainfall Data and Spatial Soil Modelling. ITC and Gadja Mada University, Netherlands and Indonesia.

National Drought Mitigation Centre. 2006. What is Drought: The Concept of Drought. [Online]. Retrieved from: http://www.drought.unl.edu/whatis/concept.htm#concept. [Accessed 29 March 2008].

Ndawonde, S. 2008. NGO Member: Green Network. Semi Structured Interview: 06 September 2008.

Neuman, W.L. 1997. Social Research Methods: Social Research Methods. 5th Edition Boston, Mass: Allyn & Bacon. New York.

Palmer, B. 2008. (Unpublished Masters thesis). Land Cover and land use change: Coastal development in the Eastern Cape.. Rhodes University, Cape Town.

Pellikka, P.B., Clark, P., Hurskainen, A., Keskinen, M., Lanne, K., Masalin, P. & Sirviö,T. 2004. Land Use Change Monitoring Applying Geographic Information Systems In The Taita Hills, Se-

Kenya [Online] Retrieved from: http://www.helsinki.fi/science/taita/reports/aarse_pellikka.pdf [Accessed 19 February 2009].

Phyllis, B. 1995. The Honors Thesis: A Guide of Suggestion. [Online]. Retrieved from: http://www.unomaha.edu/wwwhonor/Documents/thesis_suggestions.pdf. [Accessed 25 September 2008].

Pillay, L. (Loven.Pillay@msunduzi.gov.za). 03 April 2009. Information on *Willowfontein Water Supply.* E-mail to Sindisiwe Nyide. (nyides@dwaf.gov.za).

Ranjan, P., 2007, Effect of climate change and land use change on saltwater intrusion. [Online]. Retrieved from: http://www.eoearth.org/article/Effect_of_climate_change_and_land_use_change_on_saltwater_intrusion. [Accessed 05 December 2008].

Russell, M. 2009. The Two Faces of Unemployment. [Online]. Retrieved from: http://ezinearticles.com/?The-Two-Faces-of-Unemployment&id=215489 [Accessed 10 November 2009]

Sakenyo E. 2008. (Published Thesis). Modelling the impact of deforestation on the stream flows - A case of Chalimbana river catchment in Chongwe, Zambia. Linköping University, The Tema Institute, Department of Water and Environmental Studies. Sweden.

Savenije H. H. G., 1996, Does moisture feedback affect rainfall significantly? [Online]. Retrieved from: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V79-3YCDW10-2C&_user=10&_coverDate=12%2F31%2F1995&_rdoc=1&_fmt=high&_orig=article&_cdi=5837&_sort=v&_docanchor=&view=c&_ct=2398&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=530a1c854f4357ea1269907a47b9973c *Physics and Chemistry of The Earth*, *Volume 20, Issues 5-6*, *October-December 1995*, *Pages 507-513,* [Accessed 05 December 2008].

Showalter, P.S, Silberbauer M., Moolman, J., & Howma, A. 2000. Revisiting Rietspruit: Land Cover Change and Water Quality in South Africa (Proceedings of the ICRSE 28th Symposium of

Remote Sensing of Environmental and the 3rd AARSE Symposium held in Cape Town from 27 - 30 May 200). Cape Town: South Africa.

Smith, K. s.a. Environmental Hazards: Hydrological Hazards. Routlidge. London.

Snetsinger,S., Ventura, S. 1990. Land cover change in the great lakes region from mid-nineteenth century to present. Arizona.

Solcomhouse. 2008. Drought. [Online]. Retrieved from: http://www.solcomhouse.com/drought.htm. [Accessed 05 December 2008].

South Africa. 2002: Disaster Management Act no 57 of 2002. Pretoria: Government printers.

South African Cities Network. 2008. Msunduzi Municipality (Pietermaritzburg). [Online]. Retrieved from: http://www.sacities.net/cities/msunduzi.stm [Accessed 06 February 2009].

Statistics South Africa (a). 2006. Maps and Demographics. [Online]. Retrieved from: http://mapserver2.statssa.gov.za/profiles2006/index.aspx [Accessed 06 February 2009].

Statistics South Africa (b). 2006. Stats for the Msunduzi Local Municipality. [Online]. Retrieved from: http://mapserver2.statssa.gov.za/profiles2006/index.aspx [Accessed 06 February 2009].

Stuart, R. (raquel.stuart@kznhealth.gov.za). 11 February 2009. *Msunduzi Municipality Health Facilities Map.* E-mail to Sindisiwe Nyide. (nyides@dwaf.gov.za).

The Development of a Drought Management Plan for Rhode Island. 2007. Rhode Island Drought Facts. [Online]. Retrieved from http://www.wrb.state.ri.us/newsinfo/Drought_Facts_110607.pdf [Accessed 28 March 2008].

The Ojos Negros Research group. 2004. Drought Facts. [Online]. Retrieved from: http://threeissues.sdsu.edu/three_issues_droughtfacts0.html, [Accessed 20 March 2008].

The Oklahoma Drought Management Team, 1997, Oklahoma Drought Management Plan [Online]. Retrieved from: http://www.owrb.ok.gov/supply/drought/reports/drought_plan.pdf. [Accessed 23 August 2008].

United Nations Economic Commission for Africa. 2007. Overview of drought and desertification situation in Africa. [Online]. Retrieved From: http://www.uneca.org/csd/csd5/ACSD-5ReportonDrought_MainReport.pdf [Accessed 22 November 2009].

University of the Free State. Department of Geography. 2009. Dim 703. Bloemfontein.

US Climate Change Science Program Final Report. 2004. LAND-USE/LAND-COVER CHANGE. [Online]. Retrieved from: http://www.climatescience.gov/Library/stratplan2003/final/ccspstratplan2003-chap6.htm. [Accessed 23 August 23, 2008].

US Science Climate Change Program. 2003. Strategic Plan for the Climate Change Science Program Final Report. [Online]. Retrieved from http://www.climatescience.gov/Library/stratplan2003/final/ccspstratplan2003-chap6.htm. [Accessed 03 June 2008].

USGS. 2008. The Water Cycle: Surface Runoff. [Online]. Retrieved from: http://en.wikipedia.org/wiki/Surface_runoff. [Accessed 27 January 2009].

van Lanen H. A. J. 2007. Intensive Training Programme on “Disaster Prevention and Reduction with emphasis on Floods and Droughts”. Droughts: definitions, hydroclimatology, sensitive regions and drought processes. [Online]. Retrieved from: http://www.eu-workshop.czu.cz/syllabus/HvLanen.pdf. [Accessed 23 August 2008].

Vanderpost, C., Ringrose S. 2009. Land Cover Okavango Basin Land-use and Land-cover Change in the Okavango Basin and the Okavango Delta [Online] Retrieved from: http://www.orc.ub.bw/landcover.html [Accessed 19 February 2009].

Verburg, P.H., de Ninjs T,C., van Eck J,K., Visser, H. & deJong, K. 2003. Computers, Environment and Urban System. 28(6): 667-690.

Verburg, P.H, Veldkamp, T.A & Bouma, J. 1999. Land use change under conditions of high population pressure: the case of Java. Netherlands.

Vetter, S. 2009. Drought, change and resilience in South Africa's arid and semi-arid rangelands. *South African Journal of Science.* 105: 29-33.

Voortman, R.L. 1997. Recent Historical Climate Change and its effect on Land Use in the Eastern Part of West Africa. *Phys. Earth Journal.* 23(4): 385-391.

Watson,H,K. 1995. SHORT AND LONG TERM INFLUENCE ON SOIL EROSION OF SETTLEMENT BY PEASANT FARMERS IN KWAZULU NATAL. (Paper presented at The International Association of Geomorphologists South East Asia Conference in Singapore in June 1995 and the International Conference of the Society for South African Geographers in July 1995 in Durban. University of Cape Town, Cape Town.

Webster. Edu. s.a. Research Methods. [Online]. Retrieved from: http://www.webster.edu/~woolflm/statmethods.html. [Accessed 25 September 2008].

Wikepedia. 2007. Umgungundlovu District Municipality. [Online]. Retrieved from http://en.wikipedia.org.wik/Umgungundlovu-District-Municipality. [Accessed 24 September 2007].

Wikepedia. 2008. Drought in Australia. [Online]. Retrieved from: http://en.wikipedia.org/wiki/Drought_in_Australia. [Accessed 01 April 2008]

Wikipedia. 2009. Pietermaritzburg. [Online]. Retrieved from: http://en.wikipedia.org/wiki/Pietermaritzburg [Accessed 06 February 2009.

William, M. 2001. Start your research: Research methodology [Online]. Retrieved from http://www.nrf.ac.za/yenza/research/resmeth.htm. [Accessed 25 September 2008].

Yahoo Answers. 2009. What Causes Drought in Australia. [Online]. Retrieved From: http://answers.yahoo.com/question/index?qid=20091207180900AAfrIwi [Accessed 19 November 2009].

Zondi, S. 2009. Project Management Practitioner: Cedara Rainfall Station. Semi Structured Interview: 14 January 2009.

Zonneveld, I. S. 1993. Population And Land Use in Developing Countries: What is meant by Land Use Change. National Academy Press. Washington, DC.

Appendices

Appendix 1: Blank Questionnaire

Date: October 2008

Name of the interviewer: Sindisiwe Nyide

QUESTIONNAIRE FOR INDIVIDUALS INVOLVED IN COMMUNITY PROJECTS IN WILLOWFONTEIN

I am registered student at University of the Free State, in Bloemfontein. I am doing Masters in disaster management. Conducting research is one of the prerequisites to complete my studies. The information collected will be used for academic purposes, also help the community. Please be assured that the information you will provide is confidential, and no identification is required.

The objective of the questionnaire is to investigate whether change in land use has led to drought occurrence in the area or not. Please be honest, when answering all questions. One answer must be chosen from each question. Indicate your choice with a cross (an "X") and also put some of your answers in spaces provided. The questionnaire consists of 24 questions

A: BACKGROUND INFORMATION

Question 1

Gender

1	1. Male	
2	2. Female	

Question 2

Marital Status

1	Single	
2	Married	
3	Widowed	
4	Divorced	
5	Separated	

Question 3

Age in years

1	61 and above	
2	41 to 60	
3	31 to 40	
4	21 to 30	
5	20 and below	
6	Other	

Question 4

How long have you been involved in a community project, in years?

1	0 to less than a year.	
2	More than 1 year to less than 2 years.	
3	More than 2 years to less than 5 years.	
4	More than 5 years to less than 10 years.	
5	More than 10 years.	

Question 5

How many are you in your community project group?

1	More than 3 but less than 5	
2	More than 5 but less than 8	
3	More than 8 but less than 10	
4	More than 10 but less than 15	
5	More than 15	

Question 6

Type of community project you are involved in?

1	Construction	
2	Poultry	
3	Farming	
4	Other: specify	
5	More	

Question 7

How many community projects are you involved in?

1	Only one	
2	Two	
3	More than 2	

Question 8

What income do you get from the community project per annum in rands?

1	0 - 100	
2	101 - 500	
3	501 - 1000	
4	1001 - 5000	
5	More than 5000	

Question 9

What is your source of water?

1	Running water in the house	
2	Communal tap	
3	River	
4	Other (Specify)	

B INFORMATION

Question 10

How many years have you been living in this area?

1	Zero to less than a year.	
2	More than 1 to 2 years	
3	More than 2 years to 5 years	
4	More than 5 years to 10 years	
5	More than 10 years	

Question 11

Which disaster is the most common disaster in the area?

1	Drought	
2	Floods	
3	Fire	
4	Other: Specify	

Question 12

What can you say about the amount of rainfall over the past 5 years?

1	Decreased	
2	Increased	
3	Not changed	

Question 13

Has water availability been the same in the past ten years?

1	Yes	
2	No	
3	Do not know	

Question 14

Do you think change in land use has exacerbated drought impacts?

1	Yes	
2	No	
3	Do not know	

Question 15

How many businesses do you have in the area?

1	Zero to less than a one	
2	More than 1 to less than 2	
3	More than 2 to 5	
4	More than 5	

Question 16

Which sector is mostly affected by drought occurrence in the area?

1	Crop farming	
2	Cattle farming	
3	Goat/sheep farming	
4	Market gardening	
5	Other (Specify)	

Question 17

Do you agree with the following statements?

	Statements	1. Yes	2. No	3. Do not know
1	The increase of houses in the area has minimized the water availability.			
2	There has been rainfall shortage in the past ten years.			
3	The water resources have been destroyed since developments took place in an area.			
4	Water resources have been destroyed by the change in land use in the past few years.			
5	The developments are the cause of overpopulation in the area.			

Question 18

How has change in land use affected you?

1	Positively	
2	Negatively	
3	Not affected	

Question 19

How frequent do you experience household water shortage for washing, cooking and cleaning in the area?

1	Every year	
2	Once in two years	
3	Once in three or more years	

Question 20

What are the major land use changes that have occurred since 1976?

1	Houses	
2	Farming	
3	Planting	
4	Other: Specify	

Question 21

Did you change the way you were using the land from 1976 to 2006?

1	Yes	
2	No	
3	Other: Specify	

Question 22

How do you feel about the current state of the land use?

1	Too much developments	
2	Not enough developments	
3	No developments	

Question 23

What has been the role of local government in preventing land change effects?

1	No role	
2	Limited role	
3	Enough role	
4	Too much involvement	

Question 24

What would you like to see happening in the area, in order to reduce water shortage, hence drought?

THE TIME YOU HAVE TAKEN TO ANSWER THE QUESTIONNAIRE IS HIGHLY APPRECIATED***

Appendix 2: Willowfontein Vegetation in 2008 (photo by S. Nyide)

Appendix 3: Willowfontien River state in September 2008 (photo by S. Nyide)

Appendix 4: List of the focus group participants

NAME	ORGANISATION
1. Mrs E. Chamane	Phuthumani Farming Cooperation
2. Mr A. Mhlongo	Phuthumani Farming Cooperation
3. Mrs M. Dlamini	Siyathuthuka Gardens
4. Mrs P. Buthelezi	Siyathuthuka Gardens
5. Mr J. Phetha	Vuka Uzenzele Gardens
6. Mr. A.M. Ndlovu	Mbovula Gardens
7. Mr G. Dlamini	Buhlebuyeza Cooperation
8. Mr. S. Luswazi	Buhlebuyeza Cooperation
9. Mr Z. Mndaweni	Buhlebuyeza Cooperation

Appendix 5: Interviewees List

NAME	ORGANISATION	DATA OBTAINED
Face-To-Face-Interviews		
1. Mr Ndawonde	NGO: Green Network	Willowfontein background
2. Mrs Chamane	NGO: Community Project	Willowfontein background
3. Mr Gcabhashe	MDM DM Centre	Disasters in the Province
4. Focus Group	Willowfontein Community Members	Willowfontein background, opinions, recommendations
5. Mr Marais	DLA	Aerial photographs
Telephonic Interviews		
6. Mr Jaca	Ward 22 Councilor	Willowfontein location
7.Mr Malima	Ward 22 Councilor (PA)	Willowfontein background
8. Mr Mkhize	Ward 14 Councilor	Willowfontein background
9. Mr. Zondi	Cedara	Rainfall data
e-mail Interviews		
10. Mr Charindiara	SSA	Population statistics
11. Mr Motsima	SSA	Willowfontein Population
12. Mr Pillay	MM	Water supply
13. Mr DeVilliers	SAW	Rainfall data
14. Mrs Mogaswa	DWAF	Surface water runoff
15. Ms Mfeka	DOE (KZN)	UDM schools
16. Mr Raquel	DOH (KZN)	MM Health facilities

Appendix 6: Disclosure document from SAWS

DISCLOSURE STATEMENT

The provision of the data is subject to the User providing the South African Weather Service (SAWS) with a detailed and complete disclosure, in writing and in line with the requirements of clauses 1.1 to 1.3, of the purpose for which the Specified Data is to be used. The statement is to be attached to this document as Schedule 1.

1.1 Should the User intend using the Specified Data for commercial gain then the disclosure should include the following:

1.1.1 the commercial nature of the project in connection with which the User intends to use the Specified Data;

1.1.2 the names and fields of expertise of any participants in the project for which the Specified Data is intended;

1.1.3 the projected commercial gains to the User as a result of the intended use of the Specified Data.

1.2 Should the User intend using the Specified Data for the purposes of conducting research, then the disclosure should include the following;

1.2.1 the title of the research paper or project for which the Specified Data is to be used;

1.2.2 the details of the institution and supervisory body or person(s) under the auspices of which the research is to be undertaken;

1.2.3 an undertaking to supply SAWS with a copy of the final results of the research in printed and in electronic format; and

1.2.4 the assurance that no commercial gain will be received from the outcome from the research.

If the Specified Data is used in research with disclosure being provided in accordance with paragraph 1.2 and the User is given the opportunity to receive financial benefit from the research following the publication of the results, then additional disclosure in terms of paragraph 1.1 is required.

SCHEDULE 1

Please note we only work from information written on this disclosure statement.

FULL PERSONAL DETAILS OF USER

Full Names: Sindisiwe Nyide

University or organisation: University of the Free State

Student Number: 2007 001205

Email address: (please use the same one as given in the initial requested as this is the only way we can track emails. If you want the data sent to another email address please indicate this in the data required section) nyides@dwaf.gov.za

Postal Address: Box 6706, Laager Centre, Pietermaritzburg, 3201

Supervisor: Mr Andries Jordaan, Director: Disaster Management Training and Education Centre for Africa (DiMTEC), ***Faculty of Natural and Agricultural Sciences,***
PO Box 339 BLOEMFONTEIN 9300
Republic of South Africa
Tel: +27 (0)51 401 2721
Fax: +27 (0)51 401 9336
E-Mail: dimtec.sci@mail.uovs.ac.za

Project/Thesis Title: INVESTIGATING THE EFFECTS OF CHANGE IN LAND USE ON DROUGHT OCCURENCE AT WIILOFONTEIN

THE PURPOSE
Please indicate a detailed description of the purpose for which the data will be used.
I need the data for my research. Basically I would like to determine if the change in land use has affected drought characteristics. I am intending on doing this by looking at the previous rainfall in my area. This will thus help me determine if the rainfall pattern has changed in my area or not. I will be able to detect whether rainfall has be frequency has increased or decreased.

DATA REQUIRED (please include place and period and in what format you would like the data in) Please remember to acknowledge that you received data from the South African Weather Service in your thesis or when publishing.

LOCATION OF THE STUDY AREA(S)
My study area is Willowfontein. It is located in South Africa, KwaZulu Natal province.
It is found within the uMgungundlovu District Municipality, specifically in Msunduzi Local Municipality. It is found in Pietermaritzburg.

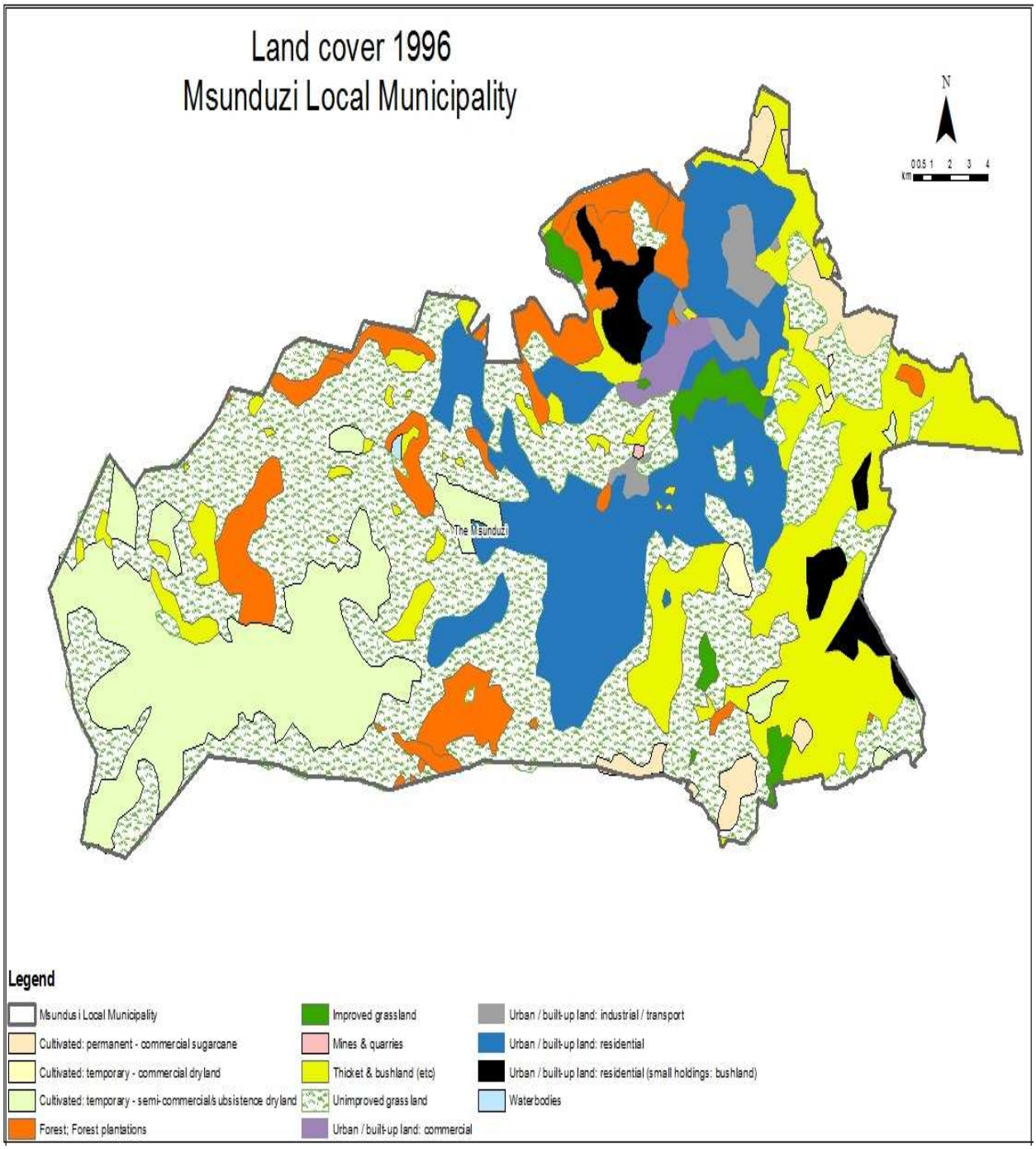
Special Requests:

- The rainfall data from 1996 – 2006. If possible please send it in months or even days.
- **Can I please get data specifically about my area: Willofontein, if not then about the Local Municipality or City.**
- **Please send the data in tables, graphs, and in the way that I can be able to understand, interpret it.**
- **Notes about how to interpret data: what does the data mean?**
- **Any relevant information I didn't mention will be highly appreciated.**

Signed: S. Nyide

The User Sindisiwe Nyide Date 23 September 2008

Appendix 7: Land Cover Map of Msunduzi Municipality in 1996 (UFS 2009:1)



Appendix 8: Land Cover Map of Msunduzi Municipality in 2000 (UFS 2009:1)