Plant diversity patterns of a settlement in the North-West Province, South Africa

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Dedicated to my parents,
William and Suset Davoren

"Urban and rural landscapes are not two places, but one. They create each other, they transform each other's environments and economies, and depend on each other for survival. To see them separately, is to misunderstand where they came from and where they might go in the future"
Cronon, 1991

Abstract

In recent years the composition of urban vegetation has become far more complex than that of the surrounding natural vegetation. This is mainly due to the influence that humans have on the creation of new plant communities and the management of urban green spaces. Green spaces are fundamental to the restoration and maintenance of biodiversity in areas that have been severely impacted by urban development. Green spaces provide various ecosystem services and benefits for the health and well-being of urban residents, and can help to reduce the effects of global climate change.

The most understudied green space in the entire urban green infrastructure is homegardens. Homegardens contribute greatly to the species composition of urban and rural settlements and are important *in situ* conservation sites that help to protect rare and endemic species. They are essential agricultural systems, especially in rural settlements, that provide both sources of additional income generation and food supply. In developing countries such as South Africa, very few studies have been done on homegardens and the benefits they provide to homeowners and to urban ecosystems in general. However, since South Africa become committed to the United Nations Millennium Development Goals in 2000, more research has been done on the potential of homegardens for poverty alleviation.

The aim of this study was to determine the patterns of plant diversity in a rural settlement and to determine to what extent the socioeconomic status of the inhabitants influences the plant species composition of the settlement. The settlement of Ganyesa, situated in the Bophirima district in the North-West Province, was chosen for the study. Using GIS techniques, a grid was placed over the settlement and plant surveys were done every 500 m. Different land-use types were identified during the completion of the survey, namely natural areas, fragmented natural areas, fallow fields, road verges, wetlands, home gardens and institutional gardens. The national South African census data from 2001 proved to be too unreliable to accurately determine the SES of the residents in Ganyesa. Consequently, a social survey was completed by means of a questionnaire to determine the socioeconomic status of the owners of the homegardens under study.

Clear differences could be observed between the land-use types and the indigenous and alien species composition, which were indicated in kriging maps. In comparison with the natural areas, homegardens contained more alien species than the surrounding natural areas. The vegetation composition for all the homegardens were correlated with the residents socioeconomic status along a socioeconomic gradient, ranging from low, to medium to high.

ANCOVA, multiple regressions and basic statistical analyses were performed using all the vegetation and socioeconomic data. Meaningful correlations occur between the socio-economic status of the homeowners and the plant diversity of their gardens.

Keywords: Urban ecology, rural settlements, urban green space, homegardens, socioeconomic status.

Opsomming

In die afgelope paar jaar het die samestelling van stedelike plantegroei meer kompleks as die omringende natuurlike plantegroei geword. Die hoofrede hiervoor was die invloed wat mense het op die skep van nuwe plantgemeenskappe en die bestuur van stedelike groen ruimtes. Groen ruimtes is fundamenteel belangrik vir die restorasie en bestuur van biodiversiteit in daardie gebiede wat die meeste deur stedelike ontwikkeling beïnvloed is. Groen gebiede verskaf verskeie ekostelseldienste en hou voordele vir die gesondheid en welstand van stedelike inwoners in. Dit kan ook bydra tot die vermindering van die gevolge wat gepaard gaan met globale klimaatsverandering.

Die belangrikste, maar terselfdertyd swakste, bestudeerde groen ruimtes is huistuine. Huistuine verteenwoordig 'n beduidende gedeelte van die spesiesamestelling van stedelike en landelike nedersettings en is belangrike lokale bewaringsgebiede wat kan bydra tot die beskerming van skaars en endemiese spesies. Hulle is essensiële landboukundige stelsels en, veral in landelike nedersettings, dra dit by tot addisionele inkomste en voedselvoorsiening. In ontwikkelende lande, soos Suid-Afrika, was daar nog nie veel studies gedoen op huistuine en die voordele wat dit vir huiseienaars inhou nie. Sedert Suid-Afrika egter deel geword het van die Verenigde Nasies se Millennium Ontwikkelingsdoelwitte in 2000, word daar meer aandag gegee aan die potensiaal van huistuine vir die verligting van armoede.

Die doel van hierdie studie was om die patrone van plantegroeidiversiteit in ón landelike nedersetting te bepaal en om vas te stel tot watter mate die sosio-ekonomiese status van die inwoners die spesiesamestelling van plantegroei in tuine beinvloed. Die nedersetting Ganyesa, wat geleë is in die Bophirima distrik in die Noord-Wes Provinsie, was gekies as die studiegebied. Deur van GIS tegnieke gebruik te maak, was ón ruitpatroon oor die nedersetting geplaas en plantopnames was elke 500 m gedoen. Verskillende grondgebruikstipes was geïdentifiseer deur die verloop van die studie, naamlik natuurlike gebiede, gefragmenteerde natuurlike gebiede, ou lande, padreserwes, vleilande, huistuine en institusionele tuine. Die 2001 nasionale sensusdata vir Suid-Afrika was ongelukkig onbetroubaar en nie akuraat genoeg om die sosio-ekonomies status van die inwoners in Ganyesa te bepaal nie. Gevolglik was ón sosiale opname voltooi met behulp van vraelyste om die sosio-ekonomiese status van die huiseienaars te bepaal.

Duidelike verskille kon waargeneem word tussen die grondgebruikstipes en die inheemse en uitheemse spesiesamestelling. Hierdie verskille was aangedui met behulp van "kriging" kaarte. In vergelyking met die natuurlike areas, bevat huistuine meer uitheemse spesies as die

omringende natuurlike omgewing. Die plantegroeisamestelling van al die huistuine was met mekaar vergelyk langs 'n sosio-ekonomiese gradiënt wat strek van laag, tot medium tot hoog. ANCOVA, meervoudige regressies en basiese statistiese analises was uitgevoer op die plantegroei en sosio-ekonomiese data.

Sleutelwoorde: Stedelike ekologie, landelike nedersettings, stedelike groen ruimtes, huistuine, sosio-ekonomiese status.

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List of Abbreviations

BUGS I	-	Biodiversity of Urban Gardens in Sheffield I
BUGS II	-	Biodiversity of Urban Gardens in Sheffield II
EEA	-	European Environment Agency
MDGs	-	Millennium Development Goals
MOSS	-	Metropolitan Open Space System
NWPTB	-	North West Parks and Tourism Board
PRE	-	Pretoria National Herbarium
PRECIS	-	Pretoria National Herbarium Computerised Information System
SES	-	Socioeconomic Status
UGS	-	Urban Green Space
UHI	-	Urban Heat Island

Chapter 1 - Introduction

"Two consequences of the continued urbanization of the human population are that a growing proportion of the landscape is less hospitable to, and that a growing proportion of people are disconnected from, native biodiversity" (Gaston *et al*., 2007).

1.1 Introduction

Acar *et al*. (2007) stated that the urbanization phenomenon around the world has been an important component of land-use and land cover change, and its significance will undoubtedly continue to increase with the majority of the world's population swarming into cities. Approximately 5-10 % of the world's population lived in or near cities in 1990, but this grew to about half the human population in 2001 and is estimated to be two/thirds in the year 2025 (World Resources Institute, 2001). According to the United Nations Populations Fund (2007) urban areas in developing countries will accommodate nearly 80% of the projected world human population increase by 2030. Consequently, this increase in population densities in cities has led to a severe depletion of both land and natural resources, which has forced people to realise the importance of urban ecology as a basis for urban planning (Breuste, 2004) and sustainable development (Cilliers *et al*., 2004).

Urbanization is one of the main threats to biodiversity in South Africa, since large quantities of natural vegetation is constantly being destroyed in and around cities (Cilliers *et al*., 2004). The continued migration of people from rural to urban centres, constantly outweights the necessity of urban nature conservation (Cilliers *et al*., 2004). Consequently, urban nature conservation issues are frequently eclipsed by the goal to improve human well-being, which focuses on aspects such as poverty alleviation, the redistribution of wealth and wealth creation (Hindson, 1994). According to Cilliers *et al*. (2004) the lack of detailed ecological data is one of the core problems associated with the implementation of conservation-oriented policies in urban planning and management.

A lack of detailed ecological data, coupled with the growing realisation of the importance of urban vegetation studies, has led to the development of a comprehensive research programme focused on urban open spaces in certain cities in the North-West Province, South Africa (Cilliers *et al*., 2004). Studies within this programme included phytosociological and floristic surveys of the wetlands in urban areas (Cilliers *et al*., 1998; Van Wyk *et al*., 2000), the hills and ridges in urban areas (Van Wyk *et al*., 1997), vacant lots in residential, commercial and industrial areas (Cilliers and Bredenkamp, 1999b), intensively managed parks, pavements and parking areas (Cilliers and Bredenkamp, 1999a), road verges along an urbanization gradient (Cilliers and Bredenkamp, 2000) and natural grasslands and woodlands (Cilliers *et al*., 1999).

One of the first studies to document the importance of urban open space planning in South Africa was that of Poynton and Roberts (1985). Their study emphasized the need for new approaches in the planning and management of urban open spaces, as well as the importance of implementing conservation programmes for previously excluded areas such as derelict land and road verges. The study of Roberts (1993) was one of the few studies to formally describe the vegetation of an urban area in South Africa. Roberts (1993) surveyed all the remaining vegetated areas in the city of Durban, allowing an accurate interpretation of the ecological status and conservation value of the open space resources. Since the studies of Poynton and Roberts (1985) and Roberts (1993), cities such as Johannesburg, Cape Town, and Port Elizabeth have all implemented substantive urban open space planning approaches in the form of the Metropolitan Open Space System (MOSS) (McConnachie *et al*., 2008). However, plans for urban open spaces have yet to be developed and implemented in smaller cities and towns in South Africa (McConnachie *et al*., 2008).

1.2 Motivation

The extent and continued expansion of urban areas has focused a great deal of attention on the significance of native biodiversity in the remaining green spaces within urbanized areas and the most appropriate methods of managing it (Gaston *et al*., 2005a). Consequently, increasing attention is being paid to the role of homegardens in maintaining biodiversity in suburban and urban areas (Gaston *et al*., 2005a), as they constitute a significant proportion of the green spaces in urban areas (Gaston *et al*., 2005b). The study of Loram *et al*. (2007) found that high population density equates to a high density of housing and therefore a high proportion of garden area. Homegardens can cover approximately 18-27% of the urban areas of cities in the UK (Loram *et al*., 2007).

In developed countries, studies in homegardens have mainly focused on biodiversity conservation (Smith *et al*., 2006b) or manipulation (Gaston *et al*., 2005a), while the homegarden research of the last three decades in developing countries have mainly focused on either ethnobotanical documentation or the promotion of home gardening for nutritional improvement (Trinh *et al*., 2003) and poverty alleviation (Shackleton *et al*., 2008). In South Africa, botanical research concerning the homegardens of rural areas is lacking, and the only research on this topic has been few and far between. The study of Shackleton (2000) was one of the first to compare the diversity of communal areas with adjacent protected areas in the Bushbuckridge lowveld savanna, while the studies of High and Shackleton (2000) and Shackleton and Shackleton (2006) were some of the first to investigate the value of traditional products for poverty alleviation.

Poverty alleviation has been placed high on the national development agenda following South Africaôs adoption of the United Nations Millennium Development Goals (MDGs) set out in the Millennium Declaration of 2000 (Shackleton *et al*., 2008). Consequently, the number of studies in rural areas has begun to increase, with the emphasis on fully understanding the contribution that biodiversity and the natural product trade can make to achieve the goals of poverty alleviation (Shackleton *et al*., 2008). However, in order for researchers to successfully implement poverty alleviation strategies in homegardens, a complete floristic analysis of the homegardens and the socioeconomic status of the residents, is required.

1.3 Aim

The aim of this study was to identify patterns of plant diversity in a rural settlement along a socioeconomic gradient.

1.4 Hypotheses

Based on previous studies the following hypotheses were formulated:

- The species diversity of different land-use and land cover types are variable within a rural settlement.
- The species diversity of residential areas with different socio-economic status are variable and influenced by financial well-being and ability to realize desires.

1.5 Dissertation structure and content

The dissertation consists of the following chapters:

Chapter 1 provides a brief introduction and motivation that touches upon some of the main aspects that will be discussed in this dissertation, along with the main aims and hypotheses. Chapter 2 is the literature study and describes the broad context of the various aspects relevant to the ecology of urban areas.

Chapter 3 contains a complete overview of the study area, including various aspects of the Tswana culture and history, along with the environmental data of the Ganyesa area, which includes topography, geology, soil, climate, vegetation, economic activities and conservation data.

Chapter 4 describes the patterns of plant diversity for the entire settlement and compares the floristic diversity of the different land-use types with one another. The main theme in this chapter is the differences in plant diversity between natural areas and homegardens.

Chapter 5 assesses the complete floristic composition of the different land-use types in the settlement. Specific emphasis is placed on the differences between the indigenous and alien

species composition of the different land-use types, and documents the useful plant diversity of the study area, as well as the potential of biodiversity conservation in homegardens.

Chapter 6 presents the results from the social survey conducted in Ganyesa. The main objectives were to determine the residents perceptions regarding their gardens, their level of gardening activity, their socioeconomic status (SES), as well as their emotional well-being and satisfaction with life.

Chapter 7 aims to integrate the vegetation and floristic data with the socioeconomic variables following a statistical approach. This chapter essentially compares the results from this study with those of Hope *et al*. (2003 and 2006), Martin *et al*. (2004) and Kinzig *et al*. (2005).

Chapter 8 concludes the dissertation, summarizes the results relating to various aspects discussed throughout the dissertation and contains recommendations for future studies.

Chapter 2 - Literature review

"Urbanization is a global trend currently undergoing rapid acceleration with resulting negative impacts on the compositional, structural and functional elements of biodiversity" (Sandstrom *et al*., 2006).

2.1 Introduction

According to a United Nations Population Division (2004) report, the worldôs population is projected to increase by more than one-third over the next 30 years, adding approximately two billion people to the already over-populated urban areas. In South Africa the level of urbanization for 2000 was approximately 55%, 10% higher than the average for developing countries (Donaldson-Selby *et al*., 2007). This constant increase in the population and size of cities and towns around the world has sparked a growing interest on the impact that urbanization has on both humans and the environment (Hahs and McDonnell, 2006). According to Acar *et al*. (2007) the ecology of urban areas is severely affected by urbanization due to the fact that it is a rapidly growing cause of countless environmental problems, many of which occurred because ecological components were not taken into consideration during planning stages.

Niemelä (1999) stated that in order to define the concept ôurban ecologyô, the constituent words ôurbanôand ôecologyômust first be discussed. The term ôurbanôbroadly refers to a certain kind of human community with a high density of people, their homes, as well as various other forms of construction (Niemelä, 1999). The term ôecologyô however, has had various different definitions over the years (Niemelä, 1999). Haila and Levins (1992) defined four different meanings of the term, the first of which considered ecology as a science which investigates natureôs economy, in other words the flow of matter and energy or the distribution and abundance of organisms (As quoted by Niemelä, 1999). The second considers ecology as nature, which is seen as the resource base for humans, while the third views ecology as an idea, more specifically a concept that views human existence in relation to ecology the science. The last meaning considers ecology as a movement and refers to political activities that are related to ecological and environmental issues (Haila and Levins, 1992 As quoted by Niemelä, 1999).

According to Rebele (1994) urban ecology is a practical science, which deals with the environment of people living in cities and towns, as well as the associated environmental problems. In the past, urban ecologists focused mainly on patterns of species abundance (Kent *et al*., 1999) and diversity (Tilman, 1997). However, over the last decade urban ecology has evolved into a multidisciplinary field, in which ecologists collaborate with sociologists,

geographers and anthropologists (Alberti *et al*., 2003). Therefore, the nature of urban ecology is that of an applied science (Niemelä, 1999). According to Niemelä (1999) ecological research and its applications, such as establishment of protected areas, would benefit from the input of knowledge of human actions in urban areas, while the development of residential areas that maintain and improve the quality of life, health and well-being of urban residents would benefit from better understanding of urban ecosystems.

2.2 Urban ecosystems

According to McDonnell (1997) urban and suburban landscapes have in the past been severely understudied and underutilized by ecologists worldwide. The main cause for this was that ecologists were reluctant to work in human dominated areas, which were regarded as less worthy than non-urban habitats (McDonnell, 1997). However, Niemelä (1999) has identified several important reasons for ecological studies in urban settings. Firstly, ecological knowledge of the effects that humans have on urban ecosystems is vital to the creation of healthy and pleasing environments, and secondly, urban areas provide useful insights into ecosystem functioning (Niemelä, 1999), especially since the ecological processes in urban areas are comparable to those in natural ones (Walbridge, 1997). Thirdly, finding explanations for the species diversity phenomena in urban habitat types and being able to predict the changes as urbanization continues, are challenges for ecological research (Niemelä, 1999).

Moll and Petit (1994) defines an ecosystem as a set of interacting species and their local, non-biological environment functioning together to sustain life. However, in the case of an urban environment, cities can be viewed as both a single ecosystem or as several individual ecosystems (Rebele, 1994), in which fundamental patterns and processes can be decoupled by human activities (Shochat *et al*., 2006). Therefore, urban ecosystems can be defined as complex ecological entities, with their own unique set of internal rules of behavior, growth and evolution (Alberti *et a*l., 2003). Urban ecosystems differ from natural ones in terms of the level of invasion by non-native species, the lack of integration of habitat patches, the external control of succession (Niemelä, 1999), the services provided by urban ecosystems (Bolund and Hunhammar, 1999) and the level of ecosystem health (Tzoulas *et al*., 2007).

2.2.1 Ecosystem health

Costanza (1992) defines ecosystem health as the occurrence of normal ecosystem processes and functions (As quoted by Tzoulas *et al*., 2007). Therefore, based on this definition, a healthy ecosystem is one that is free from distress and degradation, is resilient to stress and is capable of maintaining its organisation and autonomy over time (Lu and Li, 2003). A healthy ecosystem has the ability to provide numerous ecosystem services, while an increase in the ecological stress levels reduces the quality and quantity of these services (Lu and Li, 2003). According to Tzoulas *et al*. (2007) the ecological functions and ecosystem services provided by a green

infrastructure can contribute to ecosystem health, as well as to public health and psychological well-being.

2.2.2 Ecosystem services

Costanza *et al*. (1997) defines ecosystem services as the benefits human populations derive directly or indirectly from ecosystem functions. Urban ecosystem services contribute to the quality of urban life of urban citizens (Bolund and Hunhammar, 1999). The six most important ecosystem services in an urban area, based on a study by Bolund and Hunhammar (1999), are air filtering, noise reduction, micro-climate regulation, rainwater drainage, sewage treatment and recreational or cultural values. Wetlands and urban green spaces are the most valuable ecosystem types, since they contribute to all or most of the listed ecosystem services (Bolund and Hunhammar, 1999). According to Alberti (2005) urbanization significantly influences the functioning of local and global earth ecosystems and the services they provide to humans and other life on earth.

2.3 Urbanization

Cities expand almost on a daily basis in every locality worldwide and are constantly homogenizing the physical environment (McKinney, 2006). According to McKinney (2006) this is mainly because cities are built to meet the relatively narrow needs of just one species, our own. Urbanization is considered to be the major driving force behind biodiversity loss and biological homogenization in developed countries, as well as in developing countries (Savard *et al*., 2000; McKinney, 2002). According to Whitmore et al. (2002) the effects of urbanization on native and introduced biota in developing countries are poorly known and the scarce evidence that exists tends to focus on the effects with regards to specific taxa in particular situations.

In comparison with the surrounding natural environment, cities are constantly in a nonequilibrium state due to the importation of vast resources of both energy and materials (McKinney, 2006). Hahs and McDonnell (2006) characterizes urbanization by the presence of artificial structures, impervious surfaces, high densities of people, domesticated plants and animals, and altered flows of energy and nutrients. However, it is important to remember that continued urbanization is essentially human induced and therefore the problems that have stemmed from urbanization are also directly or indirectly caused by humans (McKinney, 2002). The most important being habitat loss (Wilcove *et al*., 1998), biotic homogenization (McKinney, 2002; McKinney, 2006) and most recently human induced climate change (Hannah *et al*., 2004).

2.3.1 Habitat loss

According to McKinney (2006) habitat alteration due to urbanization is both drastic and increasingly widespread. As habitat loss increases from rural to urban areas (McKinney, 2002),

the remaining natural areas are increasingly fragmented into numerous smaller, remnant patches (Medley *et al*., 1995; Collins *et al*., 2000). There are four main types of altered habitats that replace the lost natural habitat, namely built habitat (McKinney, 2002), ruderal vegetation, managed vegetation and natural remnant vegetation (Whitney, 1985). Built habitat consists of buildings and any sealed surfaces, such as roads or sidewalks and of the four types it is the most prominent (McKinney, 2002).

Managed vegetation occurs in residential, commercial, as well as institutional areas and any other regularly maintained green spaces, while ruderal vegetation exists in empty lots or any abandoned farmland and old field (McKinney, 2002). Natural remnant patches are those remaining islands of the original vegetation, also known as fragmented natural areas (McKinney, 2002) or encapsulated countryside (Kendle and Forbes, 1997). These land modifications caused by urban growth, are usually long term and often intensify with time (McKinney, 2006). Habitat loss greatly contributes to the loss of populations and species in urban ecosystems (Hobbs and Mooney, 1998).

2.3.2 Biotic homogenization

As a result of the continuous expansion of cities across the planet, biological homogenization has increased at an alarming rate, since the same urban adaptable species have become more widespread and abundant (McKinney, 2006). McKinney (2002) defines urban adaptable species, as species capable of adapting to both urban and suburban conditions but that still utilize natural resources. Most urban adapted species are native species that have emigrated from the surrounding natural areas to take advantage of human created habitat (McKinney, 2006). According to McKinney (2002) the first species to disappear in the proximity of humans are urban avoiders, species that are sensitive to human persecution and habitat disturbance. Urban exploiters, are species that are dependent on human resources and are well adapted to an intensely modified urban environment, these species are mostly non-native and can be found in most cities (McKinney, 2002).

The process of replacing native species with non-native species is known as biotic homogenization (McKinney and Lockwood, 1999) and it threatens to reduce the biological uniqueness of all local ecosystems (McKinney, 2006). According to McKinney and Lockwood (1999) biotic homogenization occurs when widespread environmental change promotes the geographic expansion of some species and the geographic reduction of other species. The accelerated rate of species invasion and extinction has caused the biological diversity of urban ecosystems to change in fundamentally different ways and at different spatial scales (Rooney *et al*., 2007). According to Schwartz *et al*. (2006) biotic homogenization measures can be applied

at different organizational, spatial or temporal scales to determine native species losses and gains in an urban area or urbanizing region.

2.3.2.1 Species losses and gains

According to Hobbs and Mooney (1998) native populations are being driven to extinction, while at the same time other populations of native and non-native species are increasing in urbanized areas. However, there are some non-native species that will invade and often homogenize relatively undisturbed natural areas (McKinney and Lockwood, 1999). Therefore, species gains can often be observed at regional and local scale, but the global species richness is declining (Hobbs and Mooney, 1998). The study of Wania ***et al***. (2006) found that the increase in species richness in urban areas is not only related to increases in alien species richness, but to increases in native species richness as well.

According to McKinney (2006) urbanization is closely associated with two basic factors that increase the non-native species richness in an urban habitat, namely an increase in the importation of non-native species and the availability of favorable habitats for their establishment. Shea and Chesson (2002) have identified three main factors that contribute to the establishment of non-native populations; (1) the availability of resources, (2) reducing the threat of natural enemies and (3) altering the physical environment to improve habitability for the invading species, all of which vary in space and time. Urban environments import non-native species for various reasons, ranging from the unintentional importation of alien species due to traffic, as accidental byproducts of commerce and tourism, to the cultivation of non-native species for medicinal or ornamental purposes (Wilcove ***et al***., 1998; McKinney, 2006).

2.3.2.2 Biotic homogenization: a major conservation challenge

According to Rooney ***et al***. (2007) the growing realization that species composition defines the role that biodiversity plays in maintaining ecosystem function, highlights the need for conservation biologists to consider the many threats to biological diversity, including biotic homogenization. The replacement of native species with non-native species forms the first of two fundamentally important reasons as to why urban biotic homogenization is a major challenge to conservation (McKinney, 2006). The second reason being the impact that urbanization has on human perceptions concerning natural environments or more specifically nature in general (McKinney, 2006). The majority of urban inhabitants have become disconnected from their native biological environment and since most of the urban flora and fauna are not indigenous to the local urban environment, the ecological knowledge of urban residents is severely lacking (McKinney, 2002).

2.3.3 Climate change

On a more local scale, climate change is an important effect of urbanization. Mounting evidence indicates that global climate is indeed changing and this is mainly due to greenhouse

gas emissions caused by human activities (Hannah *et al*., 2002; Gill *et al*., 2007; Younger *et al*., 2008). These changes have resulted in rising sea level, heavier precipitation events such as floods, storms and hurricanes, increasing numbers of heatwaves, more areas affected by drought and the most prominent, elevated temperatures (Younger *et al*., 2008). According to Hannah *et al*. (2004) our ability to manage climate change will increasingly be tied to our ability to conserve the living resources of the planet.

According to Sukopp (2004) climatic conditions within a city can vary considerably, depending on the type of construction, paving, location in the city and especially, the distance to large vegetated areas. In comparison with the surrounding natural areas, urban areas have higher concentrations of air pollution and altered radiation (Sukopp, 2004). The altered surface cover of urban areas, such as less vegetated surfaces and increased built surfaces, have lead to a decrease in evaporative cooling and an increase in surface runoff, all of which contribute to the elevated temperatures in urban areas (Gill *et al*., 2007). When combined, these factors all contribute to the creation of an urban ñheat islandò (Gill *et al*., 2007). According to Solecki *et al*. (2005) the urban heat island (UHI) effect, together with summertime heat waves, sets in motion conditions that foster biophysical hazards such as heat stress and increased concentration of secondary pollutants.

2.4 Biodiversity conservation

Common and Stagl (2005) define biodiversity as the diversity of living organisms, the genes that they contain and the ecosystems in which they exist. According to Savard *et al*. (2000) biodiversity concerns that are related to urban ecosystems can be divided into three main groups, namely (1) those dealing with how to maximize biodiversity within the urban ecosystems, (2) those related to the impact of the city itself on neighbouring ecosystems and (3) those related to the management of undesirable species within the ecosystem. As urbanization increases, it is becoming increasingly important to restore, preserve and enhance the biodiversity of urban areas (Savard *et al*., 2000). According to McDonald *et al*. (2008) the effect of urban area and urban growth on biodiversity conservation is localized, but cumulatively significant, with important eco-regions, rare species and protected areas all affected.

2.4.1 Conservation strategies

According to McKinney (2002) there are several ways to conserve and protect native species in urban areas. First of all, preserving remnant natural habitats and restoring modified habitats to their original form, will reduce the impact that urbanization has on native species (McKinney, 2002). This is especially important since endangered species, as well as rare species often occur in urbanized habitats (McKinney, 2006). Secondly, by managing the large amount of residential vegetation, in ways that would promote the conservation of native species, will significantly contribute to native biodiversity enhancement (McKinney, 2002). However,

according to McKinney (2006), simply encouraging the preservation and restoration of biodiversity in urban habitats is insufficient, the most important method for promoting the conservation of native species, is by educating the urban public.

According to Miller (2005) greater integration of nature into the built environment not only has the potential to foster support for preserving biodiversity and to create opportunities for native species, but also to better the human condition. Consequently, the preservation and enhancement of urban green space is the key to biodiversity conservation (Miller, 2005). According to McDonald *et al* (2008) it is only by addressing this growing conflict between cities and biodiversity that society will be able to achieve genuine conservation in an urbanizing world.

2.4.2 Agroforestry as a biodiversity conservation tool

Based on the most recent studies, agroforestry systems can be useful tools for biodiversity conservation (Bhagwat *et al*., 2008). Ashley *et al*. (2006) defines agroforestry as the deliberate management of trees on farms and in agricultural landscapes. They have the potential to protect certain wild species and habitats outside formally protected areas (Tylianakis *et al*., 2005; Round *et al*., 2006), to maintain heterogeneity at habitat and landscape scale (Parikesit *et al*., 2004; Hemp, 2006; Kindt *et al*., 2006), to alleviate the pressure of resource-use on nature reserves and conservation areas (Murniati *et al*., 2001; Rodrigues *et al*., 2004) and to provide corridors between nature reserves and protected landscapes for migrating species (Bhagwat *et al*., 2008).

2.5 Settlements

The study of settlements touches upon almost all aspects of human social and economic activities (Daniel and Hopkinson, 1989). According to Stone (1965) the geography of settlements is defined as the description and analysis of the distribution of buildings by which people attach themselves to the land. Daniel and Hopkinson (1989) defines the term ósettlementôas a place which people inhabit on a permanent basis and where they carry on a variety of activities, such as trade, defence, manufacturing and so forth. The building patterns of settlements are greatly influenced by the land uses around the settlement, for example, it is possible that all farmsteads could be grouped together for defence and sociability or that the individual houses were built out in the fields, giving the village a more fragmented appearance (Daniel and Hopkinson, 1989). These types of settlements are than referred to as ñdispersedò or ñnucleatedòsettlements respectively (Daniel and Hopkinson, 1989).

2.5.1 Rural settlements

Stone (1965) defines the term rural as an aerial predominance of agriculture, fishing, hunting and trapping, mining or power production directly from local resources. In South Africa rural settlement patterns are influenced by various factors of survival such as the availability of land

for farming or grazing, proximity to water and its resources, mineral resources, safety from potential enemy attack and ethnic group association (Tladi *et al*., 2002a). According to Tladi *et al*. (2002a) settlement patterns and their associated population density and growth, varies in response to climatic and natural resource factors, historical and political factors, the availability of land and economic opportunities. The current driving forces behind settlement patterns are industrial employment opportunities and economic activities, which are responsible for the current rate of urbanization in South Africa, since most rural inhabitants move to urban centres in search of better job opportunities (Tladi *et al*., 2002a).

The majority of studies in settlements has focused either on urban settlements or was conducted in the developed world, while the number of studies in rural settlements, in a developing country is limited (McConnachie *et al*., 2008). In South Africa studies in rural settlements have focused on the poverty alleviation potential of various traditional products (Shackleton *et al*., 2008), the wealth-related differences and similarities in the use and value of non-timber forest products (Shackleton and Shackleton, 2006), compared the diversity of communal areas with adjacent protected areas (Shackleton, 2000), reported on the state of urban green spaces in settlements (McConnachie *et al*., 2008) and the value of plant products derived from household and agricultural land in a rural settlement (High and Shackleton, 2000).

2.6 Urban green space

According to James *et al*. (2009) the social, economic and environmental considerations of recent years, have led to a reevaluation of the factors that contribute to sustainable urban environments. Consequently, urban green space (UGS) is increasingly seen as a fundamental part of cities providing a range of services to both the people and the wildlife living in urban areas (James *et al*., 2009). This has led to the marked upsurge in studies concerned with green space in urban areas over the last few decades (Swanwick *et al*., 2003), the majority of which have mainly focused on public space (Richards *et al*., 1984), while the predominantly private green space associated with urban residential properties have received little attention even though it may be the most important green space in the daily lives of urban residents (Gaston *et al*., 2005b). Richards *et al*. (1984) identified two possible reasons for the lack of UGS studies in private gardens, namely (1) private gardens are extremely diverse and therefore difficult to study, and (2) they haven't been a direct subject of public policy and decisions. A third possible explanation for the lack of UGS studies in private gardens is ownership and the lack of permission from home owners to conduct studies in their gardens.

2.6.1 Definitions of urban spaces

As a result of the increasing number of studies concerned with UGS, there has arisen a need for clarity and consistency in the definition of the term "green space" (Swanwick *et al*., 2003). According to Swanwick *et al*. (2003) definitions are particularly important as the terms "green

spaceô and ópen spaceô seem to be used loosely and interchangeably. Green space is a relatively recent term that refers to the green environment in urban areas, while open space is used for a number of often imprecise meanings, including reference to the external environment outside urban areas (Swanwick *et al*., 2003). The Sheffield research project endeavoured to define these key terms more clearly (Swanwick *et al*., 2003).

Urban areas are made up of the built environment and the external environment between buildings (Fig. 2.1). The latter consists of green space, i.e. land that consists predominantly of unsealed, permeable, ósoftô surfaces such as trees, shrubs, grass and soil (Swanwick *et al*., 2003). Therefore, the term úrban green spaceô is an umbrella term for all areas of land covered by this definition of ógreen spaceô (Swanwick *et al*., 2003). This includes sports fields, derelict land, public parks, natural or semi-natural areas, green corridors, road verges, waterways, railways and homegardens (Smith *et al.,* 2005; Caula *et al.,* 2009). The external environment also consists of predominantly sealed, impermeable surfaces such as concrete, paving or tarmac, termed ógrey spaceô (Swanwick *et al*., 2003).

According to Swanwick *et al*. (2003) the term ópen spaceô in the UK is defined as that part of the urban area that contributes to its amenity, either visually by contributing positively to the urban landscape, or by virtue of public access. Open space, therefore consists of both, urban green spaces and civic spaces, the latter referring to the publicly accessible areas designed primarily for public enjoyment, which includes public squares, plazas and pedestrianized streets (Swanwick *et al*., 2003). These definitions and distinctions have become increasingly important, since governments are linking the future of UGS to the ever increasing population growth (Swanwick *et al*., 2003).

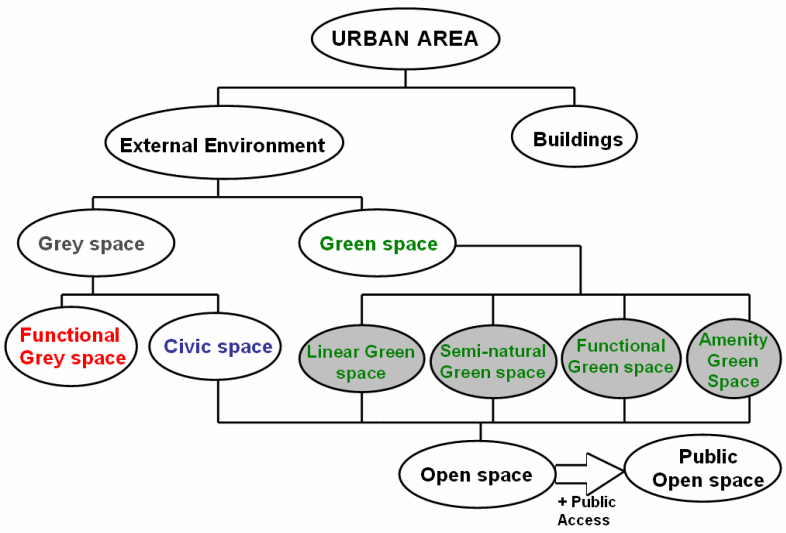


Figure 2.1: Diagram illustrating the various areas and spaces that comprise an urban environment (Swanwick *et al*., 2003).

2.6.2 Urban green space studies

The majority of UGS studies were conducted in developed countries such as the UK, USA, Netherlands and Denmark. These studies mostly focused on identifying factors that influence local decisions to protect (Broussard *et al*., 2008) and manage UGS (Broussard *et al*., 2008; Schipperijn *et al*., 2009), the extent to which local government officials and citizen support UGS policies (Barbosa *et al*., 2007; Broussard *et al*., 2008), to describe and understand which factors are correlated with UGS use (Schipperijn *et al*., 2009), the contribution of UGS to biodiversity conservation in urban areas (Gaston *et al*., 2005b; Sandstrom *et al*., 2006; Smith *et al*., 2006c) and the various benefits associated with UGS, which will be further discussed in 2.5.4. Several studies have also been conducted on the role of UGS in perceived health and psychological well-being (Ulrich *et al*., 1991; Maas *et al*., 2006) and the correlations between socioeconomic status and UGS (Solecki and Welch, 1995).

In contrast to the various studies that have been conducted in the developed world, very few studies have been carried out on UGS areas in developing countries (McConnachie *et al*., 2008). The study of McConnachie *et al*. (2008) was the first to report on the extent and state of urban green space within ten small towns in the Eastern Cape, South Africa. The objectives of their study was to quantify the current size and state of public green space and to seek patterns between this and the socioeconomic attributes of the towns (McConnachie *et al*., 2008). Their study found correlations between the general patterns of green spaces and socioeconomic indices. Towns with a lower income were more densely populated and therefore had less green space per capita (McConnachie *et al*., 2008). However, according to McConnachie *et al*. (2008) the provision of public green space for the majority of the studied towns appears to be adequate in comparison with UGS provision in the developed countries of Europe.

2.6.3 Urban green space policies

According to Swanwick *et al*. (2003) the importance of UGS in towns and cities has been recognized in varying degrees since the nineteenth century when its value in providing an escape from widespread urban air pollution was a major driving force in creating new parks and green space. However, it is only the studies of the last decade that have alerted governments to the vital importance of urban parks and green spaces (Swanwick *et al*., 2003). According to Schipperijn *et al*. (2009) the most recent national and local health policies mention the positive effects of the use of green space to promote health. In most European countries a wide range of initiatives have been implemented to increase and improve urban green spaces (Swanwick *et al*., 2003; Barbosa *et al*., 2007), as primary means of utilising their health benefits (Schipperijn *et al*., 2009). Maas *et al*. (2006) found a significant relationship between the amount of green space close to where people live and their perceived health.

According to Barbosa *et al*. (2007) a UK government agency recommended that people living in towns and cities should have an accessible natural green space less than 300 m from home, while the European Environment Agency (EEA) recommended that people should have access to green space within 15 minutes walking distance. The study of Barbosa *et al*. (2007) measured the access to public green space available to households in a major UK city. It found that green space in Sheffield was substantially underprovided relative to the government recommended targets (Barbosa *et al*., 2007). In contrast, the Europe-wide assessment of Stanners and Bourdeau (1995) reported that all citizens in Brussels, Copenhagen, Glasgow, Gothenburg, Madrid, Milan, Paris and various smaller cities do live within 15 minutes walking distance of some form of UGS (As quoted by Barbosa *et al*., 2007).

2.6.4 Benefits of urban green spaces

Urban green spaces are fundamental to the provision of ecosystem services in urban regions (Bolund and Hunhammar, 1999), the restoration and maintenance of biodiversity in areas that have been severely impacted by urban development (Gaston *et al*., 2005b; Thompson *et al*., 2005), by preserving or creating habitat and maintaining corridors for the movement of wildlife through the urban matrix (Smith *et al*., 2006b) and ameliorating urban climate and preventing the heat stress phenomena (Lafortezza *et al*., 2009). Urban green spaces can reduce the wind speed in cities (Mochida and Lun, 2008), can serve as air filters by helping to remove atmospheric pollutants (Jim and Chen, 2008), are important indicators of environmental pollution (Beckett *et al*., 1998) and can significantly reduce noise pollution (Gidlöf-Gunnarsson and Öhrström, 2007).

Urban green spaces also improve the quality of life, which includes the mental and physical well-being of people living in urban areas (Ulrich *et al*., 1991; Niemelä, 1999), promote quick recovery from surgery and relief from stress (Ulrich, 1984) and contributes to the education of the human population living in urban settlements with regards to management and conservation (Gaston *et al*., 2005b; Thompson *et al*., 2005). However, according to Smith *et al*. (2005) the ecological functions provided by green spaces will depend on their configuration (i.e. their size and distribution throughout the urban area) and composition (e.g. annual, perennial, indigenous and alien). The one green space that covers most of the urban area is homegardens, something researchers have only come to realise in the last decade (Gaston *et al*., 2005b).

2.7 Homegardens

According to Vogl *et al*. (2004) the defining criterion of homegardens are that they are adjacent to the house where the gardener(s) live. Most garden types are easily recognizable across different cultures even though the purpose of the garden and the location relative to a home or tenure varies greatly in different parts of the world (Vogl *et al*., 2004). Scientific literature distinguishes between two different types of homegardens, namely urban homegardens, also

referred to as domestic gardens, and rural homegardens (Vogl *et al*., 2004). Gaston *et al*. (2005b) defines domestic gardens as the private space adjacent to or surrounding dwellings, which may variously comprise lawns, ornamental and vegetable plots, ponds, paths, patios and temporary buildings such as sheds and greenhouses.

There are several different definitions that exist for homegardens in rural environments. Winklerprins (2002) defined homegardens as assemblages of plants about a dwelling which reveal much of the cultural history of places and of management decisions by individual holders, and which also satisfy various requirements such as food, fibre, medicine, etc. Das and Das (2005) defined homegardens as land use systems that involve the deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and invariably livestock within compounds of individual houses, which are managed by family labour. Koyenikan (2007) defined a homegarden as a garden around the house, which is used for the production of a variety of foods and agricultural products for both home consumption and income generation.

According to Vogl *et al*. (2004) homegardens can be distinguished from other types of gardens, such as an urban garden (a garden plot located at a significant distance from a house in the city), a rural garden (a garden a significant distance from a house in an area surrounded by other types of cultivated lands) and other types of gardens, such as parks, botanical gardens and community gardens. Based on these definitions the term homegarden, for the purpose of this study, is defined as the area around a home, which is used for planting ornamental plants but also for the production of food and other agricultural products, cultivated for both home consumption and as a means of generating an income. The homegardens studied in this project were comprised of lawns, medicinal, vegetable and ornamental plots, hedges grown as wind breaks and for security purposes, shade trees, remnant natural patches and bare areas that are devoid of vegetation.

Homegardens have the potential to support a rich assembly of both plant (Gaston *et al*., 2005b; Smith *et al*., 2006c; Loram *et al*., 2008a) and animal species (Gaston *et al*., 2005a; Smith *et al*., 2006b; Gaston *et al*., 2007), but the factors related to variation in biodiversity remain poorly understood (Smith *et al*., 2006b). However, predicting what the relative roles of ôinternalô and ôexternalô factors may be for biodiversity is difficult, since gardens are managed at individual levels (Thompson *et al*., 2003; Smith *et al*., 2006a) and may vary widely in land cover composition and management intensity (Smith *et al*., 2006b). In order to understand the complex structure and function of homegardens, it is necessary to study both the biophysical and socioeconomic aspects (Das and Das. 2005) of various homegardens in both urban and rural settings.

2.7.1 Previous studies in developed countries

Urban ecologists have studied virtually all aspects of urban settlements, but there has been almost no attempt to describe the composition and distribution of the flora of homegardens (Thompson *et al*., 2003). The number of studies that document the differences in species composition between gardens as a whole are also limited (Daniels and Kirkpatrick, 2006). The Biodiversity of Urban Gardens in Sheffield (BUGS I) projects were some of the first studies to investigate the resources that domestic gardens provide for biodiversity and ecosystem functioning (Gaston *et al*., 2005b; Smith *et al*., 2006c; Loram *et al*., 2008a), the factors that influence the levels of plant biodiversity associated with different gardens (Thompson *et al*., 2003) and the ways in which gardens can be manipulated to enhance biodiversity (Gaston *et al*., 2005a), while the BUGS II projects provide a detailed audit and comparative study of the size and structure of plant assemblages in gardens (Loram *et al*., 2007; 2008b).

2.7.1.1 Land cover and garden area

The conventional British garden generally contains a variety of different landcover types, for example a mown lawn, cultivated flower bed for ornamental plants, trees larger than 2 m high, a patio, hard paths and internal walls of stone or brick construction (Smith *et al*., 2005). The study of Smith *et al*. (2005) compared how extents of different vegetated landcovers changed under different housing density scenarios. Their study showed a positive correlation between garden area and landcover richness (Smith *et al*., 2005), and was later confirmed by the study of Loram *et al*. (2008b). This means that garden area partly determines the availability of particular landcovers and consequently the presence of a potential habitat for wildlife (Smith *et al*., 2005). However, due to increasing urbanization the pressure on available, undeveloped land has increased and as a result new housing plots will be smaller than those of older dwellings (Smith *et al*., 2005).

2.7.1.2 Differences between front and back gardens

The first studies to quantitatively compare the characteristics of front and back gardens were those of Richards *et al*. (1984) and Dorney *et al*. (1984). The study of Richards *et al*. (1984) found that vegetable gardens, flower gardens, trees as a whole and neglected trees were concentrated in back yards, while intensively cared for shrubs and hedges were concentrated in the front yards of Syracuse, New York. Similarly the study of Dorney *et al*. (1984) found that ornamental shrubs and trees were more than twice as common in the front than in the back yard of Shorewood, a suburb of Milwaukee, while back yards were diverse and abundant in woody vegetation, mostly tree saplings. Therefore, the composition and structure of front yards are strongly motivated by the orientation of the neighbourhood, while back yards are more personally oriented (Richards *et al*., 1984). Similarly study of Nassauer *et al*. (2008) found that for American front yard landscapes, the cultural norm is to conform to what the neighbours appear to prefer.

The study of Daniels and Kirkpatrick (2006) is one of the most recent studies to analyze the floristic, structural and artificial attributes in front and back yard gardens and was conducted in ten suburbs of Hobart, Tasmania, Australia. The aim of their study was to determine the degree and nature of the differences that may exist between these suburbs, as well as any relationship that these similarities and differences may bear to suburb characteristics (Daniels and Kirkpatrick, 2006). Similarly to the studies of Richards *et al*. (1984) and Dorney *et al*. (1984), gardens with an aesthetically appealing front yard are mainly dominated by ornamental species and small shrub cover, while the back yards are dominated by lawn cover and plants grown for food (Daniels and Kirkpatrick, 2006).

2.7.1.3 The importance of lawns

One of the most understudied aspects of homegardens is those of lawns, as very few studies have bothered to examine their contribution to the floristic diversity of homegardens. The studies of Wilson *et al*. (1992), Wilson and Watkins (1994), and Roxburgh and Wilson (2000) were the first to study lawns, however their studies were more concerned with the community assembly rules and stability of simple communities such as lawns. The first and most recent study to truly investigate the contribution of lawns to the floristic diversity of a homegarden was that of Thompson *et al*. (2004). The aim of their study was to determine the composition of lawn floras and to compare their floristic diversity with those of semi-natural grasslands (Thompson *et al*., 2004).

The results from the study of Thompson *et al*. (2004) indicted that lawns showed a clear tendency to accumulate species, either by seed or clonal expansion. According to Thompson *et al*. (2004) lawns contain an abundance of transient species such as, trees, shrubs and herbs that can rapidly transform the appearance and biomass of the typical lawn if management were relaxed. Lawns occupy an interesting intermediate position in the continuum between the natural (weeds and invader species) and completely man-made areas (controlled by human decisions) of homegardens (Thompson *et al*., 2004). Therefore, lawns have the potential to greatly contribute to the floristic diversity of homegardens.

2.7.1.4 Wildlife gardening

In response to the ever increasing levels of urbanization, the UK government has established a goal and an associated baseline indicator for increasing the range and extent of public participation in gardening for wildlife (Gaston *et al*., 2007). The use of a wildlife indicator reflects the high proportion of UGS that comprises domestic gardens (Gaston *et al*., 2004; Loram *et al*., 2007) and consequently, the potentially marked benefits that might be gained if these were managed in a fashion that is sympathetic to the conservation of native biodiversity (Gaston *et al*., 2004; 2007). The baseline assessment of this wildlife gardening indicator identified several

approaches for encouraging the presence of wildlife in gardens, these include providing bird feeders or a bird bath, providing food for wildlife, having ponds with the aim of attracting wildlife, leaving dead wood or leaves lying around, cultivating plant species that attract wildlife, compost heaps and avoiding the use of chemicals, such as herbicides and insecticides (DEFRA, 2003).

The study of Gaston *et al*. (2007) examined the relationships, across fifteen areas in five UK cities, between the proportion of households providing various garden features for wildlife or participating in various wildlife gardening activities, and housing densities and characteristics of the garden resource. The results of their study indicated that a significant number of households participate in some form of wildlife gardening and the predominant form of participation is the feeding of wild birds (Gaston *et al*., 2007). Furthermore, their study found substantial variation in the participation of wildlife gardening activities across these areas. According to Gaston *et al*. (2007) the key variables associated with the spatial variation in wildlife gardening activities were the proportion of households with access to a garden and more importantly the average garden size and proportion of land cover by gardens.

2.7.1.5 Invertebrate studies in homegardens

As part of the BUGS projects, several studies have been conducted to improve the insect biodiversity of homegardens. The study of Gaston *et al*. (2005a) tested five experimental methods for improving the biodiversity in domestic gardens. These five methods involve (1) the introduction of artificial nest sites for solitary bees and wasps, (2) small ponds, (3) artificial nest sites for bumblebees, (4) dead wood for fungi and other saproxylic organisms and (5) patches of nettles for butterfly larvae (Gaston *et al*., 2005a). The results of their study suggested that whilst some of the methods increase biodiversity, others have a low probability of success (Gaston *et al*., 2005a). However, according to Gaston *et al*. (2005a) the main function of small scale biodiversity enhancement is to develop and encourage the awareness of biodiversity and its conservation.

The study of Smith *et al*. (2006b) systematically assessed the patterns of invertebrate abundance across a substantial sample of domestic gardens in a major city in the UK, encompassing variation in urban location, density of the built environment and garden age, size and management. The results of their study indicated that a positive correlation exists between native plant species and the abundance of certain invertebrate species (Smith *et al*., 2006b). However, according to Smith *et al*. (2006b) various factors within and external to the sampled gardens were significantly related to invertebrate abundance, but very few assumed importance for more than a few taxa (Smith *et al*., 2006b). Consequently, the studies of both Gaston *et al*. (2005a) and Smith *et al*. (2006b) have indicated that appropriate garden management could have benefits for the overall conservation of biodiversity in homegardens.

2.7.1.6 The floristic diversity of homegardens

In comparison with natural areas, homegardens are floristically far more heterogeneous and contain diverse mixtures of both cultivated and volunteer species (Thompson *et al*., 2003). The study of Thompson *et al*. (2003) found that the total species richness of homegardens is almost certainly a reflection of two main factors; (1) there is a very large pool of plants available to gardeners for cultivation and (2) owing to active management and maintenance by gardeners, garden plants have a highly ôunnaturalô ability to persist at remarkably low population sizes. Similarly, the study of Loram *et al*. (2008a) found that in terms of the species richness and composition, factors such as latitude, rainfall, temperature, human population and housing density have little influence upon garden floras relative to other factors such as the availability of plants, management of gardens and the socioeconomic status of individual householders. Furthermore, homegardens are also characterized with remarkably high levels of floristic diversity (Thompson *et al*., 2003), the majority of which are alien horticultural flora (Smith *et al*., 2006c; Acar *et al*., 2007; Marco *et al*., 2008).

2.7.2 Previous studies in developing countries

In contrast to the main focus of studies in developed countries, namely biodiversity conservation (Gaston *et al*., 2005a; Smith *et al*., 2006b; Smith *et al*., 2006c), homegarden research and development of the last three decades in developing countries have been aimed primarily at either ethnobotanical documentation of the diversity and uses of garden species or the promotion of home gardening for nutritional improvement of low-income groups (Trinh *et al*., 2003). Trinh *et al*. (2003) surveyed the factors that affect the composition, structure and functions of Vietnamese homegardens. Their study found that even though homegardens are mostly for family subsistence, they are also the primary agricultural activity in the area due to the unfavourable mountainous environment and consequently, their composition is greatly influenced by the tastes of the household members, local market forces, food culture and local customs (Trinh *et al*., 2003).

Similarly the studies of Wezel and Bender (2003) and Blanckaert *et al*. (2004) found that the homegardens in Cuba and South-Central Mexico respectively, are diverse agroforestry systems in which grow a mixture of multipurpose trees and shrubs, which contribute to both the food supply and household income. The study of Murniati *et al*. (2001) found that farmers that developed both mixed gardens and rice gardens in the forest area in West Sumatra, Indonesia, were less dependent on the natural resources of the Kerinci Seblat National Park in comparison with farmers that develop only mixed gardens or only rice gardens. Therefore, gardens that contain both mixed and rice gardens can greatly contribute to biodiversity conservation, all of which consists of a multi-layered structure that consists mostly of trees and shrubs. Murniati *et al*. (2001) also found a correlation between the total income of respondents and farm type and size.

The study of Hemp (2006) found that the Chagga homegardens of Mount Kilimanjaro are capable of maintaining a high biodiversity, providing a sustainable way of land use and crop production. These homegardens are unique agroforestry systems that can reduce the resource pressure on natural forests and consequently, help to conserve biodiversity (Hemp, 2006). Koyenikan (2007) investigated the role of woman in the homegardens of Nigeria and found that they play a pivotal part in household food production, income generation and nutrition and health synergy. However, the results of the study indicated that water shortage, inadequate land, lack of knowledge and improved inputs prohibited homeowners from maximising the potential of their homegardens (Koyenikan, 2007).

There has been relatively little research done on the value of homegardens in southern Africa, even though they play an important part in the livelihood of rural residents (High and Shackleton, 2000). The study of High and Shackleton (2000) recorded the value of all plant products derived from household and agricultural land in a rural village, in South Africa. Their study found that the homegardens of Dingleydale in the Bushbuckridge region of the central lowveld, South Africa, contained a rich array of species, all of which are cultivated for their significant cash and home consumption value (High and Shackleton, 2000). Based on this rich array of studies in homegardens in developing countries, the most prominent finding that connects all studies is the main use for cultivated floras in homegardens, namely for household consumption and as a means of generating an income. Other functions for the broad diversity of plants in homegardens include medicinal, fibre, shade, fire wood, construction supplies, ornamental, and for religious and ceremonial uses (Trinh *et al*., 2003; Wezel and Bender, 2003; Blanckaert *et al*., 2004; Das and Das, 2005).

2.7.3 Homegarden management

2.7.3.1 Urban homegarden management

Homegardens present both constraints and opportunities, since they are privately owned and therefore lie outside the immediate control of local government and other administrative authorities (Gaston *et al*., 2005a). Consequently, the usual statutory tools cannot be used to improve the influence of homegardens on the protection of biodiversity (Gaston *et al*., 2005a), as they are under the direct control of the homeowners (Thompson *et al*., 2003). However, the average homeowner does spend a great deal of time and money on the maintenance of their gardens and with the right recommendations a positive difference can be made to the management and protection of biodiversity, especially native biodiversity (Gaston *et al*., 2005a).

2.7.3.2 Rural homegarden management

According to Blanckaert *et al*. (2004) homegardens particularly preserve much of the cultural history of societies, as they are the sites where many useful plant species have been subjected

to intense management regimes over extended periods. Therefore, the technique of homegarden management serves as a reflection of the wisdom of traditional cultures and their ecological knowledge that have evolved over the years (Das and Das, 2005). Blanckaert *et al*. (2004) categorized the management of homegardens in South-Central Mexico, into three main groups, namely *cultivated* (plants that are sown or planted by the homeowner), *protected* (plants that the owner protects or encourages) and *spared* (plants that grow spontaneously in the garden, but are not removed).

The study of Trinh *et al*. (2003) found that homegarden management in Vietnamese homegardens are determined by a complicated interplay of factors such as the tastes of the household members, food culture and local customs, local, regional and international market forces, government agricultural policy and local development projects. Therefore, it is essential to better understand the basic mechanisms that govern homegarden diversity, so that the integration of homegardens into national conservation programmes could be optimised (Trinh *et al*., 2003).

2.7.4 The importance of homegardens

Homegardens provide various functions for both the urban and rural environment. They are important *in situ* conservation sites (Blanckaert *et al*., 2004 ; Das and Das, 2005) for both plant and animal species, as they can be manipulated to increase the occurrence of both invertebrate (Gaston *et al*., 2005a; Smith *et al*., 2006b) and wildlife species (Gaston *et al*., 2007), can help to protect native (Gaston *et al*., 2005a) and endangered plant species (Trinh *et al*., 2003; Blanckaert *et al*., 2004; Das and Das, 2005) and can also serve as gene pools for eroding indigenous tree species (Das and Das, 2005).

Homegardens are reservoirs of the current and potential resources that are available for cultivation (Blanckaert *et al*., 2004), most of which are multi-purpose species in various vegetation strata (Trinh *et al*., 2003; Blanckaert *et al*., 2004; Das and Das, 2005). According to Trinh *et al*. (2003) homegardens are a promising avenue for exploring on-farm conservation of plant genetic resources since they can serve as refuges for crops and crop varieties that were once more widespread in the agroecosystem. They are also important agricultural systems, especially in rural settlements, that provide both sources of additional income generation and food supply (Murniati *et al*., 2001; Wezel and Bender, 2003; Blanckaert *et al*., 2004; Das and Das, 2005; Hemp, 2006).

2.8 Socioeconomic aspects

According to Theobald (2004) a clearer understanding of the role of humans in modifying natural ecosystems is vital to making progress on many contemporary environmental issues. However, the most important challenge is to integrate socioeconomic and ecological data to

better understand human-dominated ecosystems (Theobald, 2004). The study of Kinzig *et al.* (2005) found that augmenting traditional gradient analysis with consideration of the cultural and economic characteristics of residents occupying different urban neighbourhoods improves understanding of patterns of biodiversity within the urban matrix. However, not all patterns of urban biodiversity are equally affected by the cultural or socioeconomic status of the human residents, since different organisms in different locations tend to vary with respect to the degree of two different human influences, namely; "top-down" and "bottom-up" (Kinzig *et al.*, 2005).

2.8.1 'Top-down' and 'bottom-up' influences

Kinzig et al. (2005) defines "bottom-up" human influences as those influences that reflect the integrated outcomes of small-scale (individual or household) choices or actions, and therefore reflect the economic, social or cultural differences among smaller groups. Whereas top-down human influences reflect the management strategies and decisions made at city-level (Kinzig *et al.*, 2005). One example of a "top-down" influence can be seen in the control that is exerted on the perennial plant diversity in parks by the municipal council, which mainly include decisions concerning landscaping and management and therefore, decisions concerning parks will most likely be driven by efficiency or even aesthetics rather than the socioeconomic status of different cultural groups (Kinzig *et al.*, 2005).

Consequently, plant diversity in parks wouldn't be expected to vary greatly with respect to socio-economic and cultural characteristics (Kinzig *et al.*, 2005). However, the study of Solecki and Welch (1995) suggested that parks can even function as boundaries between neighbourhoods with different socioeconomic characteristics. On the other hand, the perennial plant diversity in neighbourhoods is mostly controlled by "bottom-up" processes, more specifically, household landscaping choices (Kinzig *et al.*, 2005). Therefore, the plant diversity in neighbourhoods will show significant variation with respect to socio-economic or cultural characteristics (Kinzig *et al.*, 2005). Consequently, it is becoming increasingly important for scientists as well as conservationists to find ways of effectively incorporating an understanding of how humans, and more specifically urban residents, are interacting with their environment (Kinzig *et al.*, 2005).

2.8.2 The 'luxury' effect

Past studies have suggested that the diversity in human-created habitats have less to do with variation in the traditional limiting resources, but more to do with human preferences for a particular landscape, along with the availability of financial resources to realize those landscapes (Hope *et al.*, 2003). According to Hope *et al.* (2003) the resource-diversity relationship then becomes one of financial rather than natural resources, which interacts with land-use, legacy effects and certain other socio-cultural factors. Therefore we can conclude that a positive relationship exists between plant diversity and wealth. Hope *et al.* (2003) defined the relationship between wealth and plant diversity as the "luxury effect", i.e. as their economic

resources increases, humans inhabit urban landscapes with higher plant diversity. More specifically, the relationship between plant diversity and wealth appears to be similar to the link that can be seen between species composition, socio-economic status and the physical structure of the vegetation in residential yards (Hope *et al*., 2003).

Chapter 3 - Study area

"The human poverty index for South Africa increased from 16.4% in 1995 to 31.7% in 2002, reflecting an increase in 1.7 million people living on less than US$1 per day" (Department of Environmental Affairs and Tourism, 2006).

3.1 Introduction

Our study area is the rural settlement of Ganyesa in the North-West Province, one of the smallest in South Africa. This province is completely landlocked, as it is surrounded by four other provinces of South Africa, namely the Northern Cape in the west, the Free State in the south, Gauteng in the east, Limpopo in the north-east and has Botswana as a northern neighbour (De Villiers and Mangold, 2002; Anon, 2004). According to De Villiers and Mangold (2002) the North-West Province occupies a total area of 116 320 km², which is approximately 9.5% of the total area of South Africa and is geographically situated between 25 and 28 degrees south of the equator and is 22 and 28 degrees longitude east of the Greenwich meridian. The capital of the North-West is Mafikeng and some of the most important towns in the province include Potchefstroom, Klerksdorp, Rustenburg, Orkney, Vryburg and Stilfontein (Anon, 2004).

In South Africa 53.7% of the population is estimated to live within an urban environment, while approximately 65% of the population in the North-West Province lives in rural areas and only 35% live in urban areas (Tladi *et al*., 2002b). However, due to the lack of employment opportunities in rural areas, there has been an increase in the rate of urbanization (Tladi *et al*., 2002b). A total of 60.7% of the population of the North-West Province is currently regarded as economically active, but the province does have a potential labour force of approximately 1.2 million people of which 62.3% are employed (Tladi *et al*., 2002b). According to Tladi *et al*. (2002b) the economically active population is that part of the population that is able to work and who are aged 15 and older, this includes those who are employed and unemployed. The North-West Province has an unemployment rate of approximately 38%, which is the fourth highest in South Africa (Tladi *et al*., 2002b).

According to Tladi *et al*. (2002b) the North-West Province is administratively divided into four district municipalities, namely Bophirima, Central, Southern and Bojanala Platinum, which are further subdivided into 21 local municipalities. The majority of the population in the North-West Province is concentrated in the Bojanala Platinum district, while the least number of inhabitants live in the semi-arid Bophirima district (Anon, 2004). Roughly 3.4 million people live in the North-West Province, which constitutes 8.3% of the population of South Africa (Tladi *et al*., 2002b). The North-West Province has an annual growth rate of approximately 3.1% per annum and the main languages spoken are Setswana, Afrikaans and IsiXhosa (Anon, 2004). Since

there are no large cities within the province, the distribution of settlements, particularly smaller ones, have largely been influenced by policies of colonialism and consequently very few of these settlements are self-sustaining (Anon, 2004).

3.2 Bophuthatswana and the Tswana people

The Tswana people are the dominant cultural group in Ganyesa. According to Norman-Smith *et al*. (1977) the Tswana have always comprised a conglomerate of various mutually dependent tribes which, despite several temporary ad hoc alliances, were usually inclined to fragment rather than to integrate. Therefore, the Tswana society is intensely pluralistic and the word Tswana is most probably derived from Tswana, which means õthe little ones who break awayö and is a reflection of the Tswanaös tendencies to fragment rather than amalgamate into larger units like the Zulu (Norman-Smith *et al*., 1977).

3.2.1 History

According to Tladi *et al*. (2002a) the history of the settlement patterns of the Tswana people dates back to 1300 ï 1600 AD when the first Sotho ethno-linguistic group moved southwards from the Great Lakes of East Africa, and settled in the vast open spaces of what were later called Botswana, Eastern Kalahari, Transvaal and Orange Free State, most of which today forms part of the North-West Province. The early Tswana settlers were moved to what later became Bophuthatswana on the basis of ethnicity in terms of the South African Bantu Trust Act of 1913 and 1936 (Tladi *et al*., 2002a). The larger Tswana towns such as Dithakeng, Kuruman and Ramoutsa, were built along the lines of Iron Ore deposits (Tladi *et al*., 2002a). The Tswana villages were divided into wards or *dikgoro* for administrative purposes and the main occupational activities of these villages were stock-raising, crop farming and mining (Tladi *et al*., 2002a).

After the establishment of the Bophuthatswana Legislative Assembly in 1972, the homeland was divided into 12 magisterial districts, which consisted of 75 SeTswana speaking tribes (Tladi *et al*., 2002a). The communities in Bophuthatswana consisted mostly of smaller tribes or sections of tribes, smaller than 5 000 members and only five Tswana tribes had more than 30 000 members (Norman-Smith *et al*., 1977). Since none of these areas had any large cities or towns, the period between 1973 and 1975 saw the unsuccessful claims to Mafikeng, Brits, Rustenburg, Zeerust, Lichtenburg and Vryburg by the Bophuthatswana government (Tladi *et al*., 2002a). The republic of Bophuthatswana came into being on the 6th of December 1977 when the Tswana people were given sovereign independence (Norman-Smith *et al*., 1977). After the general elections in 1994, South Africa entered a period of new regionalisation and consequently these areas all became part of what is now the North-West Province (Tladi *et al*., 2002a).

3.2.2 Culture

3.2.2.1 Social system

The social system of the Tswana people is communal in nature, which means kinship and descent play an important role (Norman-Smith *et al*., 1977). According to Norman-Smith *et al*. (1977) the most important social groupings directly determined by kinship criteria are the family, the lineage, the totem group and finally, the tribe. The origin of various Tswana tribes can in fact be traced back to the heads of families and lineages that have hived off from the main groups (Norman-Smith *et al*., 1977). The principles of decent and kinship still play an important role in the ordering of Tswana societies, as they are used to determine marriage partners. In Tswana societyøs, marriage between cousins is commonplace, which further contributes to the endogamous character of the Tswana society (Norman-Smith *et al*., 1977). The Tswana people view marriage as a contract, not only between man and wife, but between the families concerned and therefore it is expected that bride-price (*bogadi*) be delivered at the solemnisation of the marriage (Norman-Smith *et al*., 1977).

3.2.2.2 Tribal authority structure

The Tswana tribal area consists of tribal wards which are the basis of tribal administration and it is at this level that the administration of justice commences, under the leadership of the sub-chief or ward chief and his council (Norman-Smith *et al*., 1977). According to Norman-Smith *et al*. (1977) the tribal chief is the unifying factor within the tribe and together with his advisory council, he is the highest political authority within the tribe. The tribal chief is seen as the representative of his ancestors and those of his tribe, therefore all members of the tribe accept his right to make laws which must be observed by everyone (Norman-Smith *et al*., 1977). The chieføs decisions are conveyed to the rest of the tribe by the sub-chiefs, who meet regularly to discuss matters of importance (Norman-Smith *et al*., 1977). However, according to Norman-Smith *et al*. (1977) the chief is subject to the supreme authority of the state.

3.2.2.3 Agriculture

Agriculture has greatly influenced the history, culture and tradition of the Tswana people (Norman-Smith *et al*., 1977). Crop production and animal husbandry both play an important role in the daily lives of the traditional Tswana families and like most African people, the Tswana regard cattle as an index of wealth and status (Norman-Smith *et al*., 1977). In the past, cattle were the primary medium of exchange and even more importantly, they were used to make up the bride-price (*bogadi*). Cattle is usually kept at cattle posts, were they range freely over the surrounding pastures that are normally not fenced off in any way (Norman-Smith *et al*., 1977). The owners of cattle posts, often share them with others, however no one is allowed to bring cattle to the posts without permission (Norman-Smith *et al*., 1977).

According to Norman-Smith *et al*. (1977) the traditional Tswana farmer applied a type of shifting agriculture, when a particular tract of land had been completely exhausted he would simply obtain new land from his headman. The traditional Tswana farmer also made no effort to conserve the soil or its fertility and no fertiliser was ever deliberately applied (Norman-Smith *et al*., 1977). The cultivation of crops used to be essentially a female occupation, as women weren't allowed to go near the cattle, and the area cultivated by a household depended on the number of woman available (Norman-Smith *et al*., 1977). The majority of products cultivated by the Tswana people include corn meal (sorghum), certain types of vegetables and predominantly maize which forms an essential part of their culture (Norman-Smith *et al*., 1977). The Tswana people also have a strong belief that the area around their homestead should be open and devoid of any vegetation (Fig. 3.1), which is an indication of the tidiness of the household ('lebala concept') (Cilliers *et al*., 2009). This resulted in fairly large areas of bare ground, which increases the level of soil erosion around their homes (Cilliers *et al*., 2009).

Figure 3.1: A photograph of a typical home in Ganyesa, illustrating the 'lebala concept', where the open areas around the home are largely devoid of vegetation (Photo: E. Davoren).

3.3 The Bophirima district

The Bophirima district mainly consists of poor rural areas and the majority of its population of 450 000 people speak Setswana (Anon, 2006). The larger part of the Bophirima district is known as Stellaland and the main town is Vryburg, which forms the centre of a large agricultural district (Anon, 2006). During a reconnaissance survey of the different areas in this district, Ganyesa was chosen as the study area (Fig. 3.2). Approximately 20 000 people live in or

around Ganyesa (Anon, 2006). Ganyesa is approximately 20.82 km² (2082.43 ha) and is located between 26° 35ô50òS and 24° 10ô32òE.

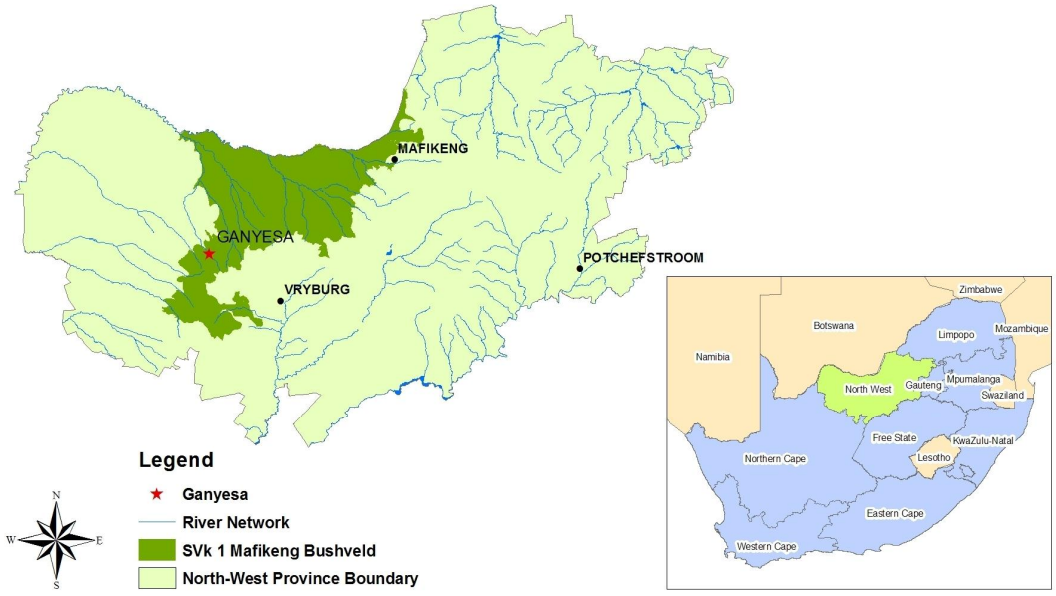


Figure 3.2: Map of the North-West Province indicating the location of Ganyesa, the Mafikeng Bushveld type, and the river network of the province.

3.4 Topography

According to De Villiers and Mangold (2002), the North-West Province is believed to have the most uniform terrain of all the provinces, with an altitude ranging from 920-1782 m above sea level. The central and western regions are characterized by flat or gently undulating plains, while the dunes, associated with the arid environment of the Kalahari, mainly occur in the far western region (De Villiers and Mangold, 2002). According to Mucina and Rutherford (2006) the Ganyesa area forms part of the Mafikeng Bushveld vegetation unit. It is situated west of Mafikeng and south of the Botswana border, at an altitude of approximately 1 100 - 1 400 m above sea level (Mucina and Rutherford, 2006).

3.5 Hydrography

3.5.1 Rivers

The North-West is a predominantly dry province with very few perennial rivers (De Villiers and Mangold, 2002). However, three of the six major drainage basins in South Africa fall within the boundaries of the province, namely the Limpopo, Orange and Vaal River basins. Ganyesa is located within the Orange River drainage basin by means of the Molopo River (De Villiers and Mangold, 2002). According to De Villiers and Mangold (2002) the Molopo River has a number of tributaries that fall within the province, namely Pepanespruit, Setlagolespruit, Ramatlabamaspruit and Ganyesaspruit, all of which are non-perennial. The Ganyesaspruit

tributary connects with the Molopo River (Fig. 3.3), which rises from the Molopo eye near Mafikeng and flows westwards to form the northern border of the North-West Province with Botswana (De Villiers and Mangold, 2002). The Molopo River was once a tributary of the Orange River system, but has long since been blocked by high dunes (De Villiers and Mangold, 2002).

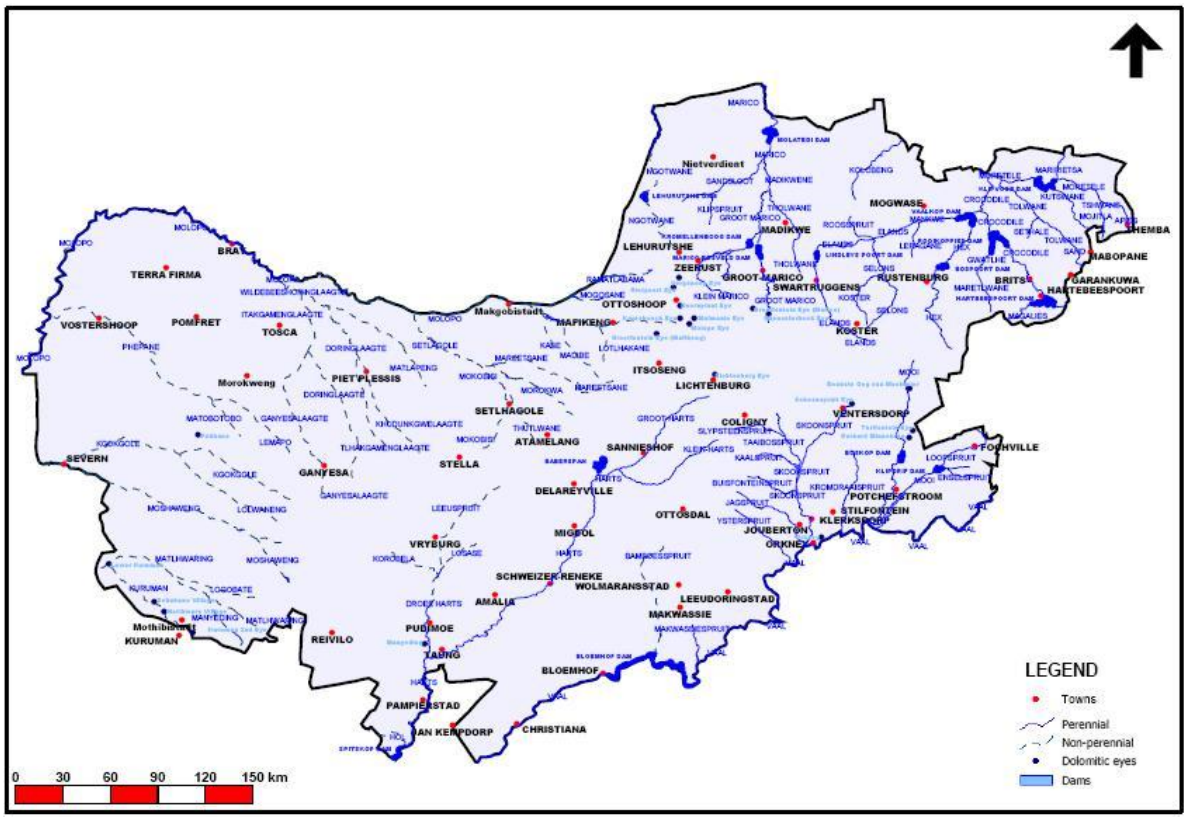


Figure 3.3: Map of the secondary, tertiary and quaternary catchments in the North-West Province (De Villiers and Mangold, 2002).

3.5.2 Wetlands and pans

According to Schuyt (2005), wetlands in Africa are an important source of water and nutrients necessary for biological productivity. Wetlands are currently considered to be the most threatened habitats worldwide (De Villiers and Mangold, 2002). De Villiers and Mangold (2002) stated that wetlands play an important role in natural filtration and purification of water as well as providing a habitat for various migrating bird species. According to Cowan (1995) the national wetland classification system has divided South Africa into several regions based on the Cowardin system used by the United States National Wetland Inventory. The North-West Province forms part of the western plateau of the Plateau Wetland Group, which has the greatest conservation of pans in the country, most of which are endorheic pans (Cowan, 1995). Endorheic pans are closed systems with no outlet and their average size is approximately 8 ha, a total of 636 pans are located in the western plateau (De Villiers and Mangold, 2002). In Ganyesa, four different wetland areas occur.

3.6 Geology and soil

3.6.1 Geology

According to De Villiers and Mangold (2002) the North-West Province is characterised by an interesting and ancient geological heritage which is rich in minerals and palaeontological artefacts. Ganyesa is located in the Kalahari group, which is the most extensive body of terrestrial sediments of the Cenozoic age in South Africa (Partridge *et al*., 2006). The Cenozoic age comprises the last 65 Ma (million years) of the earth's history and is divided into two periods, namely the Tertiary and Quaternary periods (Snyman, 1996). Sand and chert are the main rock types that can be found in the Ganyesa area (Fig. 3.4), along with rock types such as limestone, calcrete, clay and siltstone which are characteristic of the larger Kalahari group (De Villiers and Mangold, 2002). Ganyesa is also characterised by the Archaean Granites, which are the oldest rock formations in the North-West Province and mostly forms flat to slightly undulating landscapes (De Villiers and Mangold, 2002).

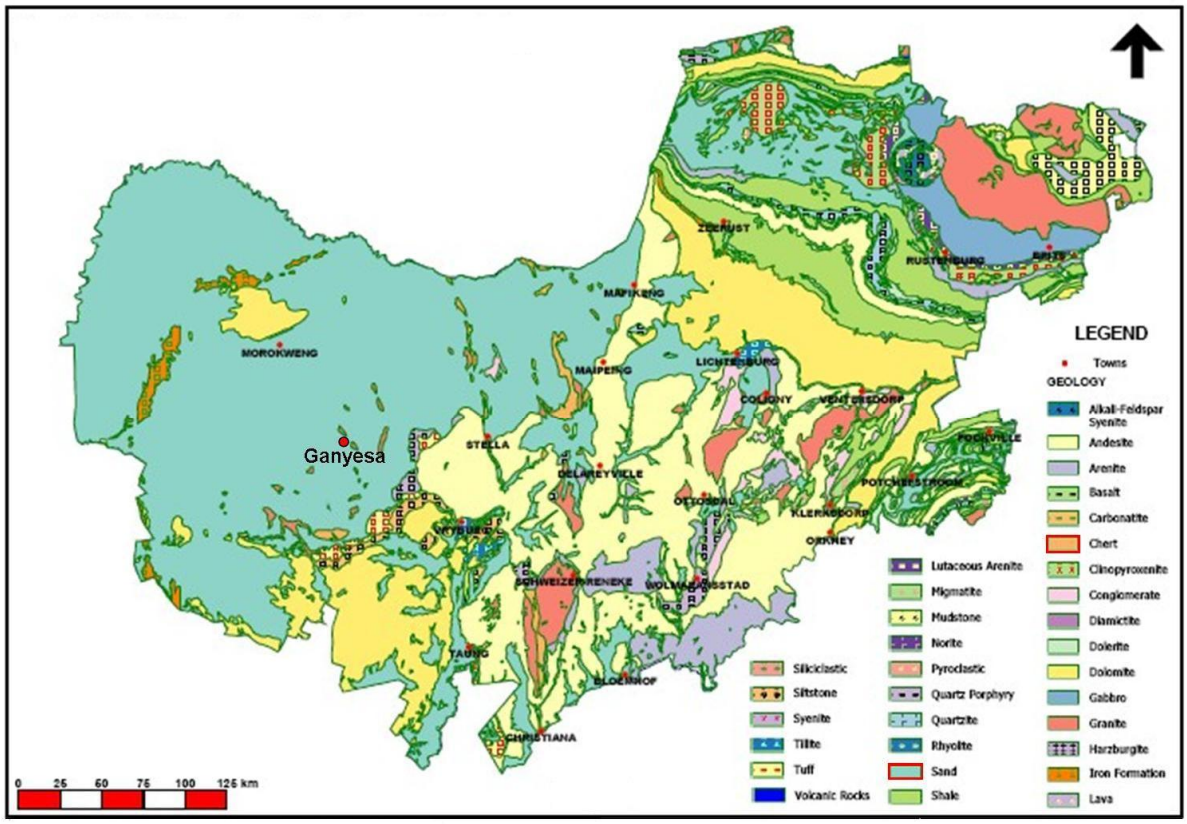


Figure 3.4: Map of the geology and rock types (De Villiers and Mangold, 2002) of the North-West Province. The main geology and rock types in Ganyesa are marked with red squares in the legend.

3.6.2 Soils

According to Mucina and Rutherford (2006) the Mafikeng Bushveld vegetation unit is characterized by Aeolian Kalahari sands of tertiary to recent origin on flat sandy plains at soil

depths of approximately 1.2 m. The soil consists of Clovelly and Hutton soil forms (Mucina and Rutherford, 2006). Low and Rebelo (1996) characterised the soil in the Kalahari Plains Thorn Bushveld vegetation type as deep sandy to loamy sands and Acocks (1988) classified the soil of the Kalahari Thornveld veld type as loose sandy soils. De Villiers and Mangold (2002) classified the Kalahari soil as freely drained, arid to semi-arid, red and yellow soils with a clay content of approximately 15%, which have developed calcareous crusts in some areas of the Ganyesa district. According to Van der Walt and Le Riche (1999) the sandy soils of the Kalahari are characterised by a sand content of 86-90% and a grain cross section of 0.02-2.00 mm, while the fine silt soils, found mostly in low-lying parts such as pans and rivers, have a high silt and clay content, with 40-85% sand.

3.7 Climate

3.7.1 Rainfall

Monkhouse *et al*. (1983) defined climate as the total complex of weather conditions, average characteristics and range of variation over an appreciable area. According to De Villiers and Mangold (2002) the climatic conditions in the North-West Province varies significantly from west to east. The western region is arid, while the eastern region is predominantly temperate and the central region is dominated by typically semi-arid conditions (De Villiers and Mangold, 2002). The eastern and south-eastern region of the North-West Province receives over 600 mm rainfall per annum (Fig. 3.5), while the central region receives approximately 550 mm per annum and the western region less than 300 mm per annum (De Villiers and Mangold, 2002). Rainfall in the Savanna Biome varies from 235 to 1 000 mm per year (Low and Rebelo, 1996). According to Acocks (1988) the rainfall in the Kalahari Thornveld veld type ranges from 400 ï 500 mm per annum, falling mostly in summer. The average rainfall in the Kalahari Plains Thorn Bushveld vegetation type is 300 mm, which falls in the summer and early autumn (Low and Rebelo, 1996).

According to Mucina and Rutherford (2006) the Mafikeng Bushveld vegetation unit is characterized by summer rainfall with very dry winters. The annual rainfall varies from 350 mm in the west to approximately 520 mm in the east. During these winter months frost is a frequent phenomenon and can occur from the beginning of May to middle October (Low and Rebelo, 1996; Van der Walt and Le Riche, 1999; Mucina and Rutherford, 2006). In the two years before this study was conducted, the Ganyesa region experienced a higher total rainfall than previous years (Fig. 3.6). In 2006 the total rainfall for the area was 730.3 mm and the mean monthly rainfall was 60.9 mm (Fig. 3.6), while in 2007 the total rainfall for the area was 267.0 mm and the mean monthly rainfall for the area was 22.3 mm. In 2008, at the time of the survey, the Ganyesa area received an average of 22 mm rain per month (ARC-ISCW, 2009). This is based on data from the Louwna weather station located in the Vryburg district (ARC-ISCW, 2009).

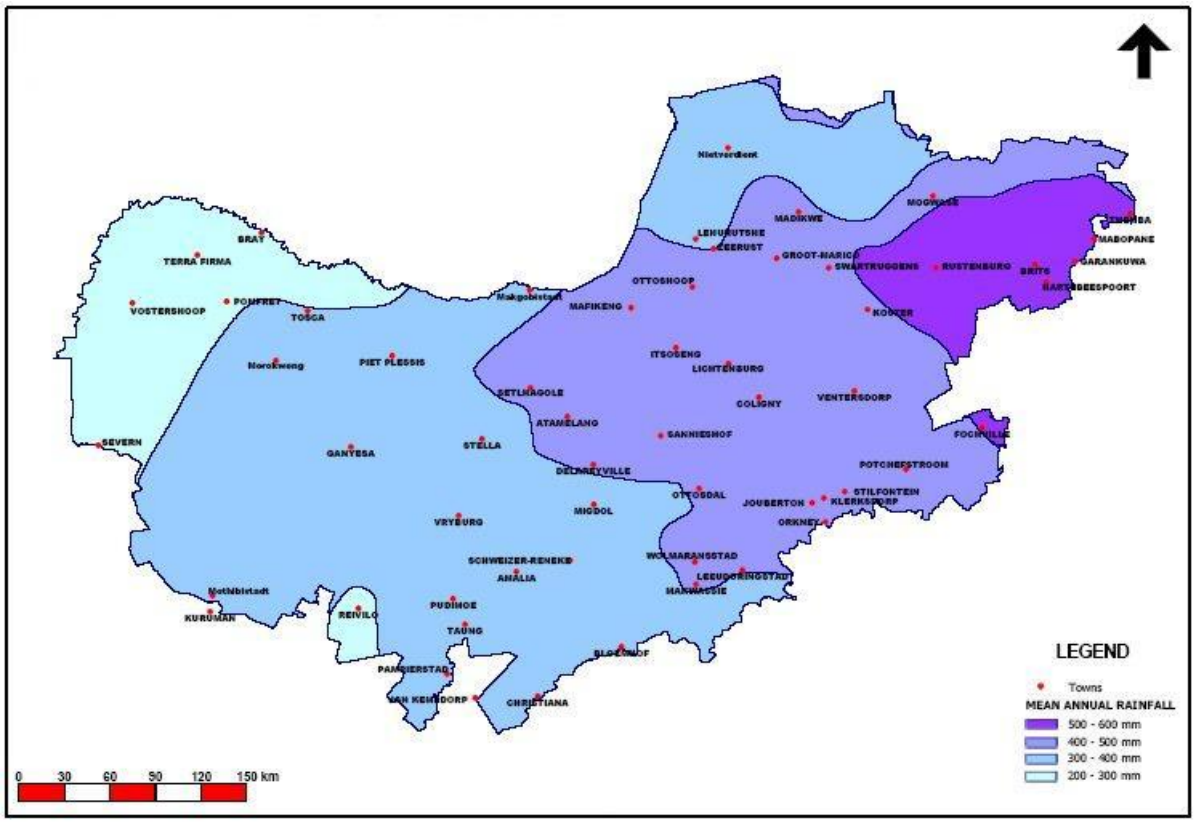


Figure 3.5: Map of the North-West Province mean annual rainfall (Mangold *et al*., 2002).

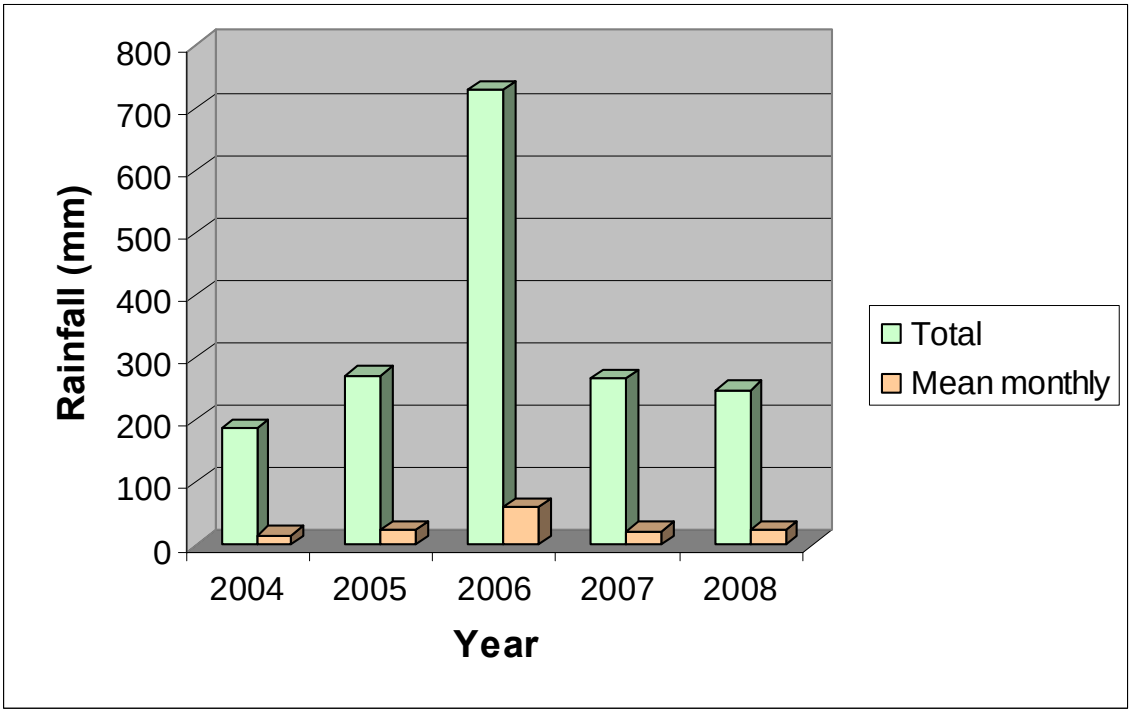
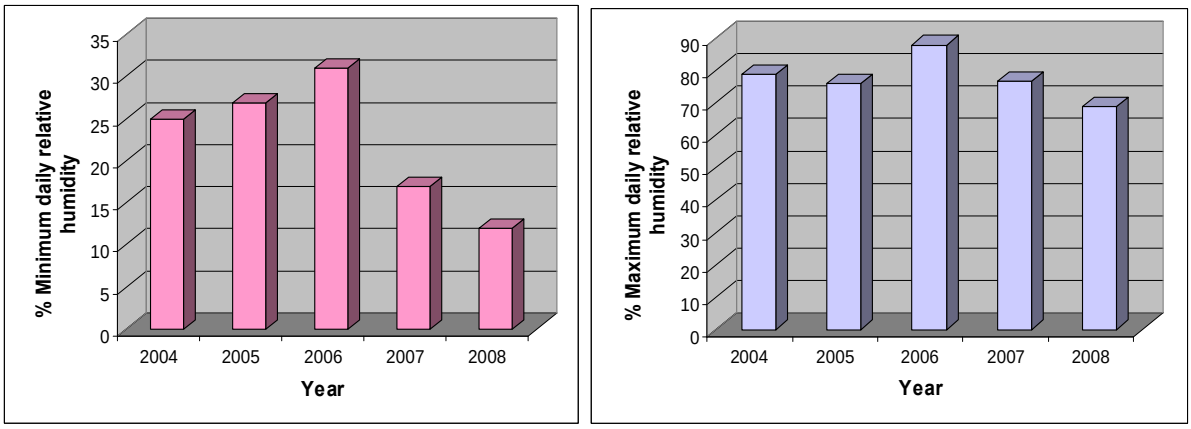


Figure 3.6: The total and mean monthly rainfall of the Ganyesa region for the period 2004ï 2008 (ARC-ISCW, 2009).

3.7.2 Humidity

According to De Villiers and Mangold (2002) the relative humidity is typically low throughout the North-West Province, being below 28% in the northern part of the province in July and between 28-30% for the central and eastern regions. February is the month with the highest relative humidity, the northern and eastern parts of the province range between 66 and 68%, while the rest of the province ranges between 64 and 66% (De Villiers and Mangold, 2002). The relatively high humidity values of the province is a consequence of high evapo-transpiration rates, which affects the flora of the region (De Villiers and Mangold, 2002). Based on the humidity data from the Louwna weather station, the average minimum daily relative humidity for the Ganyesa area in 2007 was 16.9% and in 2008 was 12% (Fig. 3.7A), the average maximum daily relative humidity was 76.7% in 2007 and 68.9% in 2008 (Fig.3.7B) (ARC-ISCW, 2009).



A) **B)**

Figure 3.7: The mean A) minimum and B) maximum percentage of the relative humidity of the Ganyesa area for the period 2004ï 2008 (ARC-ISCW, 2009).

3.7.3 Temperature

According to De Villiers and Mangold (2002) the North-West Province is also characterised by great seasonal and daily variations in temperature, being very hot in the summer, with an average daily maximum temperature of 32°C in January and mild to cold winters, with an average daily minimum temperature of 0.9°C in July. In the western region of the province the seasonal fluctuations in mean temperatures between the warmest and coldest months exceed 15°C, while the eastern and central regions experience a range between 12°C and 15°C (De Villiers and Mangold, 2002). Parts of the north-eastern and north-western regions of the province receive between 1 and 31 days of average heavy frost, while the rest of the province receives between 31 and 60 days of frost (De Villiers and Mangold, 2002). The average days of frost for the entire province are 31 (De Villiers and Mangold, 2002).

According to Low and Rebelo (1996) the temperatures for the Kalahari Plains Thorn Bushveld vegetation type varies between -9°C and 42°C, with an average temperature of 18°C.

Temperature can reach a mean monthly maximum of up to 35.6°C for November and a mean monthly minimum as low as -1.8°C for June (Mucina and Rutherford, 2006). According to the data from the Louwna weather station, the mean daily temperature for the Ganyesa area in 2007 was 17.7°C and in 2008 17.5°C (Fig. 3.8) (ARC-ISCW, 2009). The mean daily maximum temperature for 2007 was 27.2°C and 26.4°C for 2008, while the mean daily minimum temperature for 2007 was 8.8°C and 9.5° C for 2008 (Fig. 3.9) (ARC-ISCW, 2009).

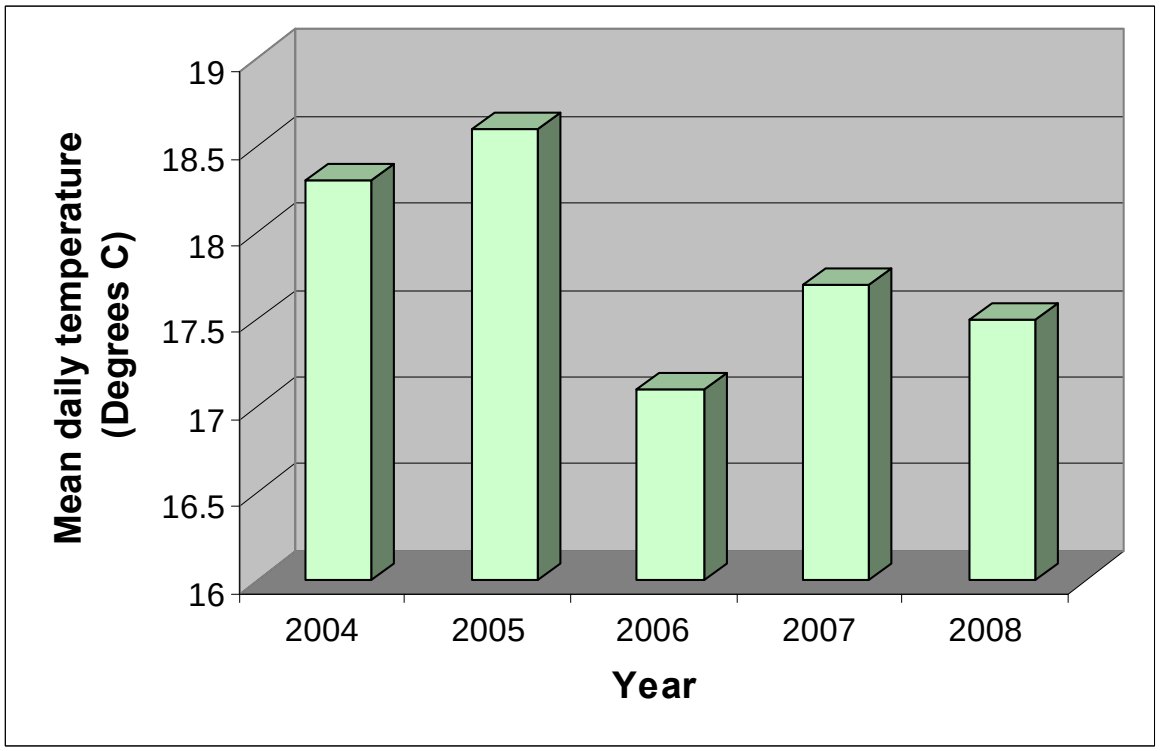
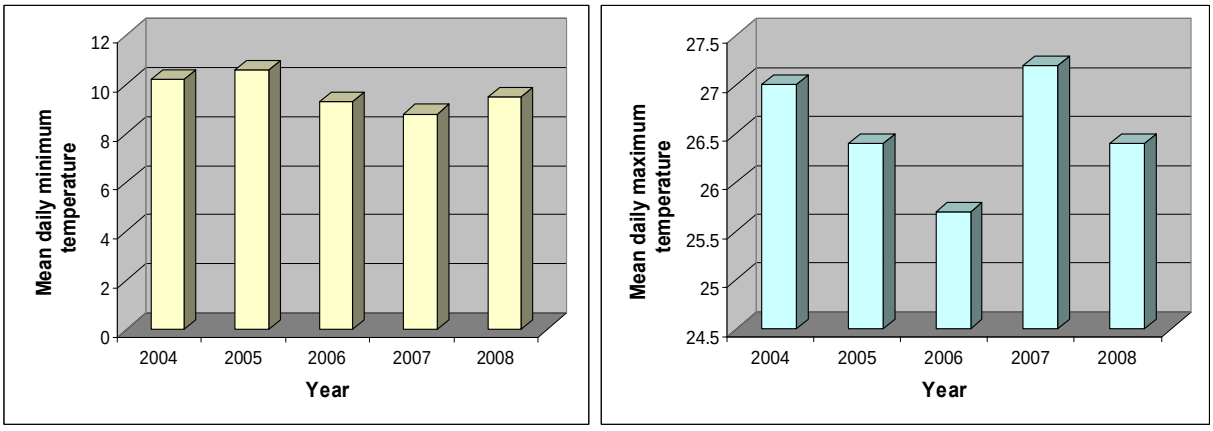


Figure 3.8: The mean daily temperature of the Ganyesa region for the period 2004ï 2008 (ARC-ISCW, 2009).



A) **B)**

Figure 3.9: The mean A) maximum and B) minimum daily temperatures of the Ganyesa region for the period 2004ï 2008 (ARC-ISCW, 2009).

3.8 Flora

The flora of the northern provinces of South Africa is represented by 204 families, 1 397 genera and 5 768 known infrageneric taxa (Retief and Herman, 1997). The three largest families in the Northern Provinces are the Fabaceae, Poaceae and Asteraceae (Retief and Herman, 1997). Furthermore, nearly 10% of the infrageneric taxa is endemic to the northern provinces, especially species in the genera *Aloe*, *Euphorbia*, *Thesium*, *Indigofera* and *Brachystelma*, with the highest occurrence of these endemics in the eastern subregion (Retief and Herman, 1997). No accurate figures exist for the flora of the North-West Province, as it has not been quantified since the province was declared post 1994 and made up of parts of the former Transvaal and Cape Provinces.

3.9 Vegetation

Scholes and Archer (1997) stated that the savannas occur where trees and grasses interact to create a biome that is neither grassland nor forest. In southern Africa the Savanna Biome is the largest Biome, occupying approximately 46% of its area and over one-third the area of South Africa (Low and Rebelo, 1996). According to Mucina and Rutherford (2006) the Savanna Biome represents 32.8% of South Africa and 74.2% of Swaziland (Mucina and Rutherford, 2006) and is also the dominant vegetation in Zimbabwe, Namibia, and Botswana (Low and Rebelo, 1996). According to Mucina and Rutherford (2006) the Savanna Biome is characterised by a herbaceous layer which is usually dominated by grass species and a discontinuous to sometimes open tree layer.

Ganyesa falls within the Savanna Biome (Low and Rebelo, 1996) and forms part of the Kalahari Thornveld veld type according to Acocks (1988), the Kalahari Plains Thorn Bushveld vegetation type (Fig. 3.10) according to Low and Rebelo (1996) and the Mafikeng Bushveld vegetation unit (Fig. 3.11) according to Mucina and Rutherford (2006). According to Acocks (1988) the Kalahari Thornveld is subdivided into two main subdivisions of this veld type, namely the Kalahari Thornveld Proper (16a) and the Vryburg Shrub Bushveld (16b).

Ganyesa is situated within the Kalahari Thornveld Proper veld type (Acocks, 1988) and lies east of the Griqualand West Centre of Endemism (Van Wyk & Smith, 2001). Acocks (1988) further divided the Kalahari Thornveld Proper veld type into four subdivisions, namely the north-eastern, eastern, western and north-western, and central forms of the veld type. Ganyesa is situated in the eastern form of the Kalahari Thornveld veld type, which is characterised by open savanna (Acocks, 1988). According to Acocks (1988), ancient cultivation in the Vryburg division has over large areas practically removed the trees, leaving what is virtually a grassveld, often dotted with only a few shrub and tree species.

The Kalahari Plains Thorn Bushveld vegetation type is characterised by a fairly well-developed tree stratum and a moderately developed shrub layer (Low and Rebelo, 1996). This woody shrub-tree layer varies from 1 to 20 m in height and may even become the dominant vegetation type in areas which are being overgrazed (Low and Rebelo, 1996). According to Low and Rebelo (1996) the grass cover depends on the amount of rainfall during the growing season. C_4-type grass dominates the grass layer during the warmer growing season but C_3-type grass tend to be more dominant where the rainfall has a stronger winter component (Low and Rebelo, 1996). The Mafikeng Bushveld vegetation unit is characterized by a well developed tree, shrub and grass layer (Mucina and Rutherford, 2006). During the survey the sampled natural areas around Ganyesa were characterised by a well-developed grass layer, with a moderately developed tree and shrub layer. However, the north-eastern and western parts of the natural areas around Ganyesa were characterised by fairly dense tree and shrub layers.

Acocks (1988) identified *Acacia erioloba* as the dominant and most important tree species in the Kalahari Thornveld Proper veld type and *Grewia flava* and stunted *Diospyros lycioides* as the dominant shrub species. The grass layer in this veld type is dominated by *Eragrostis lehmanniana*, *Themeda triandra* and *Anthephora pubescens* (Acocks, 1988). According to Low and Rebelo (1996) the tree stratum of the Kalahari Plains Thorn Bushveld vegetation type is dominated by *Acacia erioloba* and *Boscia albitrunca*, while the shrub layer is dominated by *Acacia mellifera*, *Acacia hebeclada*, *Grewia flava* and *Lycium hirsutum*. Grass species such as *Eragrostis lehmanniana* and *Schmidtia kalihariensis* form the dominant grass species of the Kalahari Plains Thorn Bushveld vegetation type (Low and Rebelo, 1996).

Dense stands of *Terminalia sericea* and *Acacia erioloba* are prominent features of certain areas. These areas are also characterized by a shrub layer consisting of species such as *Acacia karroo*, *Acacia hebeclada*, *Acacia mellifera* and *Grewia flava* (Mucina and Rutherford, 2006). The dominant tree species found in the natural areas around Ganyesa are *Acacia erioloba* and *Ziziphus mucronata* subsp. *mucronata*, while the shrub layer is dominated by *Acacia hebeclada* subsp. *hebeclada* and *Grewia flava*. The grass layer is dominated by *Cynodon dactylon*, *Eragrostis lehmanniana* and *Aristida congesta* subsp. *congesta*.

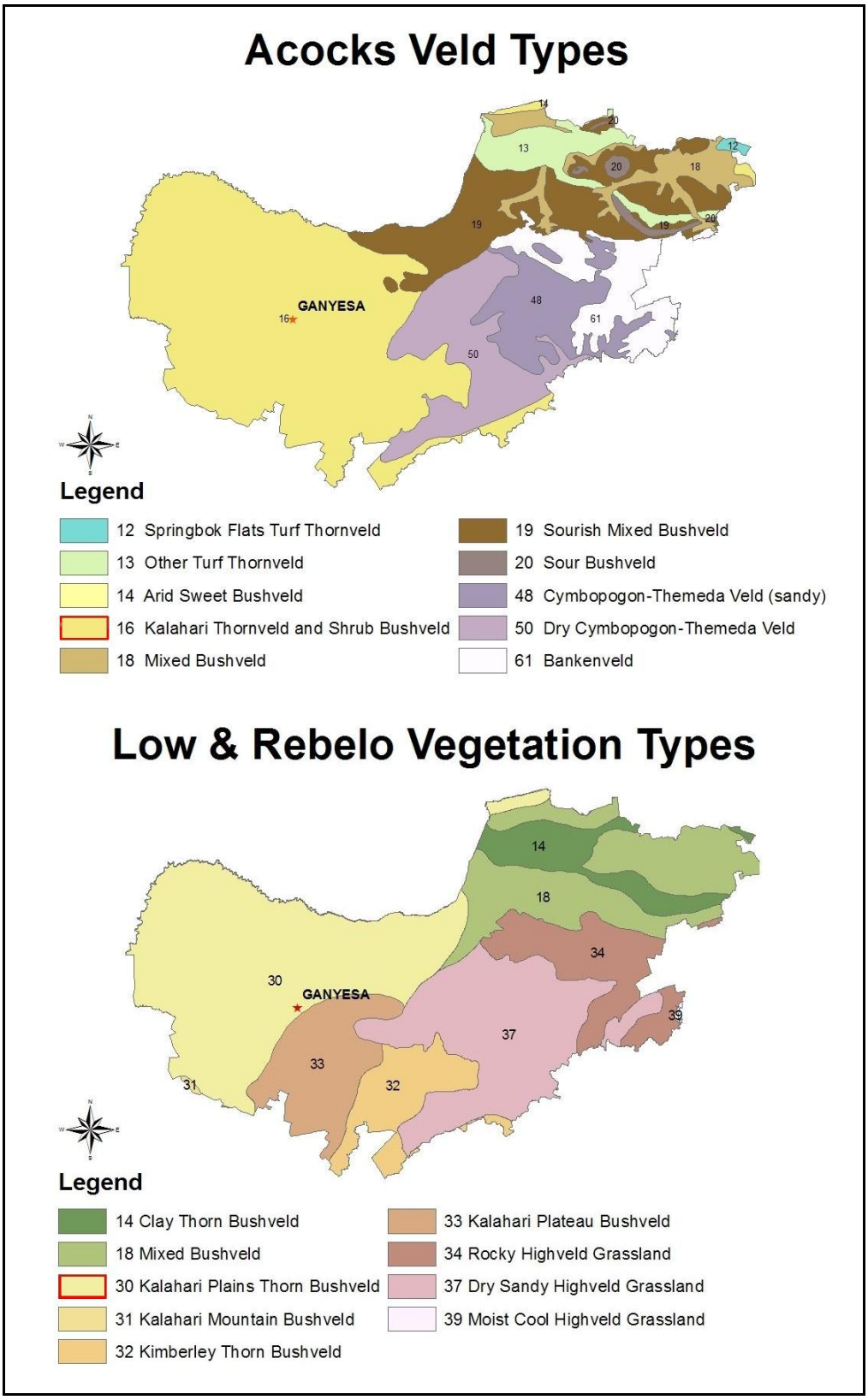


Figure 3.10: Maps indicating the North-West Province veld types as described by Acocks (1988) and the vegetation types as described by Low and Rebelo (1996). The main veld and vegetation types in Ganyesa are marked with red squares in the legend.

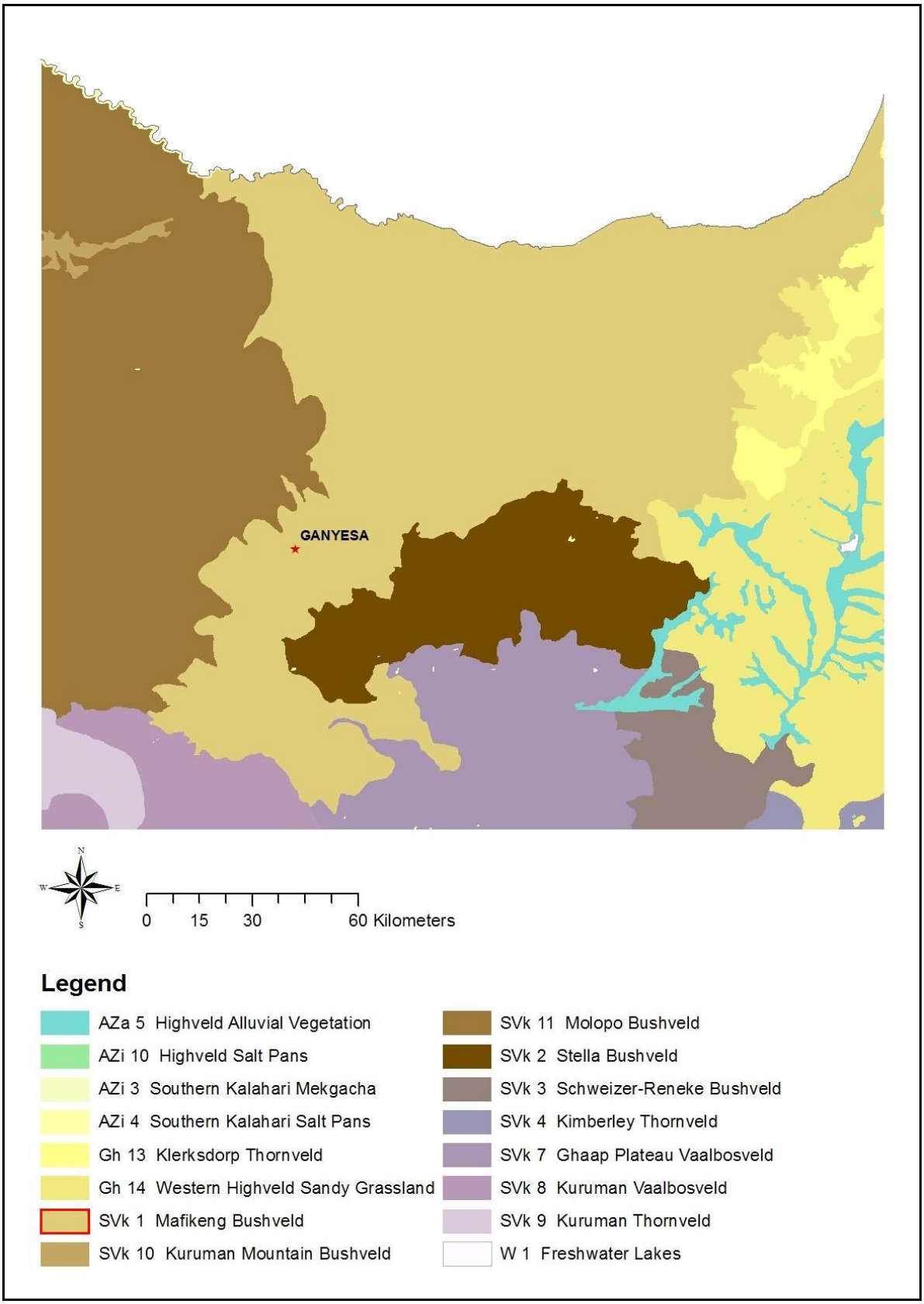


Figure 3.11: Map of the different vegetation units of the Ganyesa region as described by Mucina and Rutherford (2006). The main vegetation unit in Ganyesa is marked with a red square in the legend.

3.10 Economic activities

In relation to the other provinces, the economy of the North-West Province is weak, with a 4.9% contribution to the national Gross Domestic Product (GPD) and a 2% economic growth rate (Tladi and Tlhomelang, 2002). The economy of the North-West Province is derived from a variety of sectors, the main contributors being mining and agriculture (Tladi and Tlhomelang, 2002). The economic status of the North-West Province currently indicates a dependence on the production of primary commodities such as platinum, gold, and agricultural products (Tladi and Tlhomelang, 2002). These commodities are in turn influenced by world commodity prices and favourable climatic conditions, both of which are factors over which the Province has no control and therefore increases its level of vulnerability to exogenous influences (Tladi and Tlhomelang, 2002). According to Low and Rebelo (1996) livestock and game farming are the major economic activities of the Kalahari Plains Thorn Bushveld vegetation type around Ganyesa, however there are also some important mines that occur within this region.

3.10.1 Mining

According to Visser et al. (2002) mining has been the backbone of the South African economy since the discovery of diamonds and gold towards the end of the 19th century. However, by definition, mining is not sustainable in the long term, since the minerals being extracted were formed and deposited over millions of years in geological time and therefore can be classified as non-renewable resources (Visser *et al*., 2002). It accounts for one third of the national Gross Domestic Product (GPD), approximately 50% of foreign exchange earnings and employs 12% of the workforce directly and up to one third of the workforce in South Africa indirectly (Visser *et al*., 2002). According to Tladi and Tlhomelang (2002) the mining sector is the lead contributor to the North-West Provinceõs economy, both financially and by its labour absorption capacity. Mining contributed 35.5% to the domestic economy of 1996 and employs approximately 118 000 employees in the North-West Province (Tladi and Tlhomelang, 2002).

In recent years the North-West Province has become known as the Platinum Province, since platinum has overtaken gold as the most valuable mining product (Visser *et al*., 2002). In 1994 the North-West Province produced the third largest amount of gold, approximately 139.2 tons, 24% of the total production for South Africa and produces 70% of the worldõs platinum from the platinum mines in the Rustenburg region (Visser *et al*., 2002). Mining exerts a severe negative impact on the environment and as a result the North-West Province has several mechanisms in place to ensure responsible environmental conduct through structures such as the Provincial Inter-Government Forum (PIGF) and a Provincial Committee for Environmental Co-ordination (PCEC) (Visser *et al*., 2002).

3.10.2 Agriculture

Second to mining, agriculture is the most important economic activity in the North-West Province (Visser *et al*., 2002). In the past, the government considered agricultural development as a high priority activity, as it was considered critically important to the overall social and economic development of the province (Visser *et al*., 2002). Approximately 85% of the total surface area of the North-West Province is classified as agricultural land, with 66% classified as grazing land and 34% classified as potentially arable (Visser *et al*., 2002). According to Tladi and Tlhomelang (2002) the agricultural sector provides approximately 80 000 formal employment opportunities in the North-West Province, most of which are for males and rural areas are the main beneficiaries of these employment opportunities.

According to Visser *et al*. (2002) the primary agricultural practices in the North-West Province consists of mixed crop and livestock farming in the east, with a progression to almost exclusively livestock farming towards the west. Multi-cropping is a common agricultural practice, as it offers different levels of livelihood sustainability and at the same time protects the land against degradation (Visser *et al*., 2002). Commercial forestry is absent in the North-West Province due to the low rainfall levels experienced across the Province, but commercial maize farming has contributed significantly to the countryøs economic growth (Visser *et al*., 2002). In 1996 the gross income from the total commercial agricultural products in the North-West Province amounted to 7.4% of the total for South Africa (Visser *et al*., 2002). According to Visser *et al*. (2002) the gross income from grain crops, horticultural products and livestock products from the North-West Province amounted to 14.7%, 8% and 7.4% respectively of the total for South Africa. The inhabitants of Ganyesa are mostly crop and livestock farmers.

3.10.3 Tourism

In the past few years the North-West Province has become an attractive tourism destination, with its sunny climate, magnificent bird life and diverse natural and cultural heritage which enhances the provinceøs eco-tourism potential (Visser *et al*., 2002). The North West Parks and Tourism Board (NWPTB) has approximately 713 tourism products currently listed on their tourism database (Visser *et al*., 2002). Based on the database, 37% of all existing tourism establishments occur in the eastern region of the province, 22% occur in the central, 31% in the southern and 10% in the western regions of the province (Visser *et al*., 2002).

The southern and eastern regions host approximately two-thirds of the tourism activity in the North-West Province, but covers less than a third of the land area (Visser *et al*., 2002). In comparison, the western Bophirima region covers almost half of the land area in the Province, but represents only 10% of the tourism facilities (Visser *et al*., 2002). According to Visser *et al*. (2002) the Ganyesa area has the potential of becoming a major wilderness destination equalling the world renowned experiences of the Kalahari Gemsbok Park and Etosha.

3.11 Conservation

In recent years the conservation and utilisation of biodiversity has become increasingly important and one of the greatest driving forces behind conservation efforts, has been the demand for ñunspoiledò areas by international tourists (Mangold *et al*., 2002). According to Mangold *et al*. (2002) the global economic trends make South Africa an ideal place for a relatively inexpensive holiday and the North-West Province offers a diverse range of activities and experiences. In 1998 South Africa had 12,820.73 km² formally protected areas and approximately 2,156.36 km² was managed by the NWPTB, while 16,064.37 km² was informally protected and managed by private residents or municipalities (Kumleben et al., 1998). The protected area in the North-West Province is represented by Proclaimed Provincial Nature Reserves, Municipal Nature reserves, Natural Heritage Sites, National Parks, Protected Natural Environments, Private Nature Reserves and Conservancies (Mangold et al., 2002).

According to Mucina and Rutherford (2006) there has been a substantial loss of savanna area due to cultivation, more so than any other transformational land use practice. In principle, the conservation of the Savanna Biome is believed to be relatively good, but this is mainly due to the presence of the Kalahari Gemsbok and Kruger National Parks that are located within the biome (Low and Rebelo, 1996). According to Low and Rebelo (1996) this high level of areas conserved in South Africa, belies the fact that half of the savanna vegetation types are inadequately conserved since less than 5% of the area falls within reserves. However, a great deal of the area is used for game farming which contributes to its preservation, provided that sustainable stocking levels are maintained (Low and Rebelo, 1996). Tourism and big game hunting contribute to the conservation of the savanna area (Low and Rebelo, 1996).

The conservation status of the Kalahari Plains Thorn Bushveld vegetation type is considered to be very poor (Low and Rebelo, 1996). Mucina and Rutherford (2006) classify the conservation status of the Mafikeng Bushveld vegetation unit as vulnerable, despite 16 % of the area being targeted for conservation. However, a very small area in the Mmabatho Recreation Area is being conserved, while little conservation strategies are being directed into statutory conservation areas (Mucina and Rutherford, 2006).

Chapter 4 - Patterns of plant diversity

"More buildings and infrastructure will be constructed in the next 50 years than have been built throughout human history" (Orr, 2002).

4.1 Introduction

According to the United Nations Centre for Human Settlements (1996), increased urbanization provides a prevailing source of land-use change worldwide. Alberti *et al*. (2003) stated that many ecological studies treat urban areas as homogenous entities and combine all anthropogenic factors into one aggregated variable, despite urbanization being multidimensional and highly variable across time and space. Most studies consider urban areas as one land use type and consequently never consider categorizing urban habitats into subunits or different land-use types according to the structure, density or function of built-up areas (Godefroid and Koedam, 2007). Godefroid and Koedam (2007) further stated that few attempts have been made to assess the relative influence of the types of built-up areas and land-use on the patterns of biodiversity.

In the last few decades urbanization has not only been regarded as a major threat to biodiversity but has also been the cause of habitat destruction of natural areas (McKinney, 2002; Miller, 2005; Kühn and Klotz, 2006). However, the pioneering work of Godefroid and Koedam (2007) found that cities are capable of supporting strikingly high biotic diversity, which is supported by an earlier study by Thompson *et al*. (2003) that found that garden floras show remarkably high levels of floristic diversity. Studies have indicated that cities are richer in plant species than the surrounding areas (McKinney, 2002; Hope *et al*., 2003; Kühn and Klotz, 2006), which could in part be ascribed to the influx of alien species both from intentional and unintentional introductions (Wilcove *et al*., 1998; Miller, 2005; McKinney, 2006), but also due to natural factors, as in some regions cities were developed in areas of natural heterogeneity which naturally supports high levels of biodiversity (Kühn and Klotz, 2006).

The proportion of non-native species is useful as an indicator of the intensity of disturbance caused by human activities (Sukopp *et al*., 1979). The impact that humans have on urban ecosystems can create the perfect environment for the establishment of alien species (Godefroid, 2001). The studies of both Kent *et al*. (1999) and Godefroid (2001) indicated that the proportion of native species in urban areas have been increasingly reduced due to urbanization, while the proportion of alien species has markedly increased. The study of Smith *et al*. (2006c) indicated that plant assemblages in urban domestic gardens in the United Kingdom are dominated by alien species and the study of Thompson *et al*. (2003) found that gardens contain a much higher abundance of species than any other community type. Marco *et*

al. (2008) confirmed that private gardens contain a large biodiversity strongly dominated by alien species.

Over the last few decades ecologists have applied spatial modeling to explore the response of ecological systems to disturbances occurring at spatial scales (Perry and Millington, 2008). According to Spokas *et al*. (2003) the use of geospatial models to estimate the distribution of different environmental phenomena is becoming increasingly popular. The term geostatistics is used to describe a range of statistical techniques for determining the relationship between spatially distributed values, leading to their estimation at unsampled locations (Chappell, 1998). Geostatistics has been used in ecological research to determine spatial heterogeneity at different scales for soil properties, plants, fungi and small arthropods (Acosta-Mercado and Lynn, 2002). According to Acosta-Mercado and Lynn (2002) geostatistics is a powerful technique for quantifying the degree of autocorrelation among samples. Furthermore, geostatistics provides two sources of data, namely the scale of the patch (the size of the patch) and what proportion of the total variation observed can be accounted for by the spatial factors or, in other words, how predictable is the pattern (Acosta-Mercado and Lynn, 2002). According to Robertson (1987) the application of geostatistics can significantly aid the interpretation of studies that explicitly deal with spatial or temporal patterning or studies with data that exhibit autocorrelation.

The approach being followed in this study is one of the first to compare floristic diversity between several different land-use types. Studies on urban floras tend to compare only a few land-use types (Kent *et al*., 1999, Kühn and Klotz, 2006). In this chapter the main objectives are to apply ordinations and a general geostatistical approach to determine (1) whether the land-use types of rural areas influence species composition and patterns of a rural settlement, (2) what contribution homegardens make towards the urban floristic diversity of a rural settlement in a developing country, and (3) the relationships between alpha, beta and gamma plant diversity of a rural settlement.

4.2 Materials and Methods

4.2.1 Vegetation survey

A grid was placed over the settlement with points approximately 500 m apart with ArcView 9.2 (Esri, 2006), to meet the requirement for the application of geostatistics (Fig. 4.1). A plant survey was done at each grid point location. During the survey, the land-use type was identified for each of these points, and could be one of the following: natural areas, fragmented natural areas, fallow fields, road verges, wetlands, homegardens and institutional gardens (Fig. 4.1). Parks, which are a common land-use area in most urban areas, were absent from this settlement. At each point the plant species were sampled according to a 100 point frequency

survey. Each of the sample plots was 20 x 20 m in size and five transects of 20 points each were placed inside the sampling plot. The first transect was placed 2 m from the edge of the sampling plot and the rest were spaced 4 m apart (Fig. 4.2). Along each transect the nearest tree, shrub, forb and grass species at intervals of 1 m, was noted and identified. If no plant occurred within 0.5 m before or after the point and 2 m perpendicular to the transect, bare ground was noted.

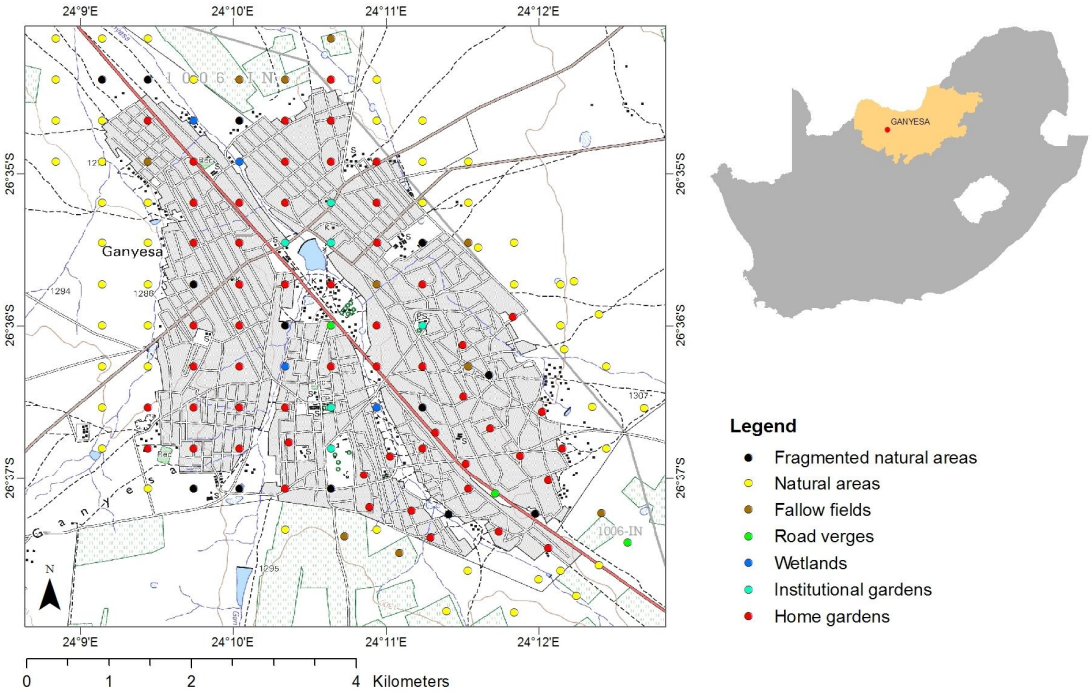


Figure 4.1: A map of the study area, Ganyesa, depicting the grid of sampling points and the different land-use types sampled.

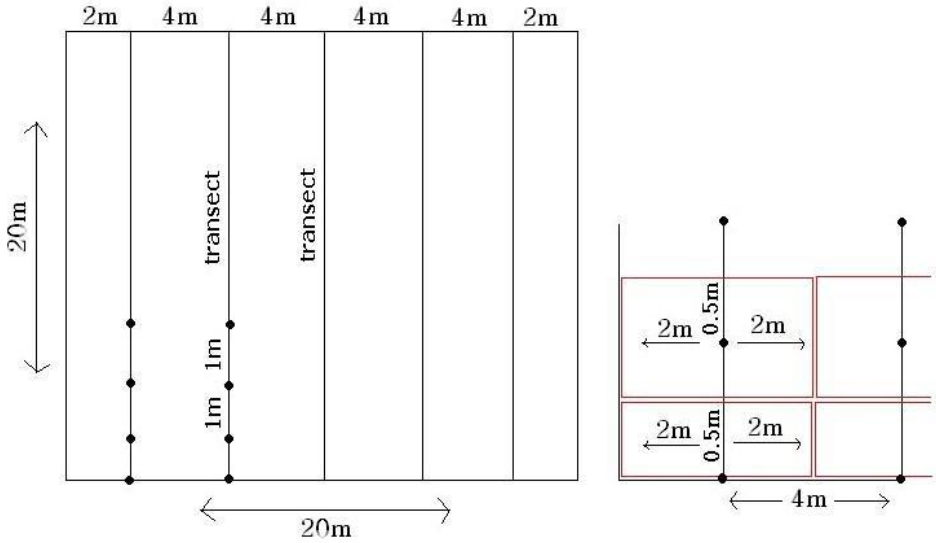


Figure 4.2: Design of a 20 ĵ 20 m sample plot with an insert of the sampling method at each 1 m point along the transect.

4.2.2 Data analysis

The frequency of all vascular plant species per sample plot was determined by calculating the number of times a species was recorded during the 100 point survey: **F = (n/100) x 100 = n**, where n = number of times a species was recorded per plot.

4.2.2.1 Kriging

Mabit and Bernard (2007) describes geostatistics as a technology developed for estimating the values of properties that vary in space from more or less sparse sample data. It can be used to quantify an unknown value, validate sampling strategy in order to improve sampling and to produce maps (Mabit and Bernard, 2007). Kriging is an advanced geostatistical procedure and one of many spatial interpolation techniques (Mabit and Bernard, 2007). Mackaness and Beard (1993) defines spatial interpolation as a process for estimating values at unsampled locations from a set of sample points and kriging as an interpolation technique that generates an estimated surface from a regular or irregular set of points.

Kriging methods take the spatial continuity of the points into consideration and it was first proposed by a South African engineer D.G Krige in 1978, who developed the technique in an attempt to more accurately predict gold mining reserves (Mabit and Bernard, 2007; Marengo *et al.*, 2008). Kriging is based on the ñregionalized variable theoryòproposed by Matheron in 1971, which accounts for the spatial variation in three parts, namely; noise, a random but spatially correlated component and an underlying structure (Mabit and Bernard, 2007; Mackaness and Beard, 1993). According to Mabit and Bernard (2007) this theory assumes that the spatial variation in the phenomenon is statistically homogenous throughout the surface.

The Kriging Tool of the interpolation techniques in the Spatial Analyst Extension of ArcView 9.2 (Esri, 2006) was used to determine the patterns of plant diversity for the settlement by using the total number of species for each sample point. Kriging maps were generated for the total, indigenous, native, alien and naturalized species richness. Indigenous species are species that occur naturally in locality, while native species are indigenous species that originate in the district or area in which they grow (Lawrence, 2005). Alien species is often referred to as alien species, which are species that do not grow naturally in a specific location and naturalized species are alien species that have become successfully established in an area (Lawrence, 2005). The first step of kriging is to estimate the underlying structure by using semi-variograms (Mackaness and Beard, 1993). According to Mabit and Bernard (2007) the semi-variogram and the variogram are basic tools for the analysis of spatial structure and is a mathematical description of the relationship between the variance of pairs of between-population variance within a distance class.

Kriging uses the closest points, weighted by the distance from the interpolated location and the degree of autocorrelation, to calculate the optimum weight at each sampling distance (Mabit and Bernard, 2007; Mackaness and Beard, 1993). There are several semi-variogram models that can be used to define the weights of the kriging function, namely spherical, circular, linear, exponential and Gaussian (Mabit and Bernard, 2007). The exponential semi-variogram model was used to generate kriging maps for the total, indigenous, native and alien species richness, while the natural neighbour interpolation method was used to generate a kriging map for the naturalized species richness since none of the semi-variogram models could generate a smooth raster. This could be due to relatively low levels of variance between the sample points. The natural neighbour method finds the closest subset of input samples and applies weights to them based on proportionate areas (Sibson, 1981). It does not generate maps of unsampled areas and consequently the surface is smooth except for the locations of the input samples (Watson, 1992).

The generated kriging maps were used to visually illustrate the alpha (Ŭ) diversity in the study area. Primack (2002) defines alpha diversity as the number of species in a certain community and it can be used to compare the number of species in certain ecosystem types or particular places. This measure is also often referred to as species richness, more specifically the term, alpha diversity, comes closest to the concept of species richness (Primack, 2002).

4.2.2.2 Multivariate analysis

4.2.2.2.1 NMDS ordination

The floristic composition of each of the sample plots in the different land-use types were compared by using an ordination method known as non-metric multidimensional scaling (NMDS). The ordinations were performed by using the Primer 5 software (Clarke and Gorley, 2001), which used the frequency data collected during the vegetation survey to compile ordinations for the total, indigenous, native, alien and naturalized species composition. The species abundance data for each of the sample points were converted to a matrix of similarities between every pair of samples and the similarities permit a low-dimensional display of biotic relationships among the samples (Clarke and Ainsworth, 1993). The ordinations derived illustrate that the distance between each plot is in rank order with their difference in species composition as determined by the dissimilarity coefficient (Williams, 2005; Kent and Coker, 1992).

According to Williams (2005) NMDS minimized stress by adjusting site positions so that the fit between ordination distances and dissimilarities are improved. Kent and Coker (1992) defined the stress function of an NMDS ordination as a measure of how well two points fit or match. According to Clarke (1993) the simplest indicator of the accuracy with which an NMDS

ordination perceives the relationship among samples, is the stress value computed for every ordination. Clarke (1993) also suggested the following rule of thumb for interpreting stress values; (1) a stress value smaller than 0.05 (< 0.05) provides an excellent representation with no prospect of misinterpretation, (2) a stress value smaller than 0.1 (< 0.1) corresponds to a good ordination, (3) a stress value smaller than 0.2 (< 0.2) can still provide a good ordination, while (4) stress values larger than 0.2 (> 0.2) have the potential to be misleading and (5) values that reach 0.35-0.4 are randomly placed and bear very little relation to the original similarity ranks. However, according to Clarke (1993) these guidelines are simplistic and stress tends to increase with increasing numbers of samples.

The NMDS ordinations generated was used to analyse the beta diversity (ß) of the study area. According to Primack (2002) beta diversity represents the rate at which species composition changes along a geographical or environmental gradient. If there is no change in the species composition along the gradient, then the beta diversity will be low. The beta diversity can be calculated by dividing the gamma diversity of a certain region with the mean of the alpha diversity (Primack, 2002).

4.2.2.2.2 Diversity indices

Research on the species diversity of communities can provide valuable information into the development and composition change of a community (Ganlin *et al.*, 2006). There are several methods for measuring diversity and most of them consist of two components, namely species richness and abundance (Magurran, 2004). Species richness simply refers to the number of species, while evenness describes how equally abundant the species are (Magurran, 1988). According to Magurran (1988) species diversity measures can be divided into three main categories; (1) the species richness indices, (2) species abundance models and (3) indices based on the proportional abundance of species. The species richness indices measure the number of species in a sampling unit, for example Margalefôs or Menhinickôs species richness indices, while the species abundance models describe the distribution of species abundances (how evenly the species are distributed), for example Pielouôs evenness, and diversity indices based on the proportional abundance of species include the Shannon-Wiener and Simpson diversity indices (Magurran, 1988).

Frequency data was used to calculate diversity indices with Primer 5 software (Clarke and Gorley, 2001). Species richness was determined with Margalefôs species richness index, species evenness with Pielouôs evenness index and both the Shannon-Wiener and Simpson diversity indices were used to determine the species diversity (Clarke and Gorley, 2001). Margalefôs species richness index (d) was calculated as:

$$d_{Mg} = (S - 1) / \ln N$$

Where S is the number of species recorded and N is the total number of individuals in the sample (Magurran, 2004).

Pielouûs evenness (Jû) was calculated as:

$$J' = H' / H'_{max} \text{ , } H'_{max} = H' / \ln S$$

The maximum diversity (H'_{max}) that could possibly occur would be found in a situation where all species had equal abundances (Magurran, 2004).

The Shannon-Wiener index (Hû) was calculated as:

$$H' = - \sum p_i \ln p_i$$

Where p_i is the relative abundance of species i (Magurran, 2004).

The Simpson diversity (D) index was calculated as:

$$D = \sum [n_i (n_i - 1) / N (N - 1)]$$

Where n_i is the number of individuals in the *i*th species and N is the total number of individuals (Magurran, 2004). According to Magurran (2004) the Simpsonûs index is heavily weighted towards the most abundant species in the sample while being less sensitive to species richness. The indices were calculated for all the plant species.

4.3 Results

4.3.1 Species diversity and composition of all the different land-use types

A comparison of all the different land-use types revealed that homegardens have the highest total plant diversity (gamma-diversity) (Fig. 4.3). Homegardens also had the highest indigenous, as well as the highest alien and naturalized plant diversity and natural areas have second highest indigenous plant diversity.

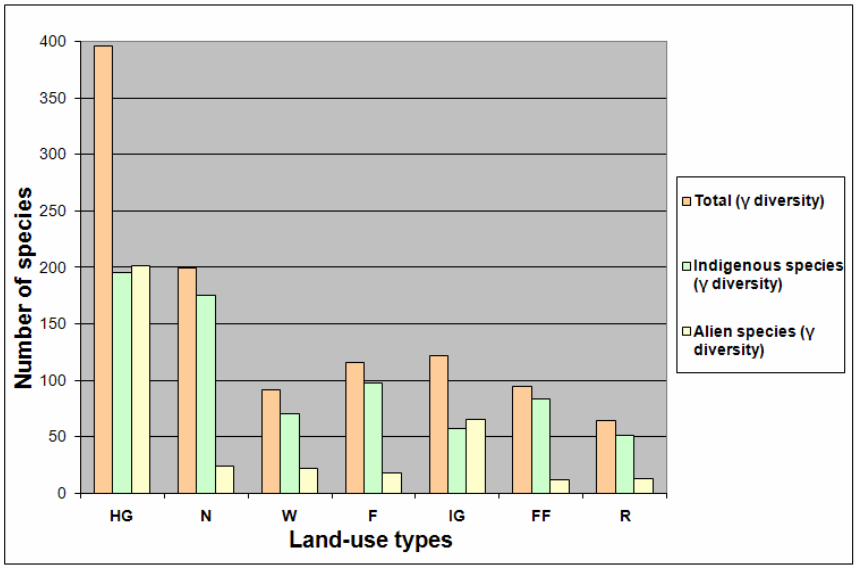


Figure 4.3: Gamma (ɔ) diversity of total species, indigenous species (indigenous and native) and alien (alien and naturalized) species is presented for each of the different land-use types. HG: Homegardens; N: Natural areas; W: Wetlands; F: Fragmented natural areas; IG: Institutional gardens; FF: Fallow fields; R: Road verges.

Wetlands contained the highest alpha-diversity (a mean of approximately 41 species per plot), closely followed by the natural areas (a mean of 40 species per plot) (Fig. 4.4). However, wetlands had a relatively low gamma-diversity indicating that even though a large number of species may occur per sample plot in this land-use type, the cumulative richness of wetlands was low suggesting that a similar assemblage of species were found in each sample plot. In contrast, homegardens had the second lowest alpha-diversity (a mean of approximately 25 species per plot) but had a high gamma-diversity (a total species diversity of 396 species), which suggests a high-turnover of species between different homegardens, resulting in a high beta diversity (Fig. 4.5). Natural areas had a higher alpha-diversity, but a lower gamma-diversity (a total species diversity of approximately 200 species).

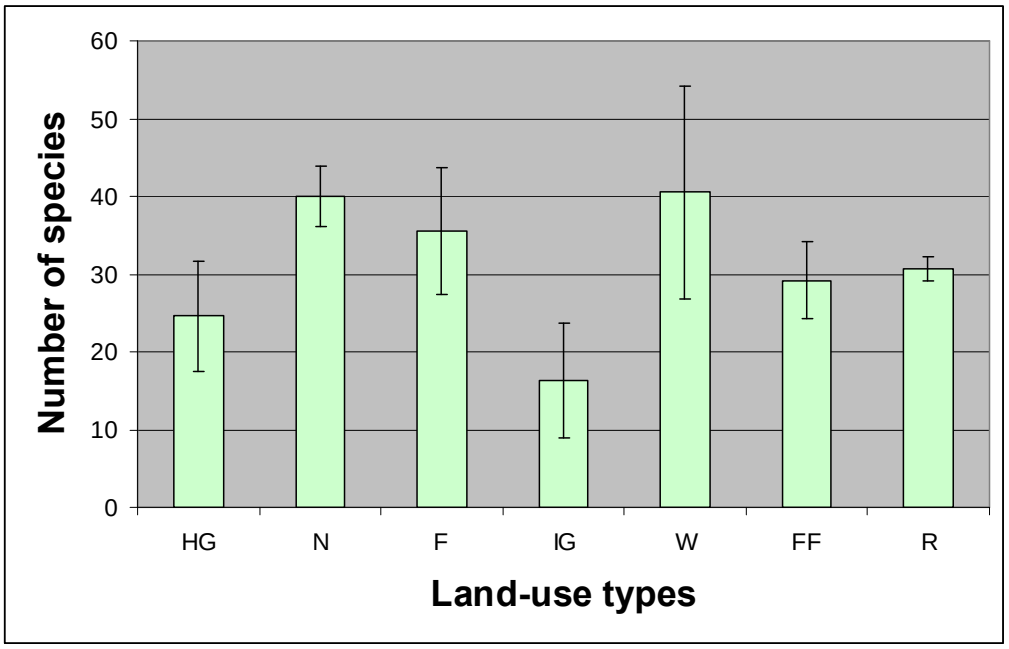


Figure 4.4: Alpha diversity, which indicates the mean number of species per sample plot, for each of the different land-use types in Ganyesa. HG: Homegardens; N: Natural areas; W: Wetlands; F: Fragmented natural areas; IG: Institutional gardens; FF: Fallow fields; R: Road verges.

Homegardens had a much higher beta diversity than the natural areas (Fig. 4.5). This was further supported by a comparison of the beta diversity between the different land-use types. This ordination approach considered the species composition per sample plot (Fig. 4.6). The stress value of the ordination was lower than 0.2, meaning that the ordination was satisfactory, but the groupings were less clear. From the ordination it could be deduced that the natural areas (Group A) had a lower beta-diversity as opposed to the homegardens (Group B), since the natural areas were grouped closer together on the graph, while the homegarden plots appeared more dispersed due to a significant variation in the species composition per sample plot (Fig. 4.6).

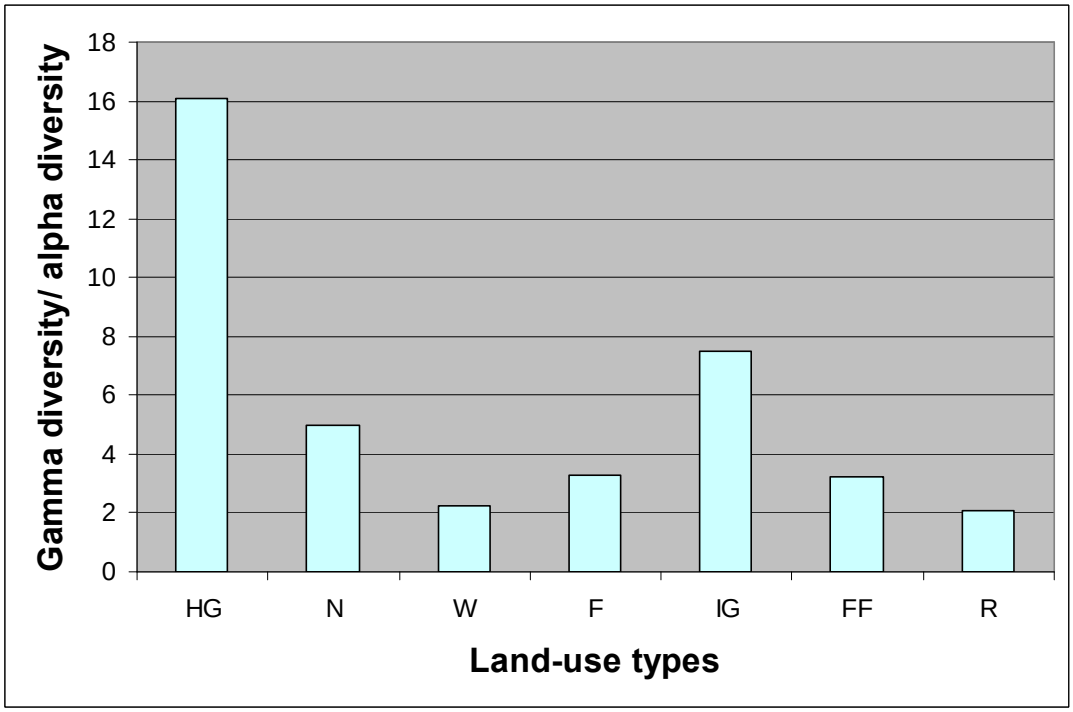


Figure 4.5: Beta diversity for each of the different land-use types in Ganyesa. HG: Homegardens; N: Natural areas; W: Wetlands; F: Fragmented natural areas; IG: Institutional gardens; FF: Fallow fields; R: Road verges.

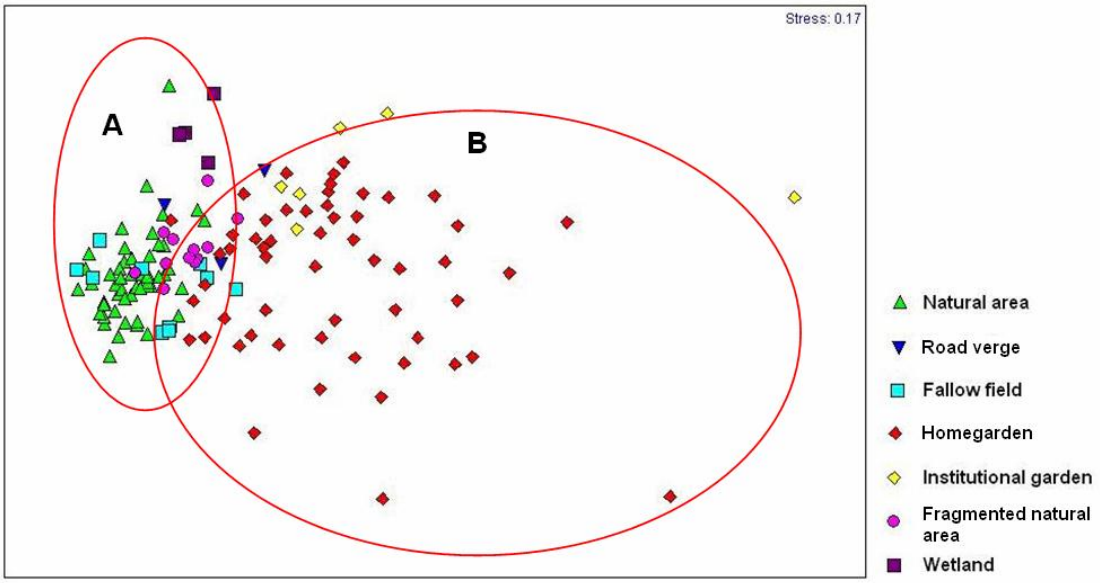


Figure 4.6: NMDS ordination of the species composition of the sample plots of all the land-use types in Ganyesa based on the total species diversity.

A kriging map of Ganyesa was compiled based on total species richness per sample plot (Fig. 4.7), suggesting that a higher alpha-diversity was present in the natural area, indicated by the green pattern on the map, as opposed to the other land-use types. The northern part of

Ganyesa was characterized by a higher alpha-diversity due to the presence of fallow fields and fragmented natural areas. The lower alpha-diversity in the southern part of Ganyesa could be attributed to the oldest residential development with less natural fragments. Inside the settlement one garden was characterized by an exceptionally high species richness, most of which were cultivated.

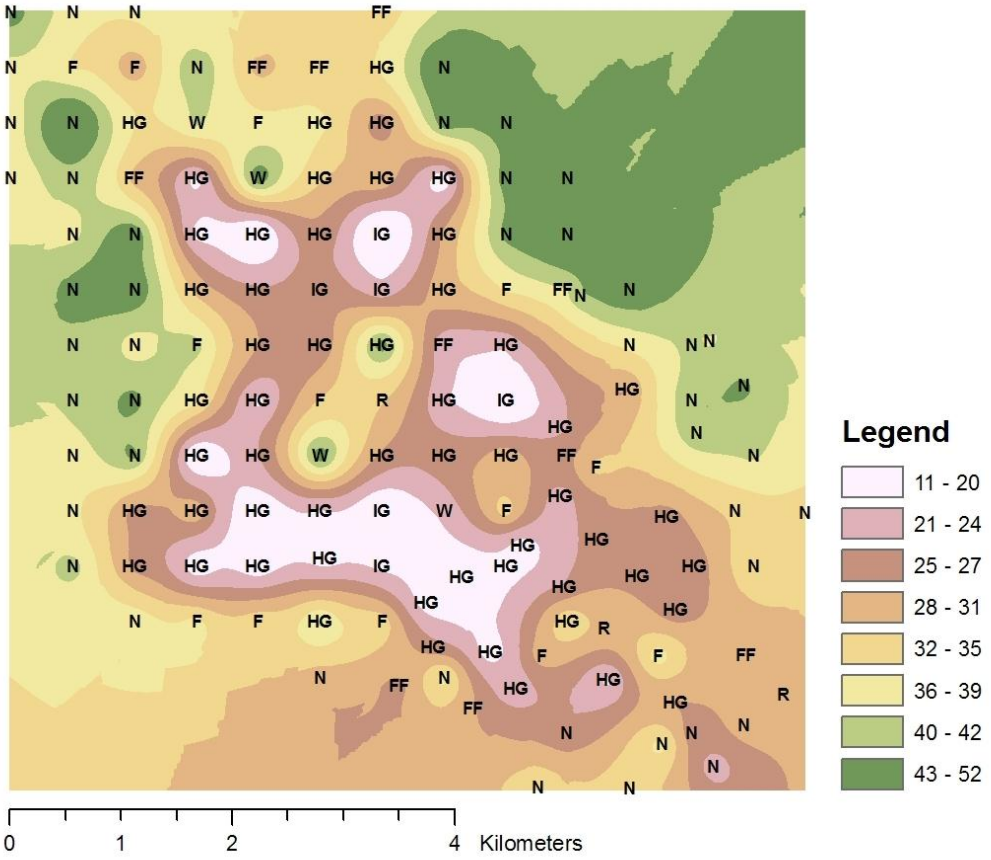
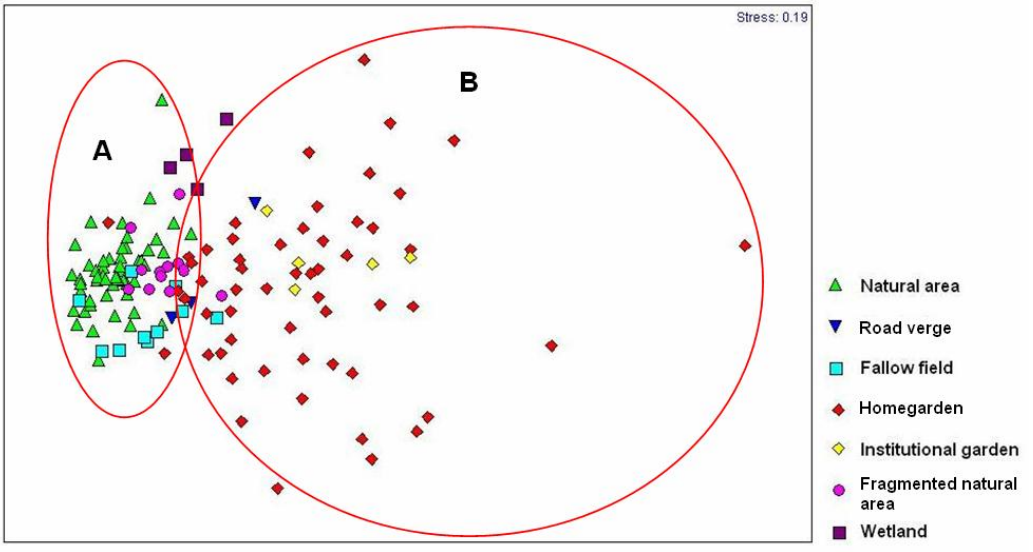


Figure 4.7: Kriging map of Ganyesa based on species richness per sample plot. FF: Fallow field; F: Fragmented natural area; HG: Homegarden; IG: Institutional garden; N: Natural area; R: Road verge; W: Wetland. Refer to the legend for an explanation of the colour coding representing number of species per sample plot.

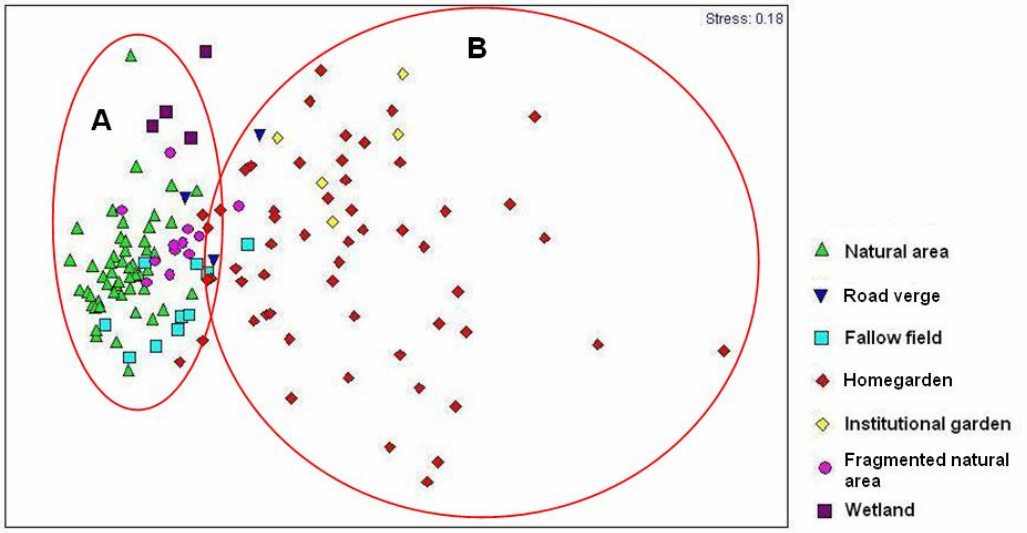
4.3.2 Indigenous and native species diversity

In total 294 indigenous species were recorded, of which 238 species were native to the Ganyesa area and the difference can be ascribed to cultivation. Consequently, the ordinations compiled based on the indigenous and native species composition (Fig. 4.8 A and B) showed similar patterns. The stress values for both the indigenous and native species were lower than 0.2, which indicated satisfactory ordinations even though the groupings of the different land-use types were not always clear. The natural areas (Group A) were grouped closer together due to a low beta-diversity, meaning the species turnover between the natural areas was low. In contrast the homegardens (Group B) were scattered due to a high beta-diversity and

consequently a high species turnover between gardens (Fig. 4.8). The majority of the natural areas tended to be floristically similar, while the different homegardens were quite dissimilar.



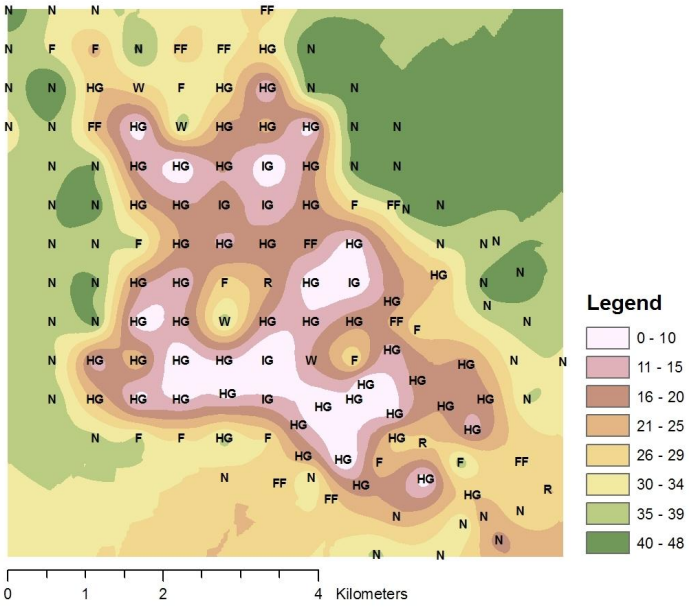
A)



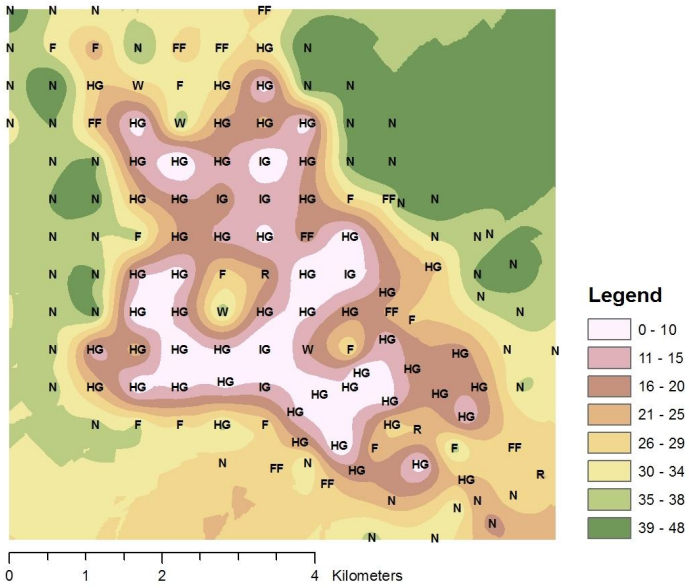
B)

Figure 4.8: NMDS ordination of the species composition of the sample plots of all the land-use types in Ganyesa, based on (A) indigenous and (B) native species richness per sample plot.

Kriging maps based on the total number of indigenous and native species distribution (Fig. 4.9 A and B) corresponded to the results of the map of the total number of species (Fig. 4.7). The natural areas around Ganyesa contained a high alpha-diversity, while the lower alpha-diversity inside the settlement could be attributed to the homegardens. There was a clear gradient, from high to low alpha diversity, from the centre of the settlement to the natural areas on the outskirts. The homegardens on the edges of the settlement were categorised by a higher alpha diversity than those inside the settlement. These homes were relatively new and the plots still contained a large number of native species.



A)



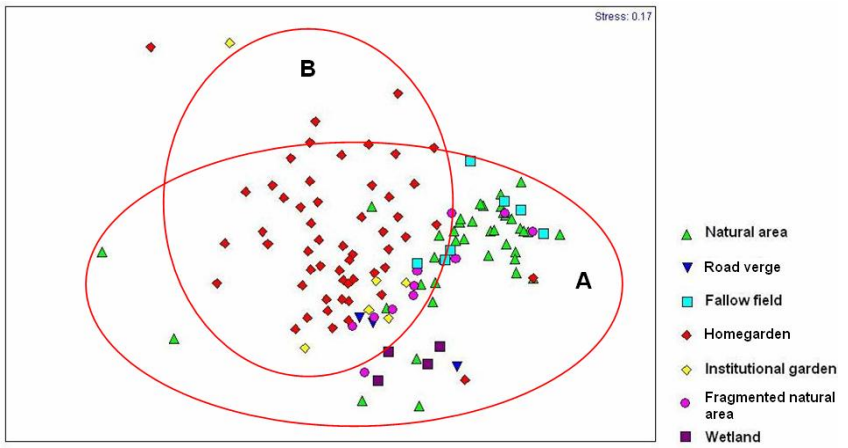
B)

Figure 4.9: Kriging maps of Ganyesa based on the number of (A) indigenous and (B) native species per sample plot. FF: Fallow field; F: Fragmented natural area; HG: Homegarden; IG: Institutional garden; N: Natural area; R: Road verge; W: Wetland. Refer to the legend for an explanation of the colour coding representing number of species per sample plot.

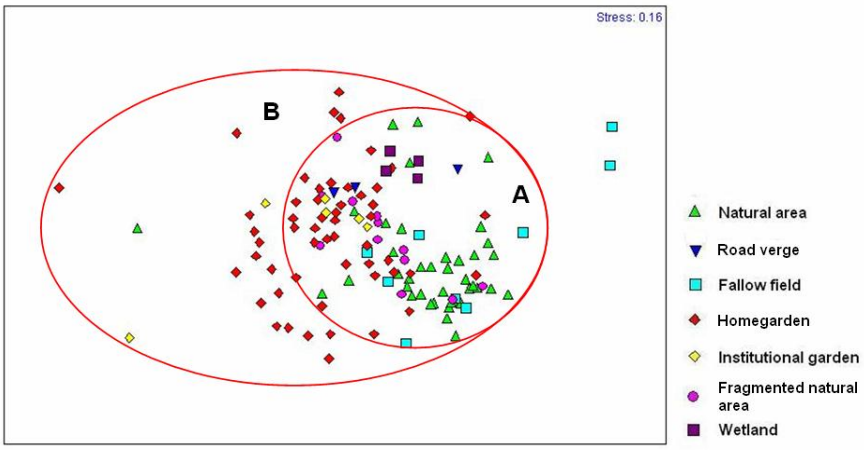
4.3.3 Alien and naturalized species diversity

In total 222 alien species were recorded, of which 57 species were naturalized. Ordinations based on the total number of alien species composition (Fig. 4.10 A and B) revealed no clear groupings for the different land-use types. However, the natural areas (Group A) still tended to group closer together than the homegardens (Group B), which had a more dispersed

appearance due to higher beta-diversity (Fig. 4.10). The groupings of the alien and naturalized species were more dispersed than that of the indigenous and native species, which formed clearer groupings (Fig. 4.8). Homegardens contained a large number of alien species, the majority of which are ornamental and food plants. However, in terms of alien species, natural areas did show some outliers indicating that unique alien species assemblages were present due to localized invasions. Naturalized weeds had a similar, but less pronounced effect on natural areas. Fallow fields showed the highest turnover of naturalized weeds, which could probably be related to succession and the occurrence of different serial communities. The stress values for both the alien and naturalized species were lower than 0.2 and statistically meaningful.



A)

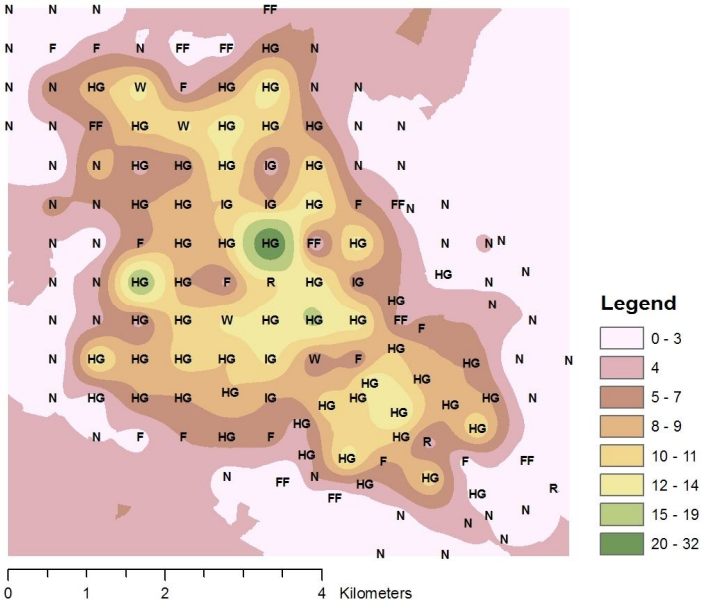


B)

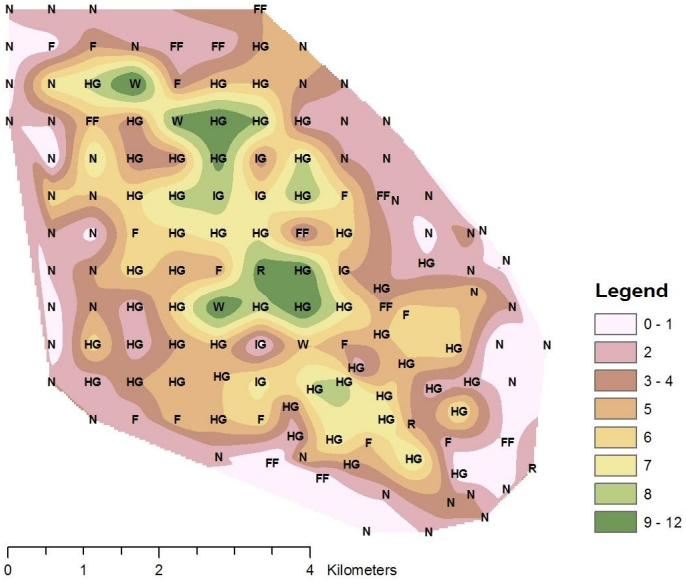
Figure 4.10: NMDS ordination of the species composition of the sample plots of all the land-use types in Ganyesa based on (A) alien and (B) naturalized species.

A different pattern of plant diversity was observed for kriging maps based on the alien species composition (Fig. 4.11 A and B) than for indigenous and native species composition. In contrast to the indigenous species composition, a higher alpha-diversity of alien species per plot was present inside the settlement than in the natural areas. This could be attributed to the presence

of homegardens, which were characterised by a high number of alien species, while the natural areas around the settlement contain a characteristically lower number of naturalized species. Wetlands tended to be richer in naturalized species when compared to other land-use types. It was also clear that naturalized species richness was higher in natural areas that are interspersed with fallow fields.



A)



B)

Figure 4.11: Kriging maps of Ganyesa based on the number of (A) alien and (B) naturalized species per sample plot. FF: Fallow field; F: Fragmented natural area; HG: Homegarden; IG: Institutional garden; N: Natural area; R: Road verge; W: Wetland. Refer to the legend for an explanation of the colour coding representing number of species per sample plot.

4.3.4 Diversity indices

Pielouôs evenness index did not show great variation between the different land-use types (Fig. 4.12A). However, the natural areas and wetlands had the greatest evenness values in comparison with the unevenness of institutional gardens. The natural areas and wetlands therefore had the most evenly distributed species composition. Margalefôs species richness index indicated that the natural areas and wetlands had the highest species richness values of all the land-use types, while the institutional gardens had the lowest species richness values (Fig. 4.12B). Shannon-Wienerös diversity index did show significant differences among the land-use types. Natural areas and wetlands had the highest value and institutional gardens had the lowest (Fig. 4.12C). The Simpsonôs diversity index did not show significant differences among the land-use types (Fig. 4.12D). However, the natural areas and wetlands did have the highest values, while the home and institutional gardens had the lowest index values. The natural areas and wetlands had the highest values in all the indices, and home and institutional gardens the lowest.

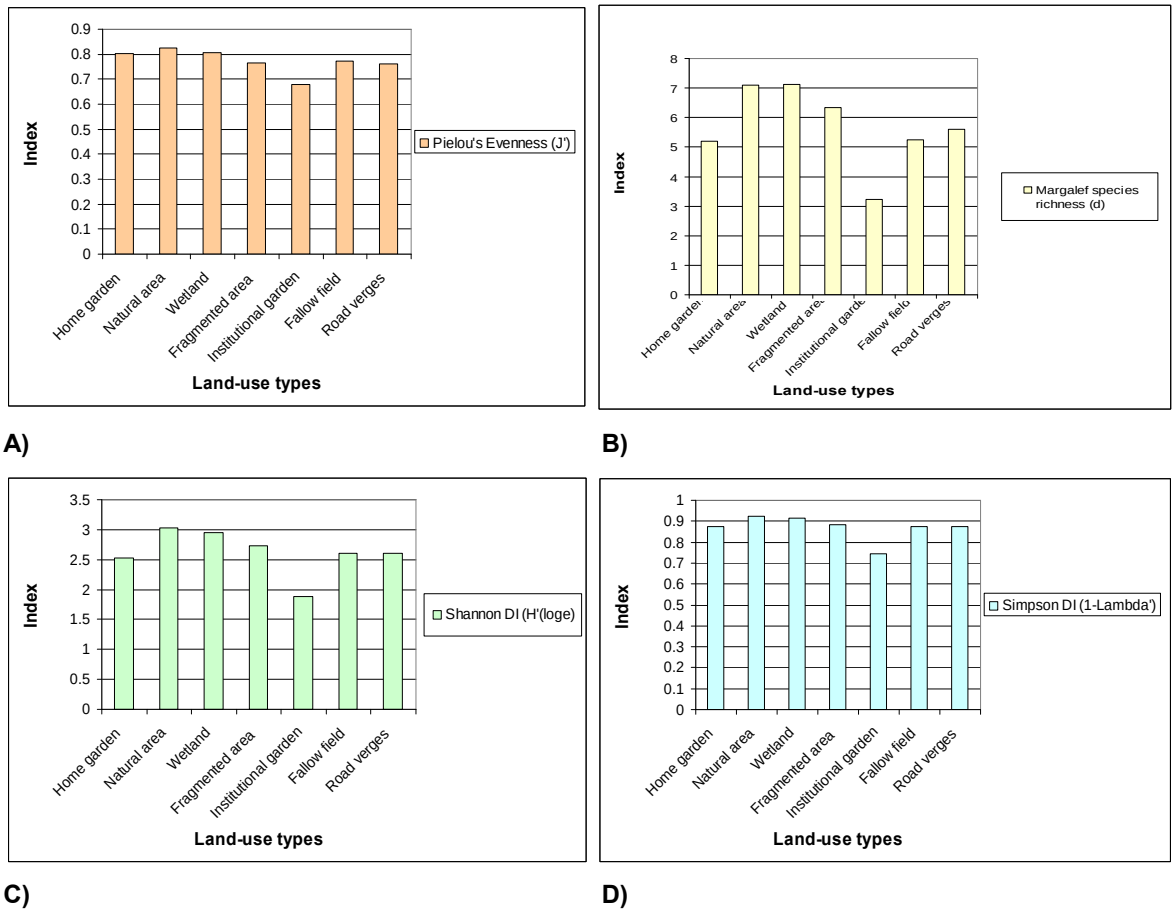


Figure 4.12: Comparative mean values of species richness (A), Pielouôs evenness index (B), Margalefôs species richness index (C), Shannon-Wiener species diversity index and (D) Simpsonôs diversity index for the land-use types of Ganyesa.

4.4 Discussion

The study of Araújo (2003) provided only partial support for the idea that areas with high human population density coincide with areas of high species richness. A study by Knapp *et al*. (2008) in Germany, found that species richness was significantly higher in urbanized than in agricultural or semi-natural areas. Similarly, our study recorded higher total species diversity (gamma diversity) inside the settlement than outside the settlement, while the alpha diversity of the natural areas outside the settlement is higher than the alpha diversity inside the settlement. The natural areas have a higher alpha diversity since the sample plot was a standard size of 20 x 20 m and therefore the homegardens were under sampled, since the plant diversity at the point where the plot is placed is limited to the planting theme, e.g. vegetables or ornamentals. Therefore, numerous species are excluded from the homegarden data sets, however chapter 5 addresses this bias as the total floristic composition of the homegardens were used for analysis. As would be expected, the natural areas were mostly dominated by indigenous and native species, while the flora inside the settlement is attributed to a high number of alien and naturalized species.

However, the studies of Deutschewitz *et al*. (2003) and Kühn and Klotz (2006) found that urban areas are capable of supporting a high native as well as a high alien species richness. This statement is also of significance in Ganyesa, a rural settlement, as many of the different land-use types inside the settlement support various native and alien species, with high alpha diversity levels in wetlands and fragmented natural areas (Fig. 4.3) inside the settlement. Alien species can be directly or indirectly introduced into urban areas due to cultivation or accidental transportation (McKinney, 2002; Deutschewitz *et al*., 2003; Miller, 2005; McKinney, 2006), while fragmented natural areas, gardens, parks and wetlands may increase native species richness (Deutschewitz *et al*., 2003).

As was shown by Kent *et al*. (1999), different land-use types in urban areas influence plant species composition and patterns. The study of Kent *et al*. (1999) was one of a few studies that have taken the species data recorded systematically across an entire city and examined the resulting species assemblages and their distributions collectively. Similarly, our study is one of few studies to systematically record the species data across a rural settlement and the surrounding natural areas, as well as comparing the species data of several different land-use types with one another. Based on a TWINSPAN analysis, Kent *et al*. (1999) identified nine interpretable groups which was further split into two main categories, namely (1) a set of groups closely related to the historical sequence of urban development and housing in the city and (2) remnants of particular semi-natural habitat types that still exist within the boundaries of the city.

Similarly to the findings of Kent *et al*. (1999), areas of recent housing development in Ganyesa had the highest total number of species, closely followed by wetlands and areas with older residential development. Homegardens had the highest total number of species (gamma diversity), while in contrast to the study of Kent *et al*. (1999), natural areas had the second highest total number of species in Ganyesa. The high total species diversity of homegardens can be explained by the high level of alien and naturalized species that are cultivated by residents, while natural areas have a low alien species richness and are mainly dominated by indigenous and native species. The homegardens and institutional gardens are the major contributors to the alien and naturalized species pools inside the settlement, while the fragmented natural areas and wetlands contribute to the indigenous and native species richness. Similarly, the fallow fields, along the edge of the settlement, contribute to the indigenous and native species richness recorded for the natural areas outside the settlement. The high gamma diversity of natural areas outside the settlement can be ascribed to South Africaôs rich indigenous flora (Germishuizen *et al*., 2006).

Both the homegardens and the institutional gardens are controlled by human intervention (home owners and the local municipality), meaning their choices and perceptions determine which species are planted or cultivated and which are removed. Homegardens contribute greatly towards urban floristic diversity, but they are mostly dominated by alien and naturalized species, the majority of which are ornamental flora or invasive weeds. However, a great deal of the naturalized species has invaded the fragmented natural areas from the homegardens. Similarly, the studies of Godefroid and Koedam (2007) and Siebert (2009) have indicated that urban areas are capable of providing temporary safe sites for potential invasive species to establish founding populations due to human behaviour. The floristics of the settlement will be further explained in chapter 5.

4.5 Summary

Liu (2001) stated that as pristine ecosystems become human-dominated or ï influenced, ecologists have begun to study the effects of human domination and are faced with many new fundamental questions. This is one of many reasons that support the increasing importance for systematically studying the species diversity of both urban and rural settlements and to compare the various land-use types in and around settlements with one another, as well as taking the level of human influence in urban and rural settlements into consideration. This is especially important when considering that only a few studies have recorded species data for more than three or four different land-use types, let alone compared the data from different land-use types with one another (Kent *et al*., 1999; Kühn and Klotz, 2006).

The main theme of this chapter is the quantification of the differences in alpha, beta and gamma diversity between the different land-use types, especially the differences between homegardens and natural areas. Homegardens had a much higher gamma diversity than the natural areas, while the natural areas had a much higher alpha diversity than the homegardens. In contrast, the study of Smith *et al*. (2006c) indicated that the alpha diversity of homegardens and natural areas are similar, while the study of Kent *et al*. (1999) found that residential areas tend to have a higher alpha diversity than natural areas. These differences are based on the different levels of human intervention. Homegardens and institutional gardens are characterised by the highest level of human intervention, while natural and fragmented natural areas are characterised with relatively low levels or no human intervention.

These contrasting species pools create a gradient along the entire settlement, which is measurable as alpha, beta and gamma-diversity. The alpha diversity can be clearly indicated on kriging maps, while beta diversity can be illustrated by means of NMDS ordinations. The main advantage of kriging is that it provides an indication of the error associated with interpolated values and it is the only method that uses statistical theory to optimize the interpolation (Mackaness and Beard, 1993). Kriging is also very intuitive and provides a useful visual comparison with results produced by other interpolation techniques (Williams, 2005) or ordinations. The results of our study highlight the potential of geostatistics for illustrating the patterns of species diversity of different land-use types across an entire settlement. However, the use of block kriging has lead to an undersampling of the homegardens, as the sampling sites were spread approximately 500 m apart on the grid system used.

When exploring a single urban or rural area the beta diversity between the homegardens is higher than that of the natural areas, since homegardens have a higher turn-over of species between the different sample plots than the mostly homogenous surrounding natural areas. However, the opposite should be true when comparing different urban areas, as the cultivated flora stays more or less constant, but the indigenous flora of the different natural areas changes considerably across vegetation units, since urban areas are often located within a single vegetation unit. My findings are therefore valuable to formulate a beta diversity theory. Future research should incorporate data from several urban ecology studies to formulate such a theory.

Chapter 5 - Floristic composition

"The most striking feature of the Earth is the existence of life, and the most striking feature of life is its diversity" (Tilman, 2000).

"Diversity at all organizational levels, ranging from genetic diversity within populations to the diversity of ecosystems in landscapes, contribute to global biodiversity" (Chapin *et al*., 2000).

5.1 Introduction

According to Tilman (2000) biological diversity, or biodiversity, has long been a source of scientific curiosity, but is increasingly a source of concern. Species diversity has noticeably been reduced within many different habitats worldwide due to human domination of the Earthøs ecosystems, consequently leading to an increase in species extinction (Tilman, 2000). Wilcove *et al.* (1998) stated that biologists are nearly unanimous in their belief that humanity is in the process of extirpating a significant portion of the Earthøs species. There are several human activities that threaten biodiversity, the single greatest threat being habitat loss (McKinney, 2006), closely followed by the spread of alien species (Wilcove *et al*., 1998) and the most recent threat ï human induced climate change (Hannah *et al*., 2004). Agriculture, livestock grazing, mining, road construction and infrastructure development are only a few causes of habitat destruction (Wilcove *et al*., 1998; McKinney, 2006).

There are various factors that influence the rate at which alien species are being introduced into urban areas, namely peopleøs growing desire to cultivate horticultural flora, which are mostly alien and invasive species, or as an unintentional by-product of cultivation, commerce, tourism or travel (Wilcove *et al.*, 1998; Miller, 2005; McKinney, 2006; Marco *et al*., 2008). Horticultural floras are a major contributor to the diversity of urban environments and are mostly characterized by ornamental plants and vegetables (Gaston *et al*., 2005b; Marco *et al*., 2008). According to Gaston *et al.* (2005b) domestic gardens and residential areas collectively represent a substantial proportion of ñgreen spaceò in urban areas and hence are of potential significance for the maintenance of biodiversity in such areas (Smith *et al*., 2005; Thompson *et al*., 2005; Smith *et al*., 2006c).

In recent years ecologists have come to realise the importance of studies of homegardens and especially the value of gardens for the protection of species (Blanckaert *et al*., 2004). According to Das and Das (2005) homegardens are the sites of conservation for a large diversity of plants both wild and domesticated, because of their uses to the household. In many countries, homegardens are considered traditional agroforestry systems used for the cultivation of a diverse and stable supply of socio-economic products (Blanckaert *et al*., 2004; Das and Das, 2005). According to May and Rogerson (1995) urban agriculture is increasingly seen as a

major means of supplementing incomes in the cities of South Africa. High and Shackleton (2000) found that rural inhabitants make considerable use of wild resources from communal areas around their settlement, as well as from arable and residential plots.

Despite the vast knowledge that is available on the alien floras of urban environments, this aspect has never been quantified for any South African urban area. The study of patterns of plant diversity in Ganyesa (Chapters 4 & 7) has provided an opportunity to assess the floristic composition of a rural settlement, albeit it only being representative of historically disadvantaged communities. The aim of this chapter is therefore to determine and analyse the floristic composition of Ganyesa to provide a baseline for comparison in future urban floristic studies of larger or culturally different urban areas in South Africa. This study assessed the most dominant families and most abundant genera and species, determined the degree to which rare and threatened species occur, established the chorology of the taxa present, compared the life and growth forms, species richness and indigenous/alien composition between different land-use types, and documented the useful plant diversity in the study area.

5.2 Materials and Methods

5.2.1 Vegetation survey

As explained in detail in Chapter 4, GIS techniques (Esri, 2006) were applied to overlay a grid over the Ganyesa settlement and adjacent areas with points approximately 500 m apart. This approach was chosen to allow for in depth analysis of biodiversity data in other chapters. In total 141 sample points were mapped within several different land-use types (Table 5.1). Plant surveys were completed for each sample area, 20 x 20 m in size. The presence-absence data collected for each of the sample areas was used to determine and analyse the floristic composition of Ganyesa. Frequency data was also collected, but not explored here. For further analysis of frequency data refer to Chapters 4 and 7.

Table 5.1: Number of sample points in each of the different land-use types according to the grid method in Ganyesa, South Africa.

Land-use types	Number of plots
Fallow fields	10
Fragmented natural area	12
Homegardens	55
Institutional gardens	6
Natural areas	51
Road verges	3
Wetlands	4

5.2.2 Data analysis

All species and habitat data were consolidated in Excel spreadsheets and further analyzed by determining the conservation status, life and growth form, as well as the geographical distribution of each species.

5.2.2.1 Chorological analysis

In order to accurately determine the chorology of all 516 species recorded for the survey sites (Appendix 2), 111 species had to be removed from the data set, due to a lack of national distribution data in Germishuizen *et al.* (2006). These species were mostly cultivated aliens. The remaining 405 species were then further subdivided into native and naturalized groups. The species that were (1) indigenous to South Africa in other parts of the country only, or (2) alien, but not naturalized in the Ganyesa region, were removed to formulate a more accurate picture of the distribution of species that naturally occur in Ganyesa. This left 292 species that are characterized as native or naturalized. Based on Germishuizen *et al.* (2006), a total of 220 species were widespread since they are present in at least eight or more of the nine provinces of South Africa, and Lesotho, Botswana, Namibia and Swaziland. The remaining 72 species with limited distributions were than categorized into one of four groups for chorological analyses based on a NMDS ordination of presence/absence data (Fig. 5.1) compiled with the Primer 5 software (Clarke and Gorley, 2001). The stress value of the ordination is less than 0.1 which corresponds to a good ordination based on the rule of thumb suggested by Clarke (1993).

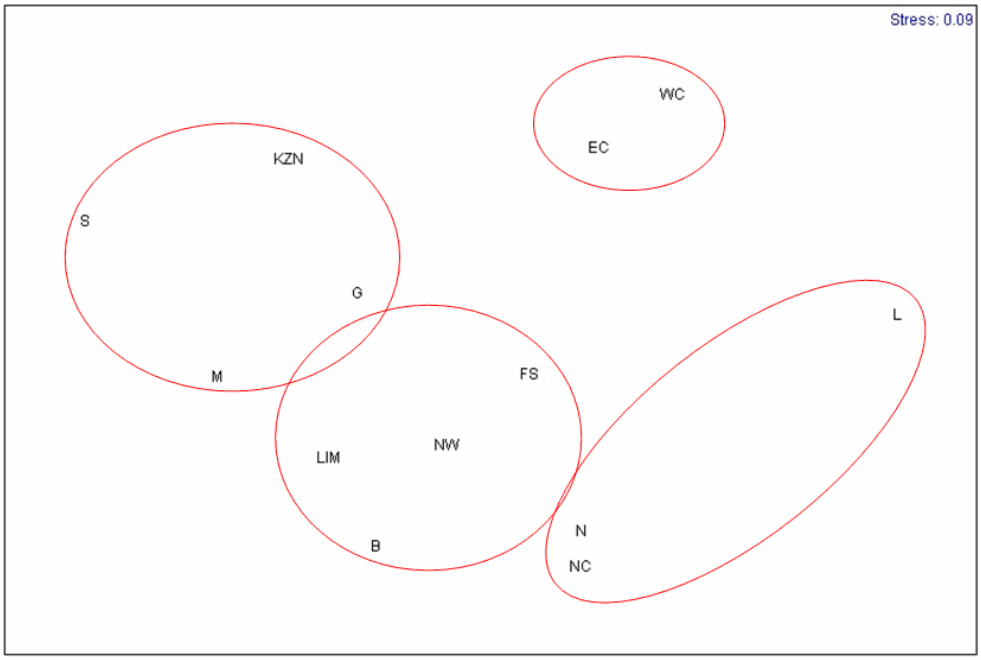


Figure 5.1: A NMDS ordination based on the species distribution in order to identify clear groupings. B, Botswana; EC, Eastern Cape; FS, Free State; G, Gauteng, KZN, KwaZulu-Natal; L, Lesotho; LIM, Limpopo; M, Mpumalanga; N, Namibia; NC, Northern Cape, NW, North-West, S, Swaziland; WC, Western Cape.

5.2.3 Herbarium specimens

According to a 2007 historical collection map of the North-West Province (Fig. 5.2) created with the Pretoria Computerised Information System (PRECIS) (Bester *et al*. 2008), Ganyesa is a floristically under-sampled region. Voucher specimens were collected during the survey and identified by comparison with herbarium specimens in the AP Goossens (PUC) herbarium. Each specimen was collected in duplicate and the duplicates were deposited in the Pretoria National Herbarium (PRE) for name verification.

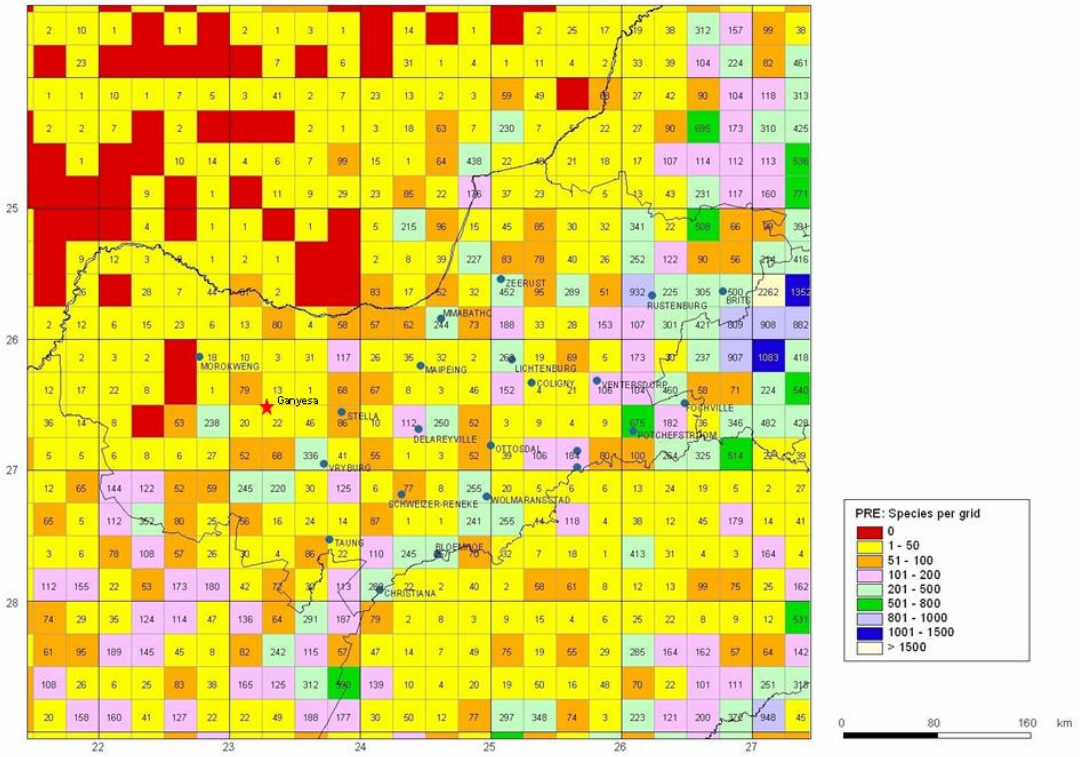


Figure 5.2: PRECIS map of herbarium specimen collections for the North-West Province (Bester *et al*., 2008).

5.3 Results

5.3.1 Twenty dominant families

South Africa has a rich floristic diversity of approximately 19 581 indigenous species (infraspecific taxa excluded), 2 267 genera and 349 families of vascular plants (Germishuizen *et al.,* 2006). According to the latest PRECIS data, the Asteraceae, Fabaceae and Mesembryanthemaceae (Table 5.2) are the three largest families in South Africa based on their species count (the number of species that make up the family) (Snyman, 2009). In total, 106 plant families are represented by the 516 species recorded for Ganyesa during the survey. As expected, the families with the highest number of taxa also include the Asteraceae and Fabaceae among the three largest families (Table 5.3). The families, Asteraceae and Fabaceae both constitute a tenth each of the total species count for Ganyesa. The family

Poaceae is the third largest family in Ganyesa, which is 9% of the total species. Based on PRECIS data it is only the seventh largest family in South Africa (Table 5.2). The dominance of families such as Solanaceae, Malvaceae, Rosaceae and Lamiaceae (Table 5.3) in Ganyesa can be attributed to the fact that most of the species in these families are extensively cultivated in homegardens for various reasons. These species can be cultivated for medicinal, ornamental or dietary purposes, to name a few. However, species from the Cyperaceae family occur naturally in wetlands which explain its high representation in Ganyesa along the non-perennial rivers of Ganyesalaagte.

Table 5.2: The ten most dominant families calculated for South Africa based on the species count (the total number of species per family). Compiled from the latest PRECIS data of SANBI (South African National Biodiversity Institute) (Snyman, 2009).

Families	Number of species	Families	Number of species
1. Asteraceae	2259	6. Scrophulariaceae	801
2. Fabaceae	1689	7. Poaceae	774
3. Mesembryanthemaceae	1661	8. Apocynaceae	694
4. Iridaceae	1158	9. Asphodelaceae	596
5. Ericaceae	955	10. Orchidaceae	513

Table 5.3: The twenty most dominant families calculated for Ganyesa based on the number of species per family. The contribution of each family towards the total species pool in Ganyesa is expressed as a percentage. The five families that are also ranked under the top 10 for South Africa are indicated with their position in superscript.

Families	Number of species	% Species
Asteraceae[1]	63	12%
Poaceae[7]	55	11%
Fabaceae[2]	44	9%
Solanaceae	20	4%
Lamiaceae	14	3%
Asphodelaceae[9]	12	2%
Crassulaceae	11	2%
Rosaceae	10	2%
Amaranthaceae	9	2%
Chenopodiaceae	8	2%
Cucurbitaceae	8	2%
Cyperaceae	8	2%
Hyacinthaceae	8	2%
Malvaceae	8	2%
Convolvulaceae	7	1%
Mesembryanthemaceae[3]	7	1%
Myrtaceae	7	1%
Oleaceae	7	1%
Sterculiaceae	7	1%
Verbenaceae	7	1%

5.3.2 Twenty dominant species

In total 516 species were recorded for the combined area including all the land-use types. Four grass species, namely *Aristida congesta*, *Cynodon dactylon*, *Eragrostis lehmanniana* and *E. trichophora,* and the herb, *Felicia muricata*, are the top five most abundant species in Ganyesa (Table 5.4). The list is dominated by herbaceous taxa, with the shrubby *Acacia hebeclada* the only exception. Only three alien, weedy species were found to be part of the group of dominants (Table 5.4), namely *Guilleminea densa*, *Schkuhria pinnata* and *Euphorbia prostrata*. All three are naturalized species that have escaped from homegardens into the natural areas. The high rate of occurrence of most of the species (Table 5.4) on the list can be attributed to their presence in both the natural areas and homegardens. Many of these are weeds.

Table 5.4: The twenty most dominant species recorded for Ganyesa based on frequency of occurrence (the percentage of sample sites in which the species was recorded). (* = alien species).

Species	Families	% plots
Cynodon dactylon (L.) Pers.	Poaceae	91%
Eragrostis lehmanniana Nees var. *chaunantha* (Pilg.) De Winter	Poaceae	85%
Aristida congesta Roem. & Schult. subsp. *congesta*	Poaceae	75%
Felicia muricata (Thunb.) Nees subsp. *muricata*	Asteraceae	70%
Eragrostis trichophora Coss. & Durieu	Poaceae	67%
Acacia hebeclada DC. subsp. *hebeclada*	Fabaceae	65%
Sida cordifolia L.	Malvaceae	62%
Guilleminea densa (Willd. ex Roem. & Schult.) Moq.*	Amaranthaceae	55%
Gisekia pharnacioides L. var. *pharnacioides*	Gisekiaceae	53%
Senna italica Mill. subsp. *arachnoides* (Burch.) Lock	Fabaceae	53%
Pollichia campestris Aiton	Caryophyllaceae	51%
Schkuhria pinnata (Lam.) Cabrera*	Asteraceae	51%
Monsonia angustifolia E.Mey. ex A.Rich.	Geraniaceae	50%
Hermannia tomentosa (Turcz.) Schinz ex Engl.	Sterculiaceae	50%
Euphorbia prostrata Aiton*	Euphorbiaceae	48%
Zornia milneana Mohlenbr.	Fabaceae	48%
Bulbine abyssinica A.Rich.	Asphodelaceae	47%
Chrysocoma obtusata (Thunb.) Ehr.Bayer.	Asteraceae	47%
Bulbostylis hispidula (Vahl) R.W.Haines subsp. *pyriformis* (Lye) R.W.Haines	Cyperaceae	45%
Selago mixta Hilliard	Scrophulariaceae	43%

5.3.3 Endemic species

Ganyesa lies east of the Griqualand West Centre of Endemism which contains approximately 2.2% endemic or near endemic species (Van Wyk & Smith, 2001). According to Van Wyk & Smith (2001) endemic taxa represent the geographical element which most naturally characterises the floristic uniqueness of a particular region. In total 24 species endemic to South Africa were found in the combined area of all the land-use types in Ganyesa (Table 5.5). The list of 24 South African endemic species can be subdivided into two groups, namely species that occur in the natural areas and those that are cultivated in homegardens. Consequently, the cultivation of endemic species inadvertently promotes their conservation and

protection, which is becoming increasingly important since a great deal of indigenous species are being replaced by alien species in homegardens. However, the figure for Ganyesa is misleading, as only four species occur in more than 10% of the sample sites, of which two are naturally occurring. *Gnaphalium nelsonii*, *Portulaca grandiflora, Selago mixta* and *Tulbaghia simmleri* were the four most abundant endemic species. *Selago mixta* is the only species of this group that also made it onto the list of the 20 most dominant species in Ganyesa (Table 5.4).

Table 5.5: A list of South African endemic species found in Ganyesa, as well as their families and the number of sample sites in which they were found.

Species	Origin	Family	Number of plots
Selago mixta Hilliard	Natural	Scrophulariaceae	61
Gnaphalium nelsonii Burtt Davy	Natural	Asteraceae	43
Portulaca grandiflora Hook.	Cultivated	Portulacaceae	20
Tulbaghia simmleri P.Beauv.	Cultivated	Alliaceae	15
Eragrostis pseud-obtusa De Winter.	Natural	Poaceae	11
Lampranthus roseus (Willd.) Schwantes	Cultivated	Mesembryanthemaceae	8
Aloe tenuior Haw.	Cultivated	Asphodelaceae	7
Lampranthus aureus (L.) N.E.Br.	Cultivated	Mesembryanthemaceae	7
Ruschia perfoliata (Mil.) Schwantes	Cultivated	Mesembryanthemaceae	7
Cotyledon tomentosa Harv. subsp. *tomentosa*	Cultivated	Crassulaceae	6
Sida acuta L. var. *acuta*	Natural	Malvaceae	6
Aptenia cordifolia (L.f.) Schwantes	Cultivated	Mesembryanthemaceae	5
Crassula ovata (Mill.) Druce	Cultivated	Crassulaceae	5
Cyperus textilis Thunb.	Cultivated	Cyperaceae	5
Agapanthus praecox Willd. subsp. *orientalis* (F.M.Leight) F.M.Leight	Cultivated	Agapanthaceae	4
Senecio scaposus DC. var. *scaposus*	Cultivated	Asteraceae	3
Crassula capitella Thunb. subsp. *capitella*	Cultivated	Crassulaceae	2
Plectranthus pentheri (Guerke) Van Jaarsv. & T.J.Edwards	Cultivated	Lamiaceae	2
Amaryllis belladonna L.	Cultivated	Amaryllidaceae	1
Euryops chrysanthemoides (DC.) B.Nord.	Cultivated	Asteraceae	1
Haworthia attenuata (Haw.) Haw. var. *attenuata*	Cultivated	Asphodelaceae	1
Hypertelis arenicola Sond.	Natural	Molluginaceae	1
Lampranthus glaucus (L.) N.E.Br.	Cultivated	Mesembryanthemaceae	1
Plectranthus saccatus Benth. var. *saccatus*	Cultivated	Lamiaceae	1

5.3.4 Endangered and protected species

Over the years species extinction has increased at such an alarming rate that it has become essential to find new ways of keeping track of species and their current status. Consequently, making it easier to determine which species require more protection than other species. One such way is by assembling updated Red Data lists, like the latest national Red List of South African plants (SANBI, 2009). This list contains 1228 species listed as rare, 716 species as

endangered, 364 species as critically endangered, 76 species as critically endangered and possibly extinct, and 33 species considered to be extinct.

In Ganyesa three species are listed in the Red List as declining species, namely *Acacia erioloba*, *Boophone disticha* and *Hypoxis hemerocallidea* (Table 5.6), meaning there are threatening processes that are nationally causing the continuous decline of these species. *Acacia erioloba* is declared a protected tree species according to the National Forests Act of 1998 (Act 84 of 1998) of South Africa. *Haworthia attenuata* and *Lampranthus aureus* are considered Endangered because these species are facing very high risks of extinction in the wild - both species were found in homegardens as cultivated flora. Both *Clivia miniata* and *Lampranthus glaucus* are vulnerable species, which means they qualify as threatened species. *Gnaphalium nelsonii* is considered a rare species, while *Drimia sanguinea* is listed as a near threatened species. *Drimia sanguinea*, *Clivia miniata* and *Lampranthus glaucus* were all found in the homegardens as cultivated flora, suggesting that homegardens are safe keepers of native biodiversity, albeit on a temporary basis.

Table 5.6: Species recorded from Ganyesa that are treated in the current Red Data List as published by SANBI (SANBI, 2009).

Taxon name	Origin	National Status	
Haworthia attenuata (Haw.) Haw. var. *attenuata*	Cultivated	Endangered	
Lampranthus aureus (L.) N.E.Br.	Cultivated	Endangered	
Clivia miniata Regel var. *miniata*	Cultivated	Vulnerable	
Lampranthus glaucus (L.) N.E.Br.	Cultivated	Vulnerable	
Drimia sanguinea (Schinz) Jessop	Cultivated	Near Threatened	
Gnaphalium nelsonii Burtt Davy	Natural	Rare	
Acacia erioloba E.Mey.	Natural	Declining	Protected tree
Boophone disticha (L.f.) Herb.	Natural	Declining	
Hypoxis hemerocallidea Fisch., C.A.Mey. & Ave-Lall.	Cultivated	Declining	

5.3.5 Species distribution

Predominantly, 70% of the native and naturalized species found in all the land-use areas in Ganyesa had a widespread distribution in southern Africa (Fig. 5.3). In the homegardens, institutional gardens and natural areas, 10% of the species originated from the ócentral provincesô(North-West, Limpopo and Free State, including Botswana). These include species such as *Eragrostis lehmanniana*, *Crotalaria lotoides* and *Gnaphalium nelsonii* as the dominant species. Furthermore, only 6% of all species that originated from the ócentral provincesôwere found in all seven land-use types, for example species such as *Selago mixta*. A maximum of 3% of the species in homegardens originated from the ósouth-western provincesô (Western Cape and Eastern Cape) and only 1% of these species were also found in both the fragmented natural areas and institutional gardens, for example species such as *Hypertelis arenicola*,

*Agave decipiens** and *Schinus molle**. Both *Agave decipiens** and *Schinus molle** are naturalized species that have moved from the home and institutional gardens into the fragmented natural areas.

A minimum of 3% of all species such as *Geigeria burkei*, originate from the ‘eastern provinces’ (KwaZulu-Natal, Gauteng and Mpumalanga, including Swaziland) and were recorded in all seven land-use types. The majority of species originate from both the ‘eastern’ and ‘western’ provinces (Northern Cape, including Namibia and Lesotho). These species can be cultivated flora or invasive weeds. However, most of the species originating from the ‘western provinces’ occur in the institutional gardens and are mostly cultivated succulents or drought tolerant, and include species such as *Aloe grandidentata*. *Harpagophytum procumbens*, *Verbesina encelioides** and *Ornithoglossum dinteri*, and was found in most of the land-use types. The majority of the species that occur in the wetlands have a widespread distribution and can therefore be classified as cosmopolitan species.

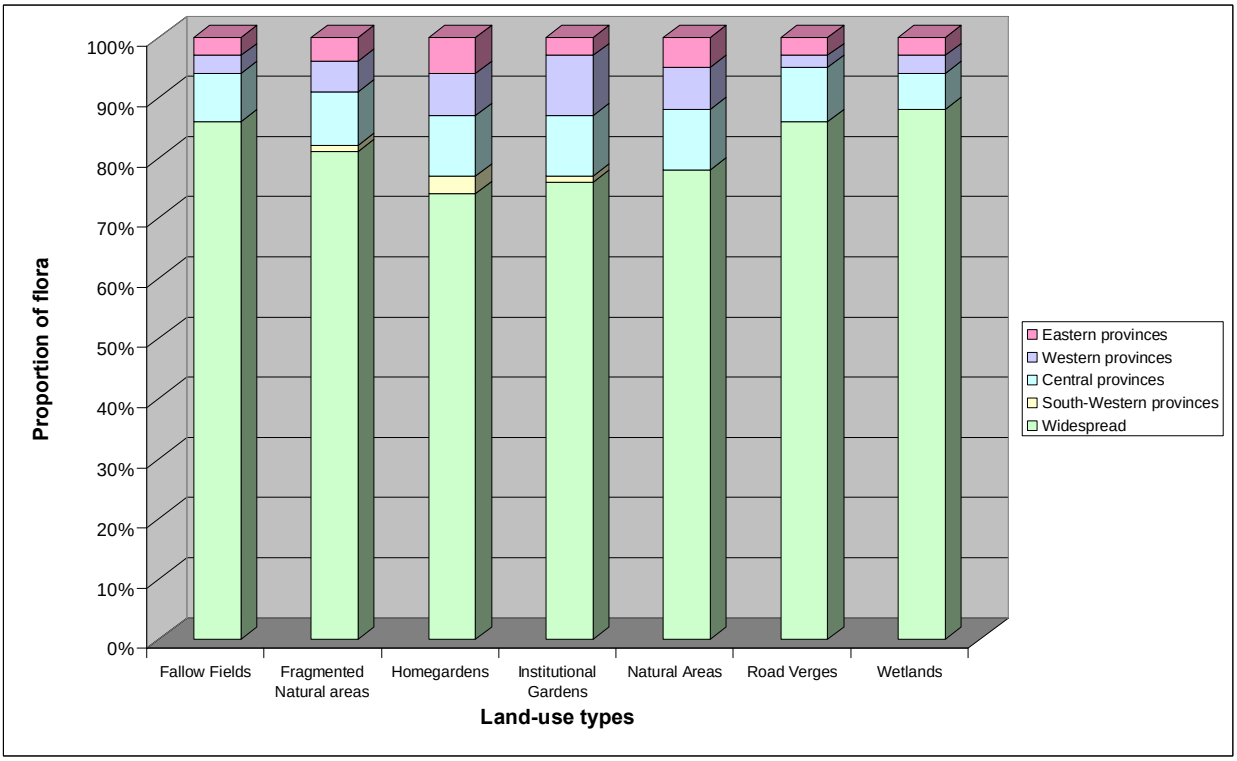


Figure 5.3: Chorological analysis of each of the different land-use types in Ganyesa.

The majority of the cultivated alien species originate from Asia (27%), South America (26%), Eurasia (12%) and North America (12%) (Fig. 5.4). Only 7% originate from Africa, 8% from Europe and 6% from Australia. The most dominant species that originated from Asia was *Prunus armeniaca** and *Punica granatum**, while the dominant species originating from South

America was *Lycopersicon esculentum* var. *esculentum** and from Eurasia was *Ficus carica** and *Sambucus nigra* subsp. *nigra**.

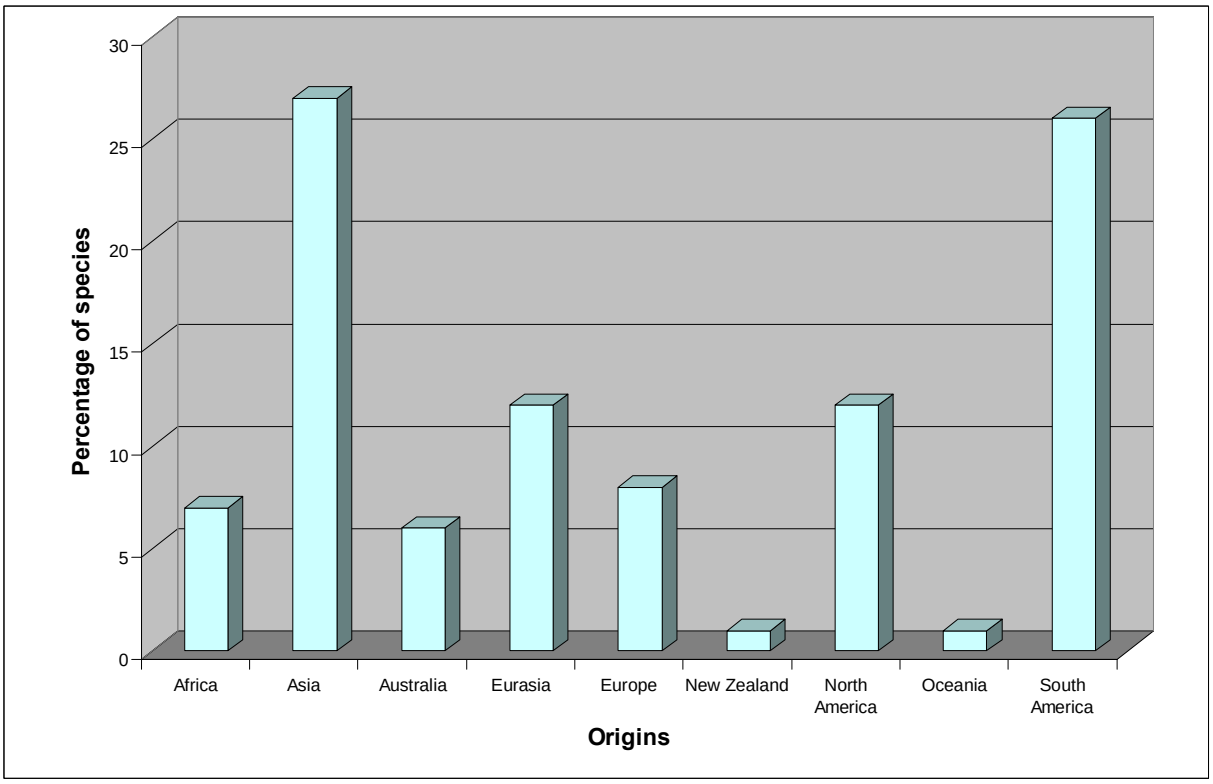


Figure 5.4: Origins of the cultivated alien species in the homegardens of Ganyesa.

5.3.6 Species richness of the different land-use types

In total, 294 recorded species are indigenous, of which 238 species are native (occurs naturally in the Ganyesa region). In contrast, 222 species are aliens, of which 57 species are naturalized (Fig. 5.5). When compared to the other land-use types homegardens had the largest number of alien and naturalized species (Fig. 5.6), and as expected the largest number of cultivated indigenous species. The majority of all alien, indigenous and native species in homegardens originate from the horticultural flora, which explains their high representation. *Prunus persica** was the dominant cultivated alien species, *Guilleminea densa** and *Chenopodium carinatum** were the dominant naturalized species, *Cynodon dactylon* was the dominant native species and *Portulaca grandiflora* the dominant cultivated indigenous species recorded for the homegardens (Table 5.7).

In the institutional gardens a similar pattern was evident since most of the species are cultivated alien or indigenous plants. However, there are many native species in home and institutional gardens since both land-use types harbour intact natural areas within the garden setup, where development or landscaping has not taken place. The true natural areas outside garden setups, however, had the largest number of native species, of which *Aristida congesta* subsp.

barbicollis was the most dominant grass species, *Bulbine abyssinica* the dominant forb species, *Acacia hebeclada* the dominant shrub species and *Acacia erioloba* the dominant tree species.

Table 5.7: The ten most dominant cultivated alien, naturalized, cultivated indigenous and native species recorded for the homegardens in Ganyesa.

Cultivated alien	Naturalized
Prunus persica (L.) Batsch. var. *persica**	*Guilleminea densa* (Willd. ex Roem. & Schult.) Moq.*
Zea mays L.*	*Chenopodium carinatum* R.Br.*
Vitis vinifera L.*	*Schkuhria pinnata* (Lam.) Cabrera*
Nerium oleander L.*	*Euphorbia prostrata* Aiton*
Morus alba L. var. *alba**	*Verbesina encelioides* (Cav.) Benth. & Hook. var. *encelioides**
Cucurbita pepo L.*	*Gomphrena celosioides* Mart.*
Canna indica L.*	*Oxalis corniculata* L.*
Arundo donax L.*	*Acanthospermum glabratum* (DC.) Wild*
Lycopersicon esculentum Mill. var. *esculentum**	*Schinus molle* L.*
Ficus carica L.*	*Bidens bipinnata* L.*

Cultivated indigenous	Native
Portulaca grandiflora Hook.	*Cynodon dactylon* (L.) Pers.
Tulbaghia simmleri P.Beauv.	*Eragrostis lehmanniana* Nees var. *chaunantha* (Pilg.) De Winter
Pelargonium hortorum L.H.Bailey	*Aristida congesta* Roem. & Schult. subsp. *congesta*
Cotyledon orbiculata L. var. *oblonga* (Haw.) DC.	*Felicia muricata* (Thunb.) Nees subsp. *muricata*
Carpobrotus dimidiatus (Haw.) L.Bolus	*Eragrostis trichophora* Coss. & Durieu
Drimiopsis maculata Lindl.	*Acacia hebeclada* DC. subsp. *hebeclada*
Artemisia afra Jacq. ex Willd.	*Sida cordifolia* L.
Acacia galpinii Burtt Davy	*Senna italica* Mill. subsp. *arachnoides* (Burch.) Lock
Rhus pendulina Jacq.	*Gisekia pharnacioides* L. var. *pharnacioides*
Lampranthus roseus (Willd.) Schwantes	*Pollichia campestris* Aiton

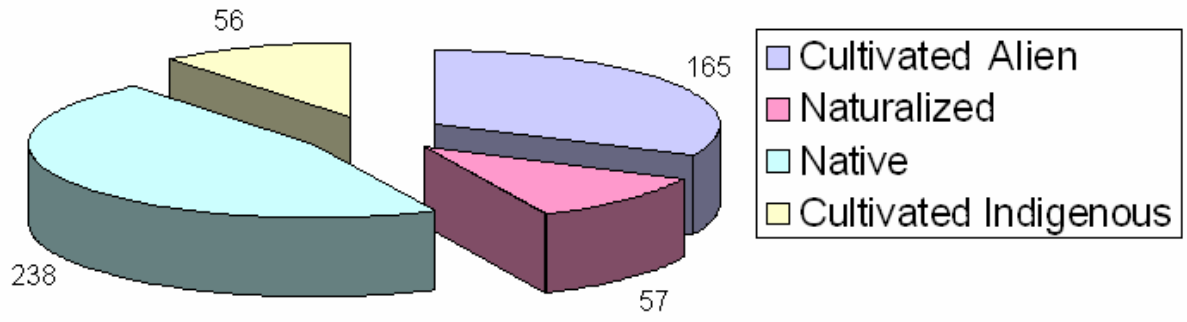


Figure 5.5: Total species richness composition of Ganyesa depicted as alien, naturalized, native and indigenous (n = 516).

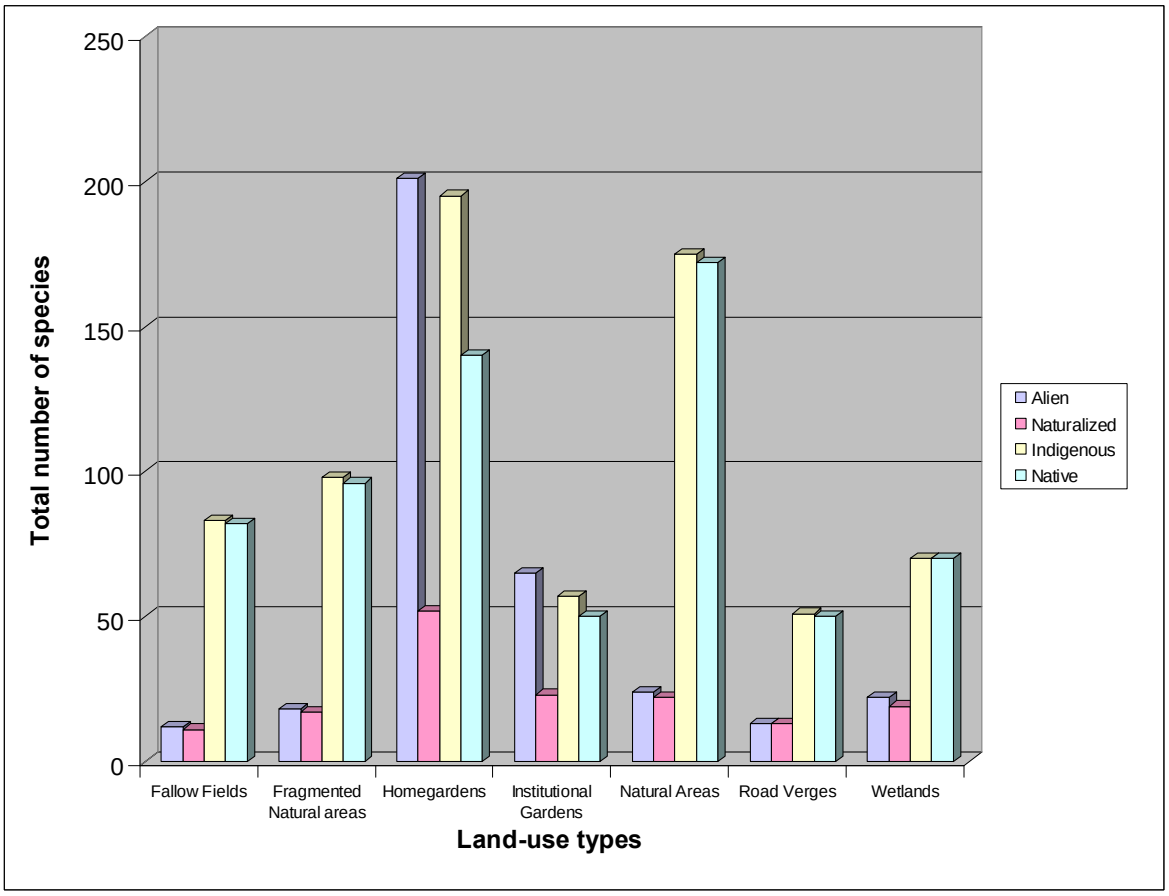


Figure 5.6: Comparison of the species richness composition of the land-use types of Ganyesa. The alien bar includes both the alien and naturalized species data, the indigenous bar includes both the indigenous and native species data and the native and naturalized species data is indicated separately.

5.3.7 Growth forms

A rich diversity of forb (non-graminoid herbaceous) species (Fig. 5.7) occur in Ganyesa. Based on the number of species per growth form, the most dominant forbs were *Sida cordifolia*, *Guilleminea densa** and *Schkuhria pinnata**. In total 164 forb species were recorded for the homegardens and 110 forb species were recorded in the natural area. The natural areas are dominated by mostly grass, forbs and shrub species, such as *Cynodon dactylon*, *Pollichia campestris* and *Acacia hebeclada* subsp. *hebeclada* respectively. In the homegardens, however, *Dodonaea viscosa* var. *angustifolia* was the dominant shrub species. The richest diversity of succulent species was recorded in the homegardens, of which the most dominant species were *Bulbine abyssinica* and *Portulaca quadrifida*. *Prunus persica** and *Acacia erioloba* were the dominant tree species, with the former only found in homegardens as part of the cultivated flora, while the latter was mostly found in the natural areas, but also remains in a few home and institutional gardens. *Ornithoglossum dinteri* is the dominant geophyte species recorded for Ganyesa and was found in most of the land-use types. In comparison with all the other land-use types, the homegardens had the richest diversity of trees, succulents,

geophytes, shrubs and forbs; most of which are cultivated species. Natural areas are characterised by the highest number of graminoids.

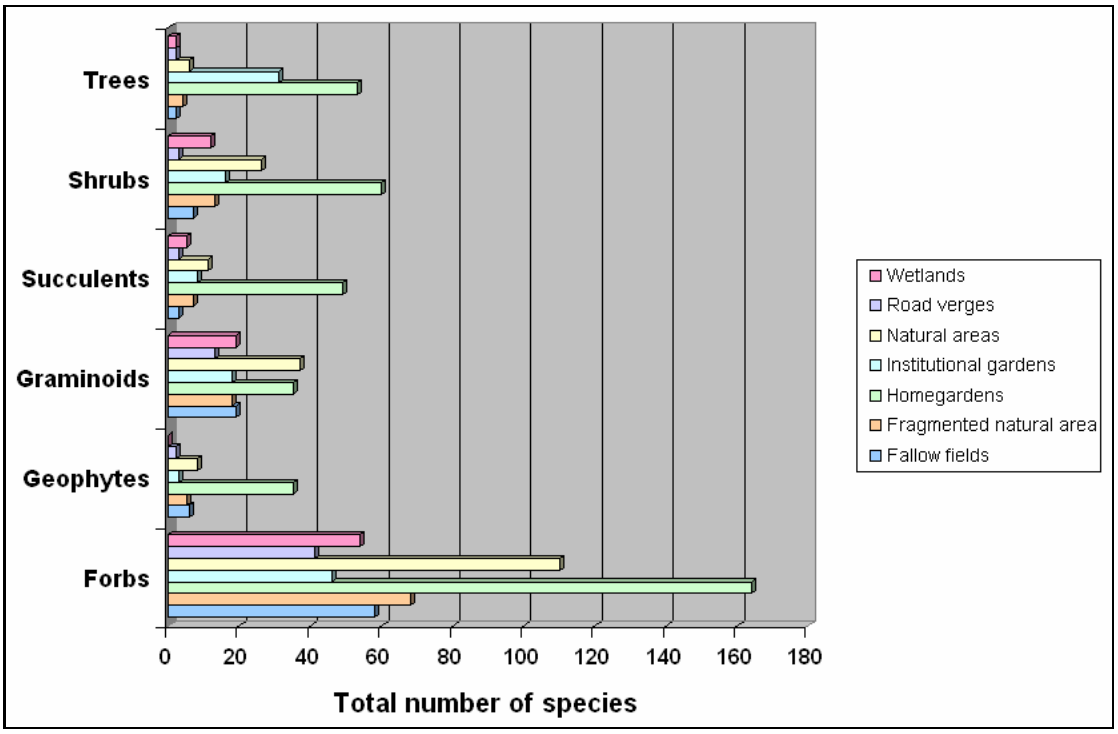


Figure 5.7: Number of species per growth form for each of the seven land-use types in Ganyesa.

5.3.8 Useful cultivated flora

The inhabitants of Ganyesa are greatly dependent on their homegardens for both food and financial support. Therefore, most of the plants cultivated in homegardens serve one or multiple purposes, the majority of which are cultivated for medicinal, ornamental or dietary purposes (Fig 5.8). *Prunus persica** and *Zea mays** are the most frequently cultivated for dietary purposes, while the naturally occurring *Tarchonanthus camphoratus* is one of the most popular species for medicinal purposes. *Bulbine abyssinica* is the most favoured for both ornamental and medicinal purposes and *Verbesina encelioides** is most often cultivated for ornamental purposes.

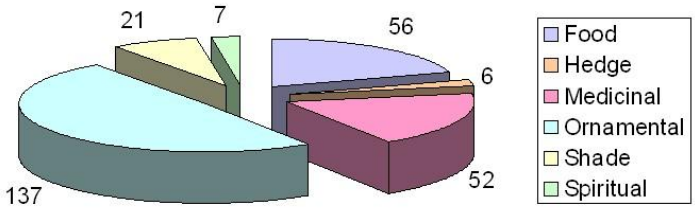


Figure 5.8: Number of species in each plant use category of cultivated species in homegardens of Ganyesa.

5.4 Discussion

5.4.1 Dominant families and species composition

Four of the ten most dominant plant families in South Africa were dominant in Ganyesa (Table 5.3). Families such as Rosaceae, Lamiaceae and Crassulaceae represent three of the ten largest families in Ganyesa and their high abundance can be attributed to the extensive cultivation of these groups as part of the ornamental flora. The families, Amaranthaceae and Chenopodiaceae were also dominant in homegardens since they are mostly cultivated for their nutritional value.

Consequently, the majority of the plant families in homegardens of Ganyesa are cultivated for their multifunctionality. Similarly the study of Das and Das (2005) indicated that most of the plant families in Barak Valley, Assam, North East India were cultivated for multiple use. However, the majority of the dominant species in Ganyesa were common native and naturalized weeds, all of which occur in disturbed areas and consequently were found in almost all the different land-use types. Similarly the study of Thompson *et al*. (2003) found that the majority of the 20 most frequently occurring species in gardens in the city of Sheffield were native or alien weeds.

5.4.2 Endangered and endemic species

Godefroid (2001) found that rare species can in fact occur within highly urbanised and densely populated areas. In Ganyesa six of the nine species listed in the Red Data list of South Africa, and nineteen of twenty-four South African endemic species were cultivated in homegardens. Many of these species are cultivated for their multiple uses, for example *Haworthia attenuata* var. *attenuata* for its ornamental and spiritual value, while *Clivia miniata* var. *miniata* is cultivated for its ornamental and medicinal value. Similarly the study of Das and Das (2005) found that homegardens are important sites for *in situ* conservation of plant diversity since many wild and rare tree species were found in the homegardens of Barak Valley, cultivated and consequently conserved due to their high commercial value.

The study of Blanckaert *et al*. (2004) found that 10% of the plants growing in the homegardens of a small village in the Tehuacán-Cuicatlán Valley in the State of Peubla, South-Central Mexico, were protected plants grown for their multiple uses. The current study emphasizes the important role that homegardens can play in the conservation of endemic and endangered species. However, the conservation of these species is in turn greatly dependant on the home owners since they are the ones that decide which species are cultivated and which are removed. These decisions in turn are adversely affected by fashion and the socio-economic status of the home owners (See Chapter 6).

5.4.3 Species distribution

The study of Marco *et al.* (2008) found that the majority of cultivated taxa recorded for homegardens in the village of Lauris in south-eastern France, originated from the Americas, Eurasia and Africa. Similarly the study of Thompson *et al*. (2003) found that the alien species found in the homegardens of Sheffield were overwhelmingly from Europe and Asia, with significant minorities originating from New Zealand, North and South America. The Ganyesa study also found that the majority of the cultivated alien species in Ganyesa originated from the Americas and Eurasia. Many of these Asian and American species flourish in South Africa as they are inherently capable of surviving in warmer climates. These cultivated alien species are all sought for their multipurpose uses as sources of food, income and ornamentals.

5.4.4 Species richness: indigenous and alien species composition

This study confirms that homegardens contain a large cultivated biodiversity, mainly dominated by alien species. A total of 396 species were recorded from the homegardens, 51% were characterized as alien (of which 26% were considered to be naturalized species) and only 49% were characterized as indigenous (of which 72% were considered to be native species). Consequently, the dominant species in homegardens are alien. Similarly, the study of Marco *et al*. (2008) confirmed that private gardens contain a large cultivated biodiversity, strongly dominated by perennial and woody alien species, and the study of Smith *et al*. (2006c) inventoried 798 alien species for 12 700 m² of gardens in Sheffield. The study of Loram *et al*. (2008a) recorded 29% British native species and 71% alien species across five cities in the UK. Therefore, it is acceptable to say that the majority of horticultural species that have been introduced into urban habitats are alien (Smith *et al*., 2006c; Marco *et al*., 2008) and can therefore have both a negative and a positive effect on the natural environment (Marco *et al*., 2008).

The introduction of these alien species can help to increase the biodiversity in urban habitats, but in the same instance it reduces the biological uniqueness of natural environments (McKinney, 2006; Marco *et al*., 2008). According to Marco *et al.* (2008), the development of gardens near natural areas holds a possible threat for the native vegetation, which is exposed to reservoirs of potentially invasive plants and genetically transformed species which can lead to development of hybrid species or ósuperôweeds. In total 201 alien species were recorded in the homegardens of Ganyesa, of which 52 species are naturalized species. These naturalized species could pose a threat to the native species diversity as they invade the natural areas from the homegardens and consequently decrease the natural biodiversity by out-competing the native species (Marco *et al*., 2008).

5.4.5 Growth forms and useful cultivated flora

The homegardens in Ganyesa contained the richest species diversity in all six growth form categories (Fig. 5.7). Most of these growth forms are cultivated for specific reasons. In Ganyesa six major plant use categories were identified in homegardens, namely shade, hedge, ornamental, nutritional, spiritual and medicinal. Similarly, the study of Wezel and Bender (2003) found that fruit trees and medicinal plants were the dominant cultivated flora categories in the homegardens of three different villages in Cuba. The study of Blanckaert *et al*. (2004) found that 68% of the plants grown in Tehuacán-Cuicatlán Valley, were cultivated and approximately 60% of these cultivated species were ornamentals, 29% were edible plants and 6.5% were medicinal.

In the study of Das and Das (2005) however, eight major plant use categories were identified, the dominant use being the fruit category followed by timber and miscellaneous. Consequently, in Barak Valley, as well as in Ganyesa, the inhabitants are greatly dependent on their homegardens, whether to generate an income or for their own consumption. In Barak Valley for example trees are mainly cultivated for household consumption and to generate an income and in Ganyesa trees are cultivated for their fruit, shade and ornamental purposes, as well as to generate an income in the case of fruit trees. Similarly the study of High and Shackleton (2000) indicated that a considerable array of plant species are nurtured or actively cultivated in homegardens on residential plots in the village of Dingleydale in the Bushbuckridge region of the central lowveld in South Africa. These species have a significant cash and home consumption value.

5.5 Summary

This chapter confirms that homegardens are floristically diverse (Thompson *et al*., 2003) and heterogeneous agroforestry systems (Das and Das, 2005). The results of this study provide evidence that homegardens are more species rich than any of the other land-use types of a rural village in South Africa. However, natural areas, which contained the second highest species richness, are more homogeneous than homegardens in terms of species diversity (Chapter 4). The majority of the species found in homegardens were cultivated horticultural floras and native and alien weeds, which furthermore confirms that homegardens contain a large plant biodiversity, the majority of which are alien or naturalized species. The cultivation of alien species in homegardens further decreases the natural biodiversity of rural and urban areas.

However, homegardens may also provide a refuge for endemic or threatened species (Das and Das, 2005). The majority of such species found in Ganyesa were cultivated in homegardens. Consequently, the conservation of these species are in turn greatly dependant on the home

owners, whose cultivation decisions are in turn adversely affected by fashion and their socioeconomic status. However, homegardens are floristically diverse and dynamic agroforestry systems that can serve as *in situ* conservation sites. Many rare and endangered species are conserved in homegardens because of their commercial and nutritional values. Consequently, homegardens should be taken into consideration for future conservation or biodiversity management projects.

Homegardens sustain the growth of a rich and diverse mixture of multipurpose species, which satisfy the various needs of households in Ganyesa. Products produced by homegardens are primarily consumed by the household or sold as a means of generating an income. Consequently, homegardens play an important part in subsistence of the inhabitants of Ganyesa. The perceptions in terms of plant and gardens, and socioeconomic status of the inhabitants of Ganyesa will be further discussed in chapter 6.

Chapter 6 - Socioeconomic survey and satisfaction of life in Ganyesa

"The world's human population is becoming concentrated into cities, giving rise to concerns that it (human population) is becoming increasingly isolated from nature" (Fuller *et al.*, 2007).

6.1 Introduction

The majority of people living in urban areas are dependent on remnant or managed public urban green spaces for direct contact with the natural environment (Fuller *et al.*, 2007). Smith *et al.* (2006a) define urban green spaces as undeveloped land in towns and cities. Sports fields, derelict land, public parks, natural or semi-natural areas, road verges, waterways, railways and homegardens are a few examples of green spaces (Smith *et al.,* 2005; Caula *et al.,* 2009). Green spaces are fundamental to the restoration and maintenance of biodiversity in areas that have been severely impacted by urban development and it provides numerous ecosystem services (Thompson *et al*., 2005; Gaston *et al*., 2005b), in addition to playing an important role in the physical and mental well-being of the human population (Niemelä, 1999).

Over the past two decades a great deal of research has been conducted on the positive response that a range of human well-being measures have had on the availability of green spaces, measures such as peopleôs general health, their degree of social interaction, mental fatigue and opportunities for reflection (Fuller *et al.*, 2007). Contact with nature or exposure to green elements, such as the gardens at hospitals help to improve the general health of patients, promote a faster recovery from surgery and provides patients with a sense of well-being (Ulrich, 1984; Elings, 2006; Lafortezza *et al.,* 2009). The occurrence of green care farms has also increased over the last few years because they help people to deal with stress, improves a sense of spiritual well-being and provides a sense of accomplishment (Elings, 2006). The study of Kaplan (1995) found that green spaces help to restore human cognitive capacities such as direct attention and the study of Hartig (2008) found that green space environments appear to have a greater capacity, compared with built-up ones, of promoting psychological restoration. However, despite their enormous potential, homegardens are seldom included in estimates of the extent of green spaces and their effect on the psychological well-being of humans (Gaston *et al.,* 2005b).

According to Vogl *et al.* (2004) the study of homegardens as distinct ecological and cultural entities in agriculture was initiated in the tropics of Southeast Asia and dates back approximately 25 years. However, the BUGS (Biodiversity in Urban Gardens in Sheffield) project in the city of Sheffield in the United Kingdom was among the first to determine the size and composition of the resources that homegardens provide for biodiversity and ecosystem

functioning in urban areas (Thompson *et al*., 2005). Homegardens in the context of this study, similarly to the study of Koyenikan (2007) conducted in the Southern agro- ecological zone of the Edo State in Nigeria, can be defined as a garden around the house for the production of a variety of foods and agricultural products for both home consumption and income generation. According to Koyenikan (2007) there are several reasons for the establishment of homegardens, such as increases to monthly income, food production, nutrition and the general health status of the household. However, in order to better understand the diverse composition of homegardens or the rationale behind various gardening decisions, certain socioeconomic factors need to be taken into consideration, as well as the socioeconomic status of the participants.

The WorkWell, Research Unit for People, Policy and Performance (2004) conducted a social survey in Potchefstroom, the aim of which was to obtain a representative indication of the socioeconomic status of Potchefstroomõs population and the satisfaction with life and emotional wellness of Potchefstroomõs citizens. A similar study has not been compiled for Ganyesa yet. The major objectives of this chapter were therefore to determine the (1) perceptions Ganyesa residents hold concerning their gardens, (2) level of gardening activity, (3) socioeconomic status (SES) and (4) emotional well-being and satisfaction with life.

6.2 Materials and Methods

6.2.1 Social survey

ArcView 9.2 (Esri, 2006) was used to overlay a 500 m point grid over the settlement and as mentioned in Chapter 4, vegetation surveys were done for each of the points on the grid. The 55 homegardens used for the vegetation survey were also used for the social survey in order to compare the vegetation data with the social survey data (Chapter 7). The homegardens extended over the entire settlement within different socioeconomic areas of Ganyesa, which insured that the data were representative of the entire settlement. The social survey was conducted with the aid of questionnaires (Appendix 3), which were used to determine the residents perceptions concerning the various aspects of their gardens, as well as to calculate their socioeconomic status (SES), gardening activities, emotional well-being and their satisfaction with life. However, questionnaires were completed for only 53 (96%) of the 55 homegardens due to the availability of residents at the time of the survey.

6.2.2 Questionnaire

The first questionnaire was tested during a preliminary survey to determine how the participants would react to the questions. The feedback from the preliminary study suggested that there were too many questions, resulting in the survey taking longer than expected. Participants also felt uncomfortable about answering certain questions. Consequently, the questionnaire was

restructured with certain questions being removed from and new questions being added to the questionnaire based on the specific livelihood needs of the residents (Figure 6.1). The questionnaire was divided into four different sections, namely; (1) perceptions, (2) levels of gardening activity, (3) socioeconomic status (SES) and (4) satisfaction with life and emotional well-being questions.

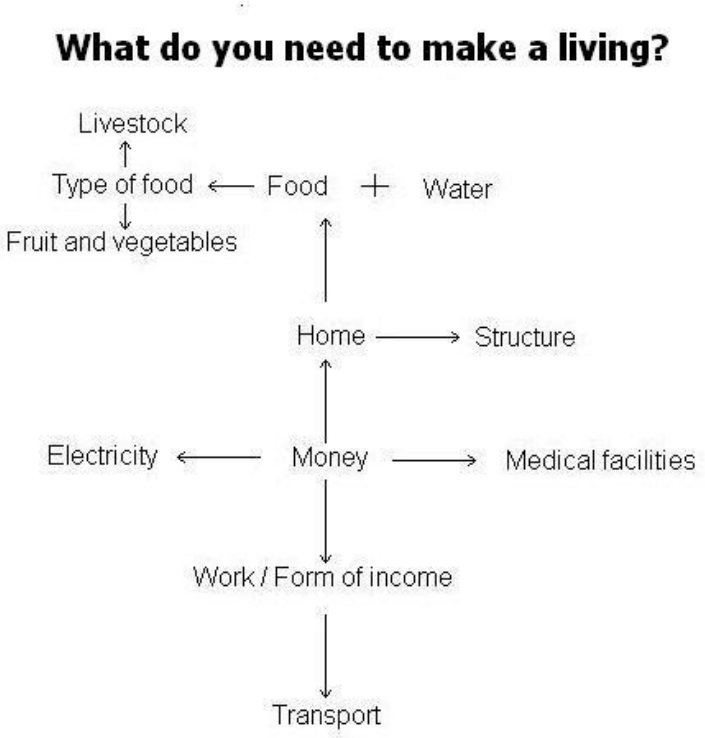


Figure 6.1: A schematic representation for the development of the questionnaire, for the social survey in Ganyesa, after the preliminary survey was completed and evaluated.

6.2.3 Procedures for completing the social survey

As mentioned in Chapter 3, the majority of residents in Ganyesa are Tswana speaking. Consequently, it was necessary to employ local, Tswana speaking field workers to interview the residents. Six field workers, with previous interviewing experience, were hired to assist with the social survey. They were trained beforehand to ensure that the questionnaire was completed uniformly. The participants in the social survey were both male and female, but preferably the adult members of the household. Each participant was assured beforehand that the questionnaire is anonymous and completion thereof was voluntary. Participants were also informed that they would not be compensated for answering any of the questions. At the beginning of each day a meeting was held with all the field workers to ensure that the questionnaire was completed as accurately as possible and each question was discussed in detail to ensure that there was no confusion surrounding any of the questions. The first questionnaire was completed by the entire group of fieldworkers to demonstrate to them how each question should be interpreted and explained to the participants. Each field worker was

taken to one of the houses chosen for the survey and then left to complete the questionnaire. This was repeated three to four times per fieldworker per day depending on the time it took to complete a questionnaire. On average 20-22 questionnaires were completed per day.

6.2.4 Data analysis

6.2.4.1 Thematic context analysis

In total four perception questions were asked to better understand the respondents feelings and ideas concerning their gardens, also to better understand how they interpret the term garden. The respondents answers were analyzed by making use of a content analysis system originally created by Staton-Spicer and Bassett (1979) that used this system to analyze the orally communicated concerns generated by three sets of respondents. Firstly, the oral communication expressed by the respondents for each of the questions were identified and separated into single units or statements (Appendix 4) and listed accordingly in excel sheets. Secondly, a coding system was created which included a code for each of the questions and categories of the respondents oral communication (Staton-Spicer and Bassett, 1979). Thirdly, the statements were further analyzed in Excel to determine how many of the respondents had similar responses to the questions and what perceptions are shared.

6.2.4.2 Gardening activity

Seven questions were asked to determine the respondents level of gardening activity. For each question the respondents were given six options to choose from (Table 6.1) and each option was allocated a specific score. These scores were allocated based on the amount of time the participants spend in their gardens or spend attending to their gardens. Individuals that spend everyday in their gardens were allocated a much higher score than individuals that were only able to spend time in their gardens twice a month (Table 6.1). During the data analysis each answer was evaluated, the values of which were added into a score that represents the respondents level of gardening activity.

Table 6.1: Example of the scoring system applied for determining the level of garden activity for each of the participants in the social survey of the rural settlement of Ganyesa.

Amount of time in garden	Scores allocated
Everyday	6
Three times a week	5
Twice a week	4
Once a week	3
Once/Twice a month	2
Three times a year	1

6.2.4.3 Socioeconomic status (SES)

The study of Hope *et al*. (2003) used three socioeconomic variables, namely median family income, median age of housing stock and human population density data taken from the U.S Census of population and housing along with several variables that served as surrogates for SES. The study of Kinzig *et al*. (2005) used only median family income as a surrogate for both cultural and economic status, while the study of Martin *et al.* (2004) used median family income from the 2000 U.S Census data along with the percentage of neighbourhood population holding graduate degrees and the percentage Hispanic/Latino population as gradient measures of neighbourhood SES. However, the national South African census data from 2001 proved to be too unreliable to accurately determine the SES of the residents in Ganyesa. This could be attributed to the fact that the settlement is constantly expanding, meaning that there are large areas for which there is no data available. In addition to the lack of data, most residents do not have a fixed monthly income and consequently median family income would not be a sufficient determining factor of SES.

Therefore, questions were formulated to serve as surrogates for determining SES (Table 6.2). The participants were given several choices for each question and based on a scoring system, scores were allocated for each specific answer and the scores were added to determine each participants SES (Appendix 3). Furthermore, the participants were divided into three SES classes based on a clustering method known as Wardôs method (Ward, 1963). Wardôs clustering method is a hierarchical agglomerative method that encompasses many diverse techniques for discovering structure within complex data sets (Hervada-Sala and Jarauta-Bragulat, 2004). The several surrogates for SES along with their associated values for each participant, was analysed with the cluster analysis function of STATISTICA 8.0 (StatSoft, Inc., 2008). The objective of a cluster analysis is to group the variables into clusters such that the elements within a cluster have high degrees of ónatural associationôamong themselves, while at the same time being órelatively distinctôfrom one another (Hervada-Sala and Jarauta-Bragulat, 2004).

Table 6.2: The most important aspects used as surrogates for determining the SES of the participants in the rural settlement of Ganyesa.

1. Type of housing structure	8. Method of earning money
2. Owned or rented house	9. Modes of transport
3. Type of sanitation	10. Monthly income
4. Type of water source	11. Number of persons living on the premises
5. Distance from nearest water source	12. Number of rooms in the house
6. Fruit and vegetables in gardens	13. Highest level of education
7. Livestock	

6.2.4.4 Satisfaction with life and emotional well-being

The last section of the questionnaire addressed the satisfaction with life and emotional well-being questions. Five questions were asked to determine the participants satisfaction with life and two questions were asked to determine their emotional well-being (Appendix 3). These questions were formulated based on the questionnaire compiled for the socioeconomic survey in Potchefstroom (WorkWell, Research Unit for People, Policy & Performance, 2004). In response to the satisfaction with life questions the participants merely had to answer yes or no, while with the emotional well-being questions the participants were given three choices, namely; always, sometimes and never. The participants answers were further analyzed with Excel. These questions were used to determine the participants feelings towards certain aspects of their way of life, as well as their living conditions.

6.3 Results

6.3.1 Perceptions concerning their gardens

6.3.1.1 Perception question 1: What is a garden the way that you understand it?

In reply to this question, 89% of the participants defined a garden as a place were you can plant trees, fruit, vegetables and flowers, while only 7% considered a garden to be a means for generating an income by selling the fruit and vegetables that are grown in the garden. Only, 2% of the participants considered a garden as a means of taking care of the environment and preventing soil erosion, while the remaining 2% of the participants defined a garden as ñlifeò (respondents direct words).

6.3.1.2 Perception question 2: Do you think that it is important to have a garden?

In total 81% of the participants considered their gardens as an important means of growing fruit and vegetables, whilst 19% viewed a garden as an important means of generating an income by selling the fruit and vegetables. All of the participants regarded a garden as an important commodity.

6.3.1.3 Perception question 3: Please tell me more about your garden/yard?

In reply to this question, 53% of the participants said that the soil in their gardens were ideal for growing fruit and vegetables, 34% considered their gardens as being ñvery cleanòand 9% of the participants viewed the ornamental flowers in their gardens as the most important part thereof. However, 4% of the participants regarded their gardens as a means for building relationships with other people and for making new friends.

6.3.1.4 Perception question 4: Why do you grow ornamental flowers?

In Ganyesa, 53% of the participants grew ornamentals because they felt it made their gardens look beautiful, 2% grew them because ornamental flowers served as decorations for their

homes and 6% of the participants grew ornamentals simply because they loved flowers. However, 22% of the participants didn't grow ornamental flowers due to a lack of money to buy seed or plants, 15% of the participants considered trees as ornamental flowers, which they planted to provide shade and to act as wind breaks, whilst the remaining 2% of the participants grew ornamental flowers for the purpose of attracting visitors and consequently, as a means of making new friends.

6.3.2 Gardening activity

On average the individuals responsible for maintaining the garden were between the ages of 50 and 60, meaning that they are mostly pensioners. While completing the questionnaires it become apparent that in 47% of the households the male members were responsible for the garden, and in 51% the female members were responsible, while in the remaining 2% of the households no active interest was taken in the garden. The majority of the inhabitants of Ganyesa had relatively high levels of gardening activity, meaning they spent at least two days per week actively in their gardens. This is understandable when taking into consideration that many of the inhabitants in Ganyesa are dependant on their gardens for food and even their livelihoods. Residents with a high socioeconomic status (Class 3) had the highest level of gardening activity, but the lowest mean number of species per garden, while residents of low socioeconomic status (Class 1) had the lowest level of gardening activity, but the highest mean number of species (Fig. 6.2).

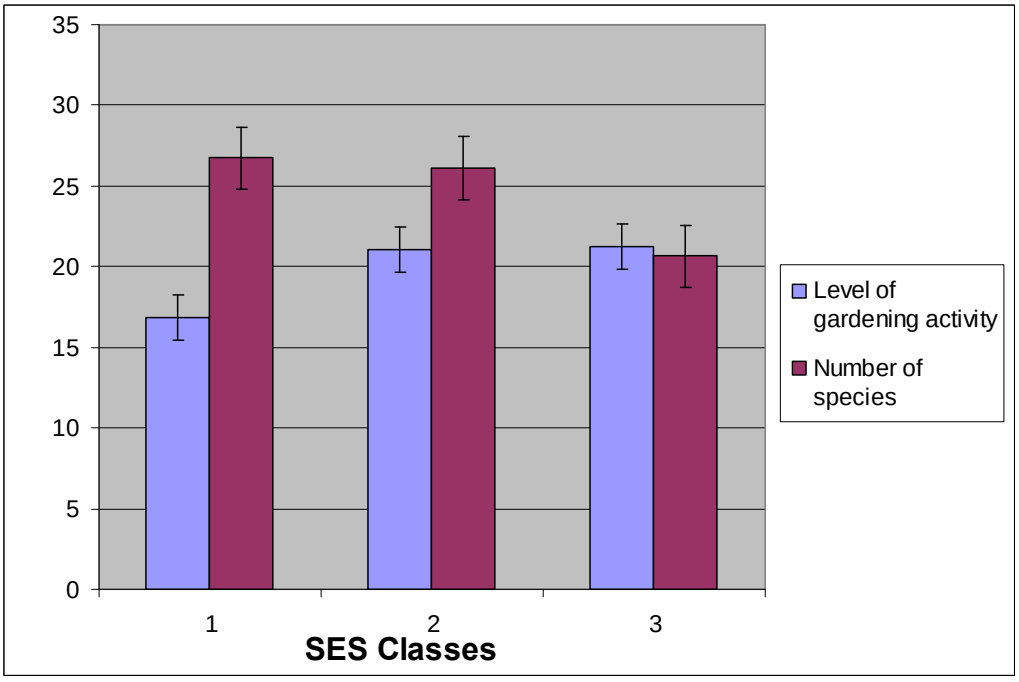


Figure 6.2: The levels of gardening activity and the average number of species found in the gardens of the respondents, arranged according to the socioeconomic classes of the participants in the social survey in the rural settlement of Ganyesa.

6.3.3 Socioeconomic status

6.3.3.1 The socioeconomic status and classes of the respondents

Based on the several surrogates used for determining SES (Table 6.2), Wardôs clustering method divided the variables into three distinct SES classes (Figure 6.3). Upon further investigation into the clusters, it became evident that the participants were grouped together mainly due to their level of education, the mean monthly income, their method of earning money and the number of residents per household. In accordance with Wardôs clustering method, the residents who formed part of class 1 had an average socioeconomic status value of 36 and were classified as having a low socioeconomic status, residents forming part of class 2 had an average socioeconomic status value of 47 and were classified as having an average socioeconomic status and the residents who formed part of class 3 had an average socioeconomic status value of 53 and were classified as having a high socioeconomic status (Fig. 6.4).

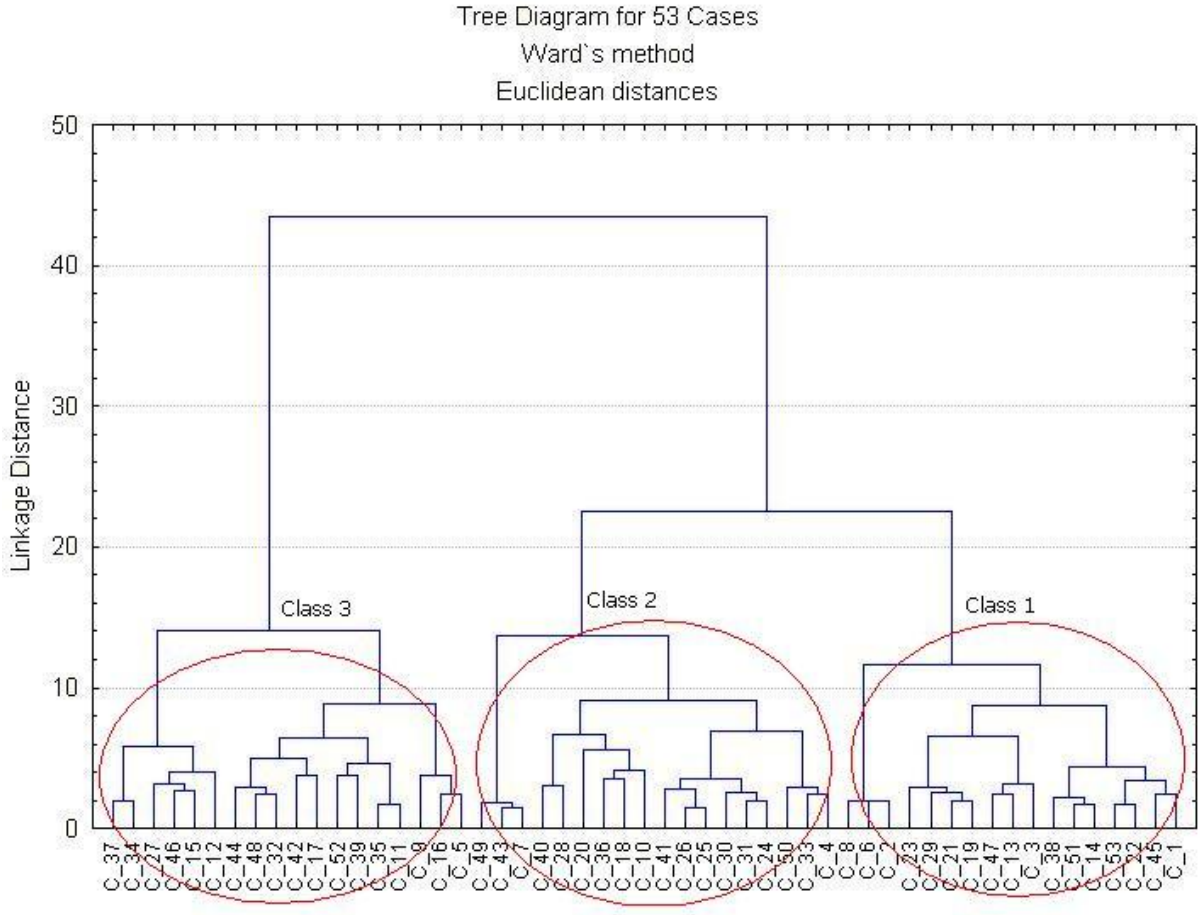


Figure 6.3: Dendrogram illustrating the formation of the three socioeconomic classes by Wardôs clustering method of the rural settlement of Ganyesa.

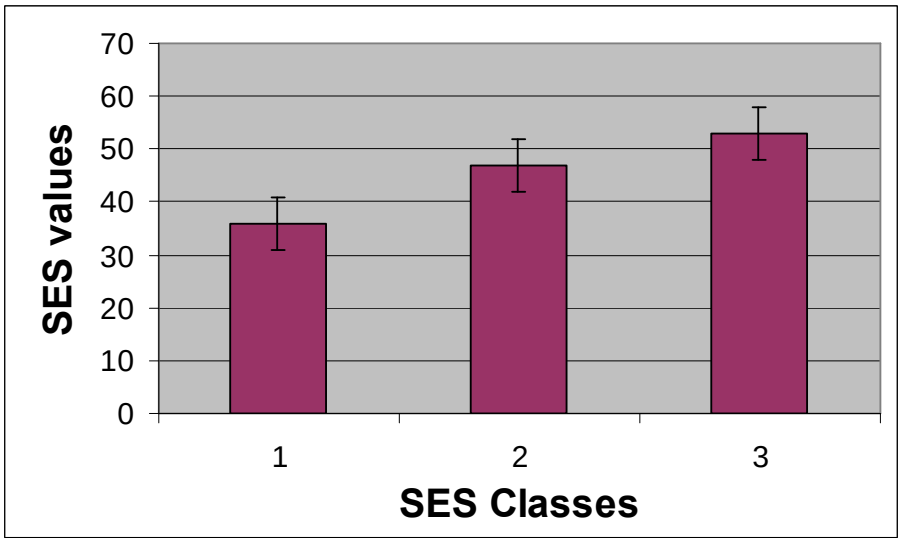


Figure 6.4: Mean socioeconomic status values of the home owners who participated in the social survey in Ganyesa, grouped according to their socioeconomic classes.

6.3.3.2 Mean monthly income

Approximately 40% of the home owners that participated in the social survey do not earn more than R 1000 a month and only 4% earn more than R 5000 (Fig. 6.5).

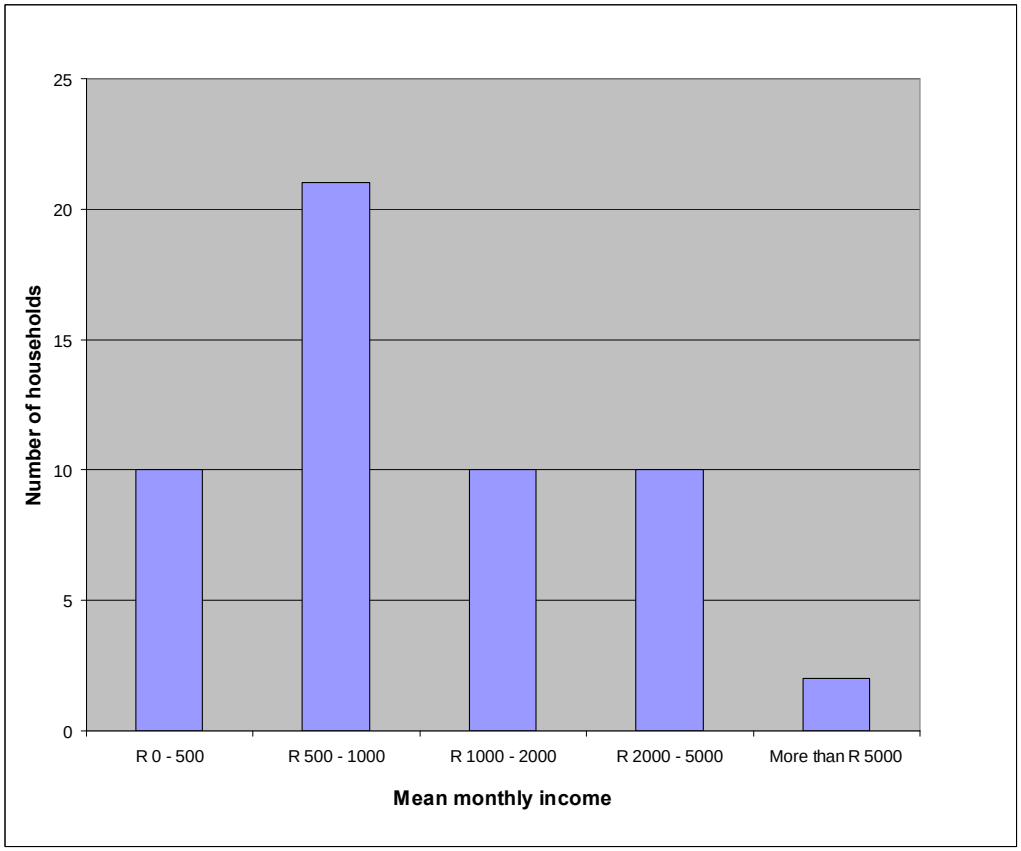


Figure 6.5: The mean monthly income of the participants in the social survey in the rural settlement of Ganyesa.

6.3.3.3 Different methods for generating an income

The majority of the inhabitants of Ganyesa relied on government grants to make a living (Fig. 6.6). Approximately 53% of the home owners that participated in the survey were pensioners and consequently received money from a pension fund, while a few of the participants received money from a disability fund. Only 9% of the participants owned businesses and 17% had a permanent job. Therefore the prevalence of low monthly incomes for most home owners could probably be ascribed to a lack of a sustainable local economy and sufficient business opportunities.

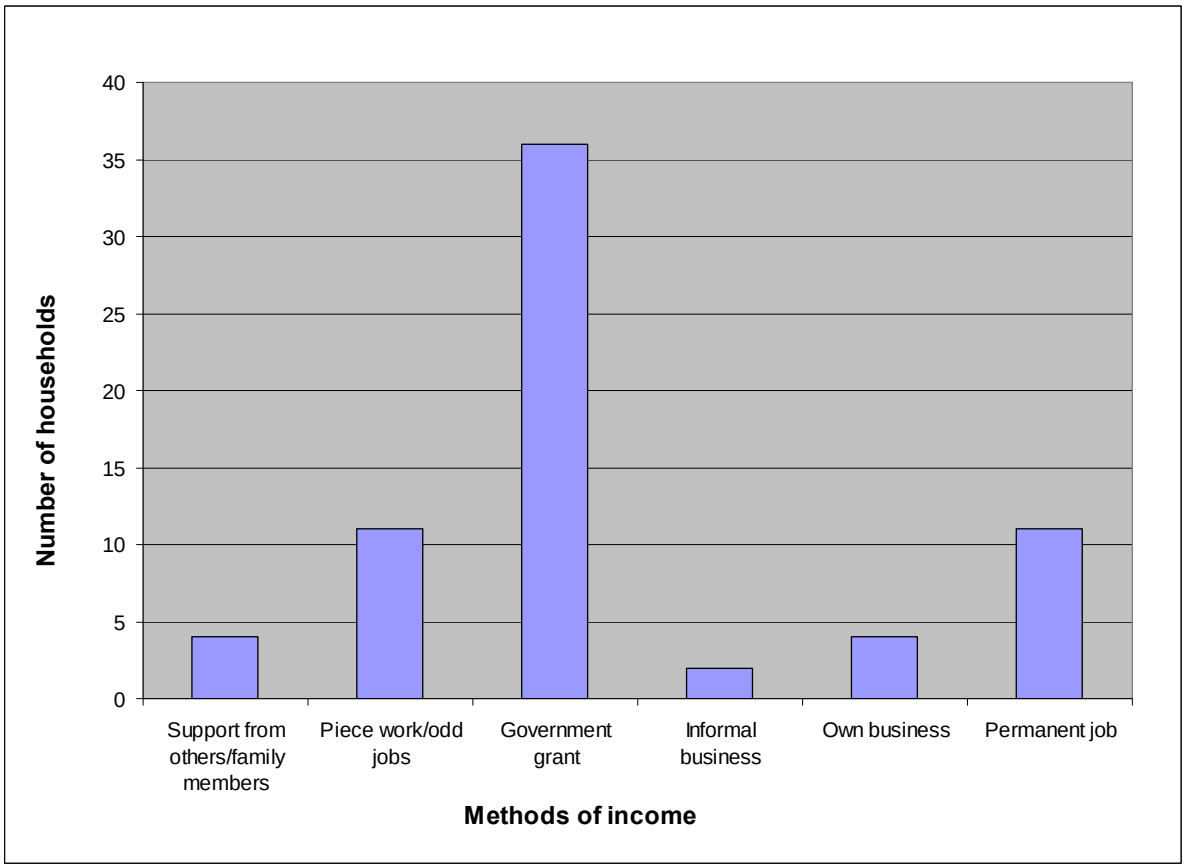


Figure 6.6: Income sources for the participants of the social survey for the rural settlement of Ganyesa.

6.3.3.4 Highest level of education

In total, 84% of the participants did not have an education level higher than secondary school, excluding Grade 12, and of this percentile 32% only attended primary school and 28% had no level of education whatsoever (Fig. 6.7). Consequently, the highest level of education for the majority of the participants was primary school. Only 10% had a Grade 12 certificate and 6% had some form of tertiary education.

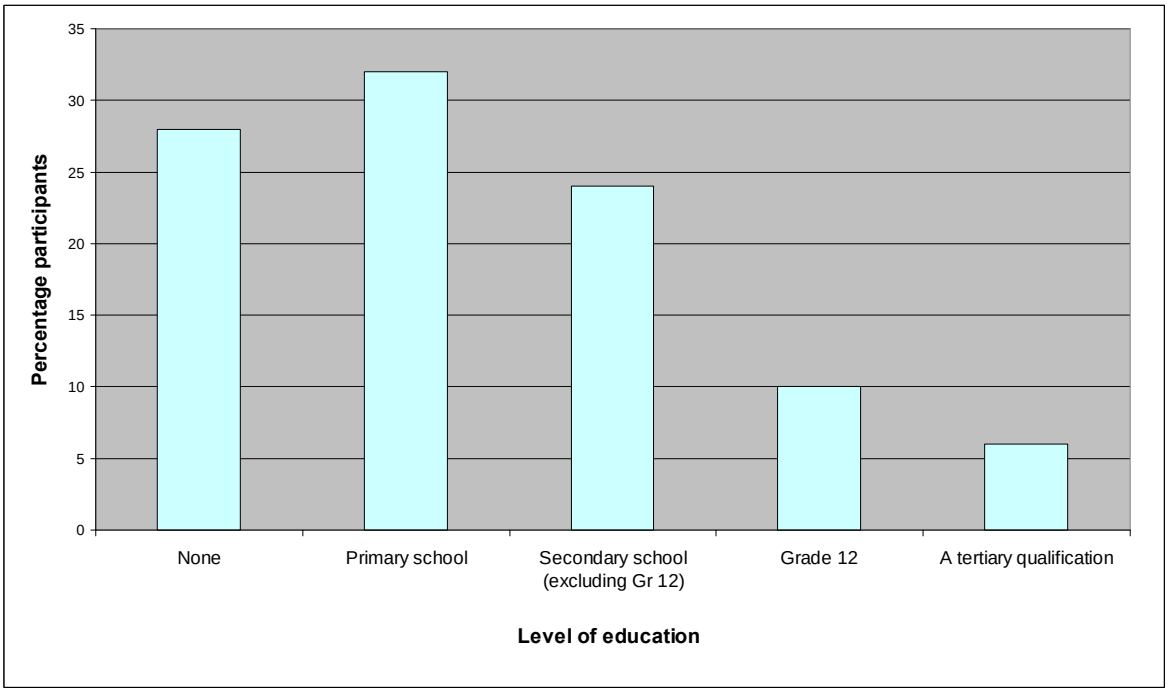


Figure 6.7: The different levels of education for the participants in the social survey of the rural settlement of Ganyesa.

6.3.3.5 Different water sources

Approximately 53% of the home owners, who participated in the survey, either had a water tap in their yard or in the neighbourôs yard (Fig. 6.8), whereas 36% of the participants were dependant on communal water taps and therefore had to carry the water home by making use of wheelbarrows or donkey carts.

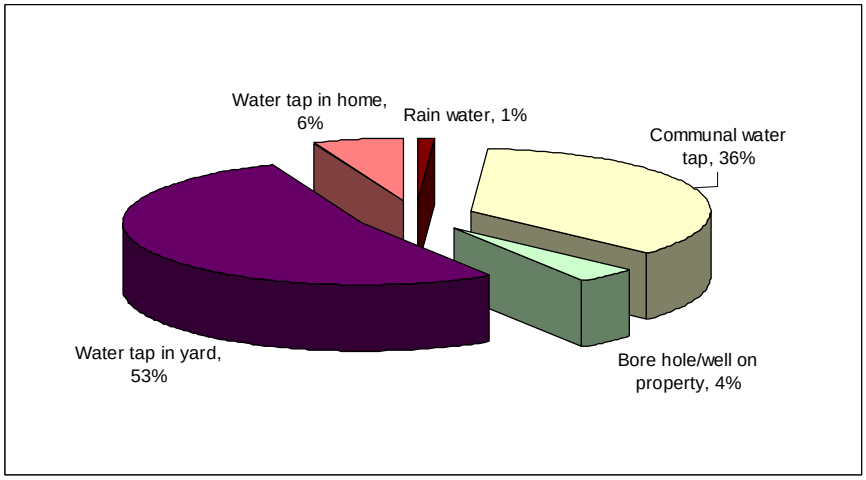


Figure 6.8: Different water sources and the number of home owners with access to it in the rural settlement of Ganyesa.

6.3.3.6 Distance from nearest water source

In total 68% the participants lived less than 100 m from their nearest water source (Fig. 6.9), and 15% lived between 500 m to 1 km away. The latter individuals made use of wheelbarrows

and/or donkey carts to retrieve the water they needed. The majority of the inhabitants in Ganyesa couldn't afford to have water pipes installed in or around their homes and consequently they were dependant on communal water taps.

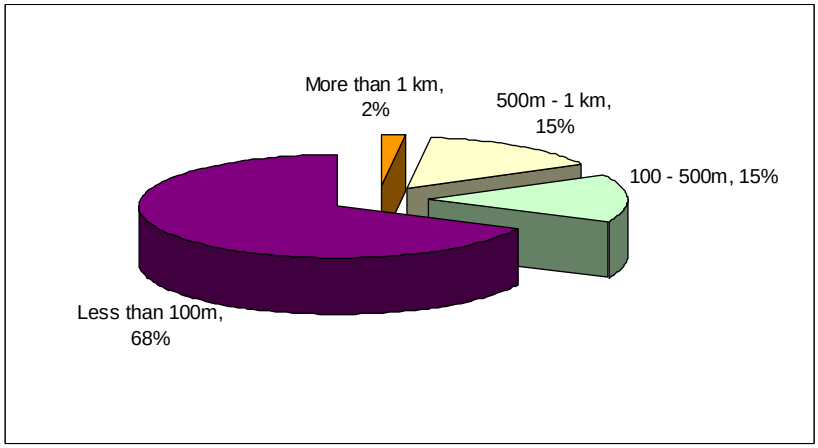


Figure 6.9: The distances from the nearest water sources for each of the participants in Ganyesa.

6.3.4 Satisfaction with life and emotional well-being

6.3.4.1 Satisfaction with life questions

In Ganyesa 60% of the participants felt that the people in their community supported each other and that their general health was good (Fig. 6.10). However, 66% of the participants in this survey felt that they were not satisfied with their lives, 57% were not satisfied with their living conditions and 62% felt that they did not have the basic resources to make a living. Consequently, a large portion of the participants were not satisfied with their current situation.

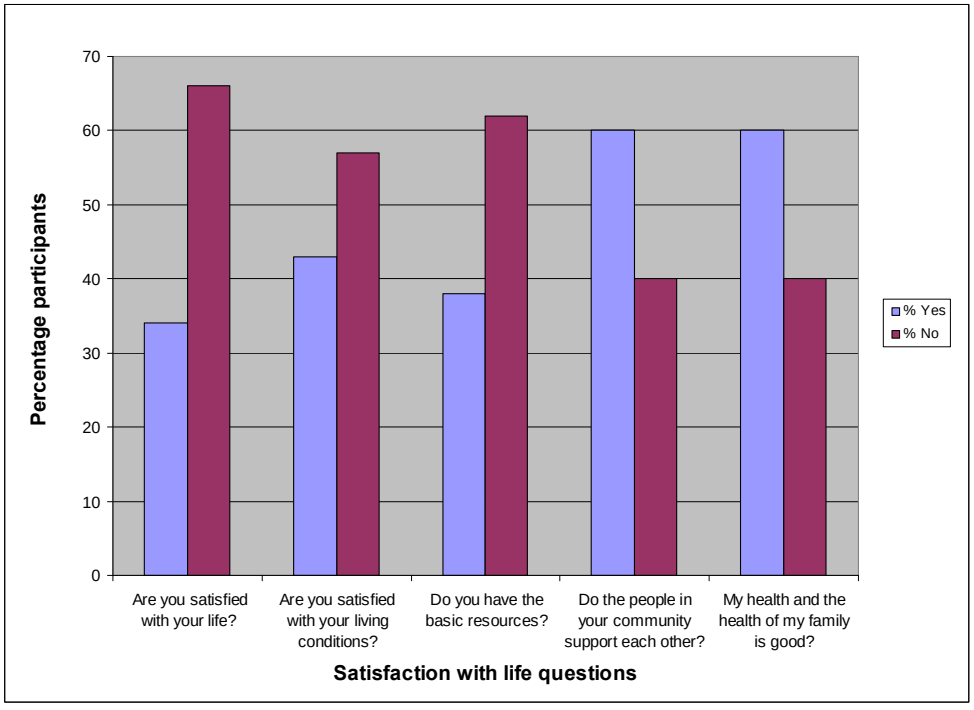


Figure 6.10: The satisfaction with life assessment in Ganyesa (2008 Survey).

6.3.4.2 Emotional well-being questions

When asked how often they felt calm, happy and peaceful, 66% of the participants replied that they only sometimes felt this way. However 25% said that they always felt this way and approximately 9% said that they never felt happy, calm or peaceful (Fig. 6.11).

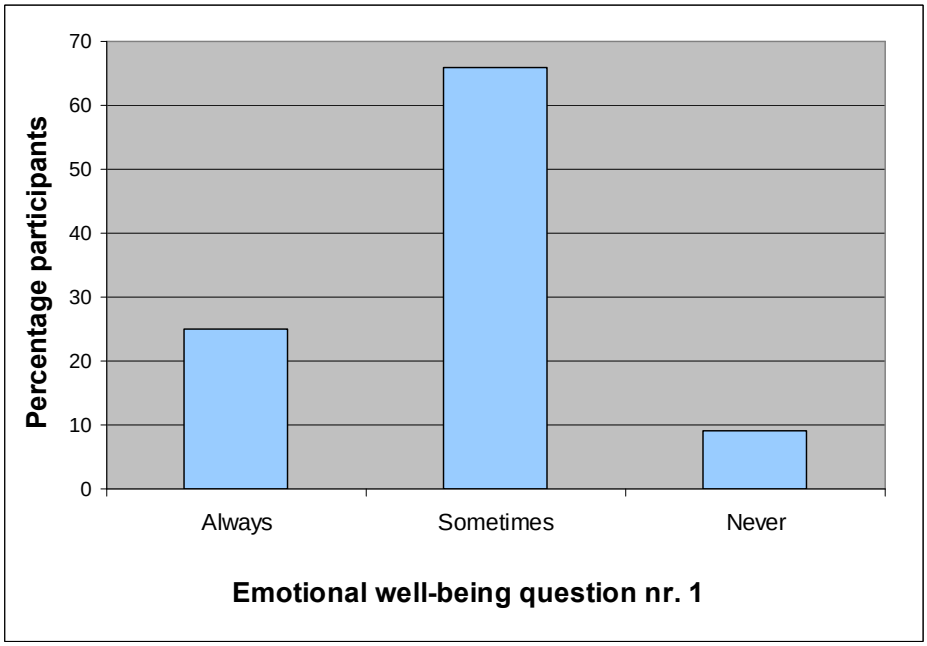


Figure 6.11: Emotional wellbeing in Ganyesa: ñHow often do you feel calm, happy and peaceful?ò

In total, 43% of the participants felt that they always had someone to turn to in times of stress, while 42% felt that they only sometimes had someone that they could rely on in difficult times. However, approximately 15% felt that they never had someone to turn to (Fig. 6.12).

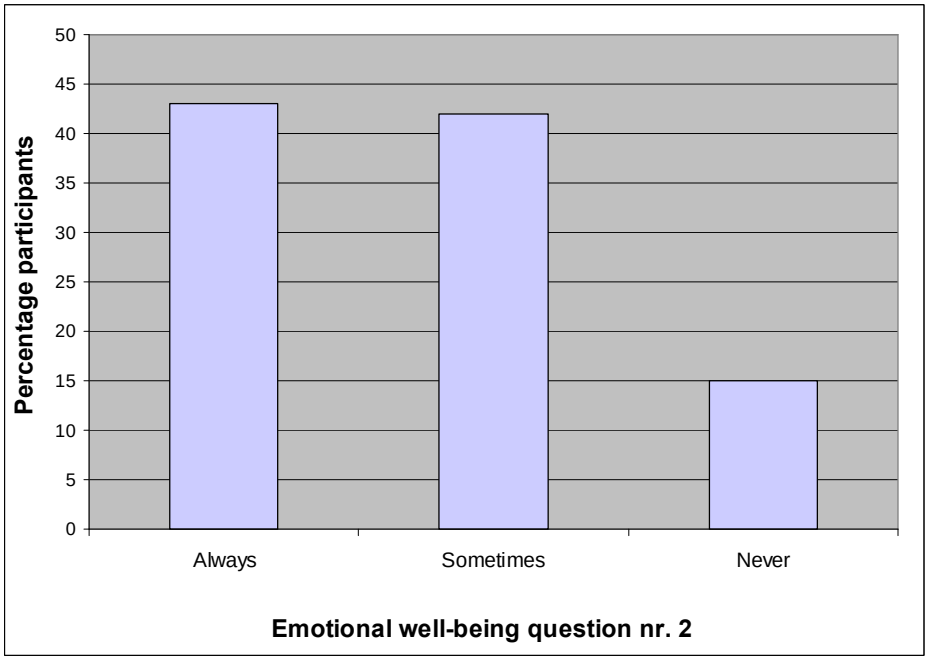


Figure 6.12: Emotional well-being in Ganyesa: ñDo you have someone to turn to in times of stress?ò

6.4 Discussion

6.4.1 Perceptions concerning their gardens

The perception questions provided valuable insights into ways in which residents in Ganyesa experienced their homegardens and helped to explain various aspects of their attitude towards gardening. The two main conceptions originating from the analysis of the perception questions were that the residents defined a garden as a place for growing their own fruit and vegetables and that one could sell these fruit and vegetables as a means of generating an income. The majority of the Ganyesa residents did not have permanent jobs and most of them were pensioners that relied on government funds. Therefore, the residents greatly relied on their gardens to provide food and a means of generating an additional income. The residents reliance on their gardens therefore further explained the residents high level of gardening activity. The analysis of the perception questions also revealed that many of the residents felt that it was important to make friends and build relationships with the people in their communities, which were enhanced by having a beautiful garden.

6.4.2 Gardening activity

As part of their culture and traditions, the Tswana people clean (sweep) their gardens, meaning that they remove all the unwanted plant material around their houses (lebala concept according to Cilliers *et al*., 2009). Consequently, the residents gardens are distinctly divided into three parts, namely the remaining natural vegetation that is gradually removed as space is required, the bare ground which is regularly swept to give a ótidyô effect, and the part of their garden in which they grow fruits, vegetables and ornamental flowers. This concept became apparent during the analysis of the perception questions since 9% of the residents felt that it was important to have a ñcleanò garden.

6.4.3 Socioeconomic status (SES)

Several surrogates where used to determine the SES classes of which three different classes where generated, but the number of residents per household proved to be an important determinant of SES. This is especially relevant in rural villages such as Ganyesa when one takes into consideration that families of all sizes may live together and not all members of the household have jobs and can therefore contribute to the family income per month.

The study of Das and Das (2005) found that only 8% of the households in Barak Valley, North East India, had between one to five educated members in the family, which were represented mainly by children and adults between the ages of 20 and 40. In Ganyesa, approximately 72% of the participants had at least one form of education. The level of education is also an important determinant of SES since only a few of the residents in Ganyesa have tertiary

qualifications or a Grade 12 certificate. This can be attributed to a lack of financial support and opportunities.

The level of education contributed a great deal to the formation of the different classes, since the majority of the residents that form part of class 3 have some form of tertiary education. Consequently, class 3 has a higher SES than the participants that form part of class 1 and 2, while class 1 has a lower SES than class 2. However, when compared with an urban settlement such as Potchefstroom, which has 5 SES classes, Ganyesa's SES classes can only be compared with the first three classes in Potchefstroom and has no representation of higher SES classes 4 and 5 (Cilliers *et al.*, *in press*).

The socioeconomic survey in Potchefstroom found that 75% of the surveyed households earned a monthly income of less than R 3 500 and only 25% earned more than R 3 500 per month (WorkWell, Research Unit for People, Policy & Performance, 2004). In Ganyesa, 78% of the participants earn a monthly income of less than R 2 000, 19% earn between R 2 000-5 000 and only 2% of the participants earn more than R 5 000. In Potchefstroom the single largest source of income is permanent jobs (salaries and wages), with 42% of the surveyed households indicating this as their main source of income, while 24% are dependent on social grants and pensions (WorkWell, Research Unit for People, Policy & Performance, 2004). In Ganyesa however, 53% of the participants rely on government grants and pensions as their main source of income and only 17% have a permanent job. This is another clear indication of increasing urbanization as most of the younger residents tend to move from rural settlements to urban areas.

6.4.4 Satisfaction with life and emotional well-being

The socioeconomic survey in Potchefstroom found that most households see themselves as happy fairly often, with support available when needed (WorkWell, Research Unit for People, Policy & Performance, 2004). Similarly in Ganyesa, more than 90% of the residents replied that they felt happy most of the time and 80% felt that they had someone to turn to in times of stress. Based on the satisfaction with life questions, the survey in Potchefstroom found that most households tend to be fairly happy according to their own accounts (WorkWell, Research Unit for People, Policy & Performance, 2004). However, when asked whether or not they were satisfied with their lives, most residents felt dissatisfied (WorkWell, Research Unit for People, Policy & Performance, 2004). In Ganyesa however, 57% of the residents were not satisfied with their living conditions, 62% felt they didn't have the basic resources needed to make a living and 66% aren't satisfied with their lives. Based on the residents replies to all five satisfaction with life questions, approximately 60% of the residents didn't feel satisfied with their lives in general.

6.5 Summary

From this chapter the following two important deductions could be made. Firstly, the inhabitants of Ganyesa are poor and generally not satisfied with their living conditions. Secondly, they however attempt to increase their quality of life with the aid of their homegardens by growing their own fruit and vegetables. The majority of the participants grow fruit and vegetables for their own consumption and as a means of generating an income. Similarly, the study of Shackleton *et al*. (2008), found that natural products clearly make a difference to the most marginalized sectors of the community by delivering a range of financial and non-financial benefits to rural areas. Therefore, homegardens not only play an important part in genetic resource conservation, but also has the potential to alleviate poverty.

Urban planners should therefore optimise the use of homegardens in poverty alleviation. However, a better understanding is needed of the role that socioeconomic status and cultural aspects plays in plant diversity patterns. Poverty alleviation has been placed high on the national development agenda of South Africa, especially since South Africa became committed to meeting the Millennium Development Goals, set out in the United Nations Millennium declaration of 2000 (Department of Environmental Affairs and Tourism, 2006), as was indicated in the Introduction of this dissertation. Since then, South Africa has paid increasing attention to current environmental problems, as well as improving the welfare of its people (Department of Environmental Affairs and Tourism, 2006).

Chapter 7 - Socioeconomics and vegetation in a rural settlement

"Arguably, more than any other system, effective management of urban ecosystems to protect biodiversity must be based on sound knowledge of the relationship between socioeconomic and cultural factors and species occurrence" (Luck *et al*., 2009).

7.1 Introduction

According to McDonnell (1997), the high levels of urbanization across the globe provides ecologists with numerous opportunities and challenges to address important ecological questions in a variety of different environments with varying levels of human involvement and activities. Moreover, as the amount of people living in cities increases every year globally, the nature of urban ecosystems is becoming increasingly important in shaping peopleõs views about the natural ecosystem (Savard *et al*., 2000). The current level of ecological understanding however, is severely inadequate to successfully predict the potential effects of increased human population density along with the associated landscape modification and energy consumption of ecosystems, populations and communities in suburban and urban landscapes (McDonnell, 1997).

Urban ecosystems represent the most extreme cases of human influence on ecosystem function (Pickett *et al*., 1997), provide unique opportunities for researchers to integrate humans into ecology (Collins *et al*., 2000) and consist of entire landscapes in which humans are the primary agents responsible for creating new plant communities (Whitney and Adams, 1980). The study of Luck (2007a) found significant positive correlations between human population density and species richness. Therefore, humans and various species may occur in the same regions possibly as a result of responding to the same underlying drivers or because of human land-use policies (Gaston 2005, Luck 2007b). According to Luck *et al*. (2009) human settlements could support a rich diversity of species if managed appropriately, but to do so urban planners must take socioeconomic variables and species richness data into consideration.

Several studies from both developed and developing countries have indicated that the socioeconomic status (SES) of urban residents serve as important indicators of vegetation composition (Hope *et al.,* 2003; Martin *et al*., 2004; Kinzig *et al*., 2005; McConnachie *et al*., 2008; Luck *et al*., 2009). These studies mainly used median household income, obtained from census data, to determine socioeconomic status (SES) (Hope *et al.,* 2003; Martin *et al*., 2004; Kinzig *et al*., 2005; McConnachie *et al*., 2008; Luck *et al*., 2009). Based on the socioeconomic variables used in these studies, there are significant increases in the plant diversity (Hope *et al.,* 2003; Martin *et al*., 2004; Luck *et al*., 2009), tree cover (Iverson and Cook, 2000; McConnachie

et al., 2008) and bird diversity (Kinzig *et al*., 2005) in urban areas occupied by inhabitants with a higher SES.

Hope *et al.* (2003) defined the positive relationship that exists between plant diversity and wealth, as the ôluxury effectõ This luxury effect is mainly caused by a profusion of human resources and higher levels of residential involvement in urban greening efforts in areas with a higher socioeconomic status (Hope *et al.,* 2003). The studies of both Martin *et al.* (2004) and Kinzig *et al*. (2005) found that residents who live in areas with a low SES are less likely to enjoy rich assemblages of vegetation in their neighbourhoods than residents who live in neighbourhoods with a high SES. The aim of this chapter is to determine the relationship between several socioeconomic variables and the plant diversity of selected households in order to determine whether these patterns repeat themselves in a rural settlement.

7.2 Materials and Methods

As explained in Chapter 6, questionnaires were used to determine the SES of the residents of Ganyesa, since the national South African census data from 2001 proved to be too unreliable during a reconnaissance survey. As most residents did not have a fixed monthly income, median family income could not be used as a sufficient determining factor of SES. Consequently, several surrogate variables were chosen to determine the SES for each participant. All statistical analyses were completed with STATISTICA 8.0 (StatSoft, Inc., 2008). Multiple linear regression analysis, such as forward stepwise regression and ANCOVA analyses were performed using vegetation and socioeconomic data. Pearson correlation coefficients were calculated to determine relationships between SES and plant diversity.

7.2.1 Multiple linear regression analysis

Multiple linear regression analysis is used to predict the score of a dependent variable based on scores of several independent variables (Tabachnick and Fidell, 2001). In regression data sets the independent variables are correlated with one another and with the dependent variable to varying degrees (Tabachnick and Fidell, 2001). According to Tabachnick and Fidell (2001) there are three major analytic strategies in multiple linear regression, namely standard multiple regression, hierarchical regression and statistical (stepwise) regression.

7.2.1.1 Stepwise regression

Stepwise regression is a controversial procedure, in which the order that variables enter the equation is based solely on statistical criteria (Tabachnick and Fidell, 2001). According to Tabachnick and Fidell (2001) stepwise regression is a compromise between forward selection and backward deletion statistical regression techniques, since the equation starts out empty and independent variables are added one at a time if they meet the statistical criteria. In order to determine the key predictor variables for this study, forward stepwise multiple regression

analysis was used. The key predictor variables were determined by the level of significance, P values. The forward stepwise regression analysis was conducted on three dependent variables and the independent variables SES and MI together with several so-called ñdummy variablesò (Table 7.1). Dummy variables are independent variables which take the value of either 0 or 1 (0; if some characteristic is not present, 1; if it is present). An example of such a variable is CW, with CW=1 if there is a communal water tap present and CW=0 if there is no tap.

Table 7.1: List of dependent and independent variables used for the forward stepwise regression analysis.

Dependent variables	Independent variables
Total number of species	HF - Formal house
Indigenous species	N - No sanitation facilities
Alien species	OH - Sanitation facilities outside home
	CW - Communal water tap
	WY - Water tap in yard
	DA - Distance from water source, less than 100m
	DB - Distance from water source, 100 - 500m
	DC - Distance from water source, 500m - 1 km
	HEN - Highest level of education - None
	HEPS - Highest level of education - Primary school
	HESS - Highest level of education - Secondary School
	HEG12 - Highest level of education - Grade 12
	HETQ - Highest level of education - Tertiary qualification
	ESF - Method for earning money - Support from family
	EPW - Method for earning money - Piece work
	EG - Method for earning money - Government grant
	EOB - Method for earning money - Own Business
	EPJ - Method for earning money - Permanent job
	SES - Socioeconomic status
	MI - Monthly income

7.2.1.2 Correlation matrix

A correlation matrix was used to determine the level of correlation between the dependent and independent variables. According to Hair *et al.* (2006) multiple R is the correlation coefficient between the predicted values of the dependent variable (using the linear regression on independent variables) and the observed values of the dependent variable. R square (R^2) is the correlation coefficient squared, also referred to as the coefficient of determination. The adjusted R^2 (R_a^2) is R^2 adjusted for the number of independent variables relative to the number of observations and its value indicates the percentage of variance of the dependent variable, which is explained by the independent variables through the multiple linear regression, for

example an R_a^2 value 0.30 indicates that the independent variables explain 30% of the dependent variable's variance.

Pearson's (r) correlation coefficient is used to determine the extent to which values of two variables are linearly related. Values equal to 0.1 (r = 0.1) indicate a small level of correlation, r values of 0.3 (r = 0.3) indicate moderate levels of correlation, while r values equal to 0.5 (r = 0.5) indicate large correlations (Cohen, 1988). In this study r Ó 0.3 will be considered as practically significant.

7.2.2 ANCOVA

According to Tabachnick and Fidell (2001) analysis of covariance (ANCOVA) is an extension of analysis of variance in which main effects and interactions of independent variables (factors) are assessed after dependent variables scores are adjusted for differences associated with one or more covariates (CVs). Covariates are variables that are measured along with the dependent variable and are correlated with it (Tabachnick and Fidell, 2001). It is however, important to assess the degree of relationship to which the factors and dependent variables are related (Tabachnick and Fidell, 2001). According to Tabachnick and Fidell (2001) strength of association assesses the proportion of variance in the dependent variables that is associated with levels of a factor, i.e. strength of association measures the level of association between variables. ANCOVA provides a rough estimate of strength of association through η^2 (eta squared) (Tabachnick and Fidell, 2001):

$$\eta^2 = SS_{effect} / SS_{total}$$

Cohen (1988) provides the following guidelines for interpreting η^2 values; $\eta^2 = 0.01$ indicates a small effect, $\eta^2 = 0.06$ indicates a medium effect and $\eta^2 = 0.14$ indicates a big effect.

7.3 Results

7.3.1 Multiple linear regression analysis

7.3.1.1 Multiple R values

The outliers that were identified with Cook's distances were removed after the first analysis of the data (Table 7.2 contains the results after the outliers were removed). Based on the adjusted R^2 values, the independent variables only explain 20% of the variance of alien species, 26% of the variance of indigenous species and 9% of the variance of the total number of species found in each of the respondent's homes (Table 7.2). SES contributed to R^2 for both indigenous and alien species composition, but not for the total number of species and neither of the p values were statistically significant. A tertiary qualification contributed to R^2 for both indigenous and alien species composition, but not for the total number of species variable and neither of the values was statistically significant. Having a formal house contributed to the total number of

species and the number of indigenous species, but not the number of alien species and neither of the HF values were statistically significant.

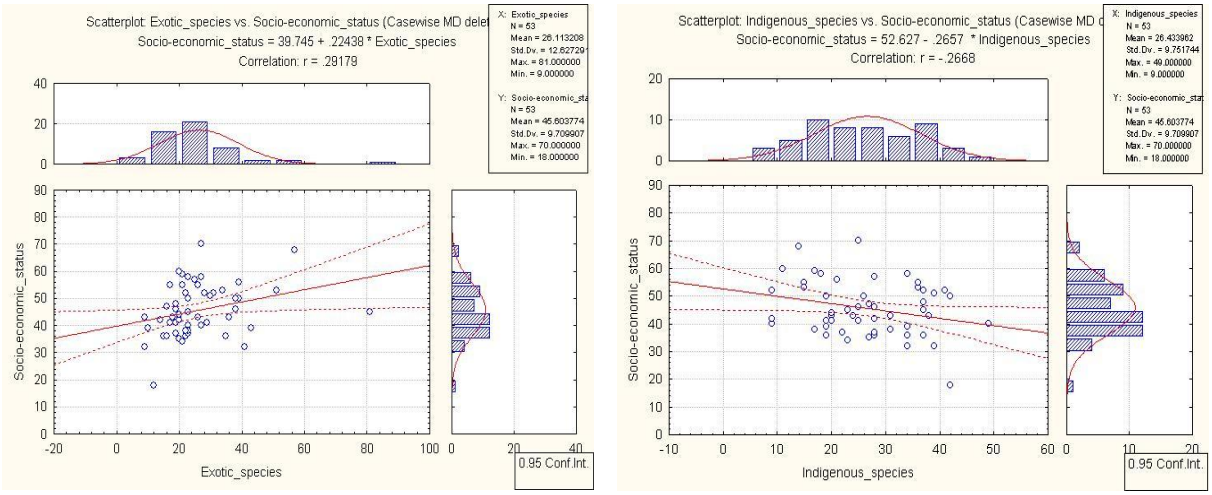
Table 7.2: Results of the forward stepwise regression analysis for the total number of species, as well as the number of indigenous and alien species.

	Total Number of Species	Indigenous species	Alien species
Adjusted R^2	0.093	0.264	0.202
HF	0.081*	0.001	-
HEG12	0.139	-	0.084
N	0.267	0.019	-
DA	-	-	0.129
HETQ	-	0.104	0.291
SES (p-level)	-	0.06	0.216
WY	-	-	0.282
EPW	-	0.158	-

* p-value for each independent variable included in the regression model

7.3.1.2 Pearson's (r) correlation coefficient

The Pearson correlation coefficient (r) values for the correlations between the alien species composition and SES indicated a positive, but small to moderate level of correlation (Fig. 7.1). The correlation between the indigenous species composition and SES indicated a negative, but small to moderate level of correlation. However, neither of these correlations are statistically significant.

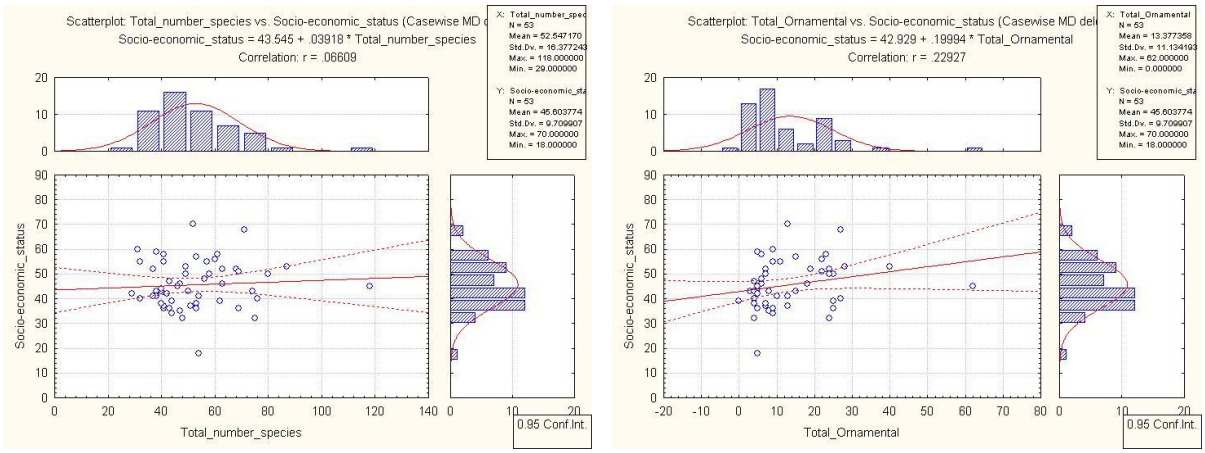


A) **B)**

Figure 7.1: Scatterplots of the correlations between the SES and (A) the alien and (B) indigenous species composition. The red line is the least-squares line, which indicates the strength of correlation and the red dashed line indicates the 95% confidence intervals, which is computed for each graph.

The correlation between the total number of species and SES indicated a positive, but small level of correlation, while the correlation between the total number of ornamental species and

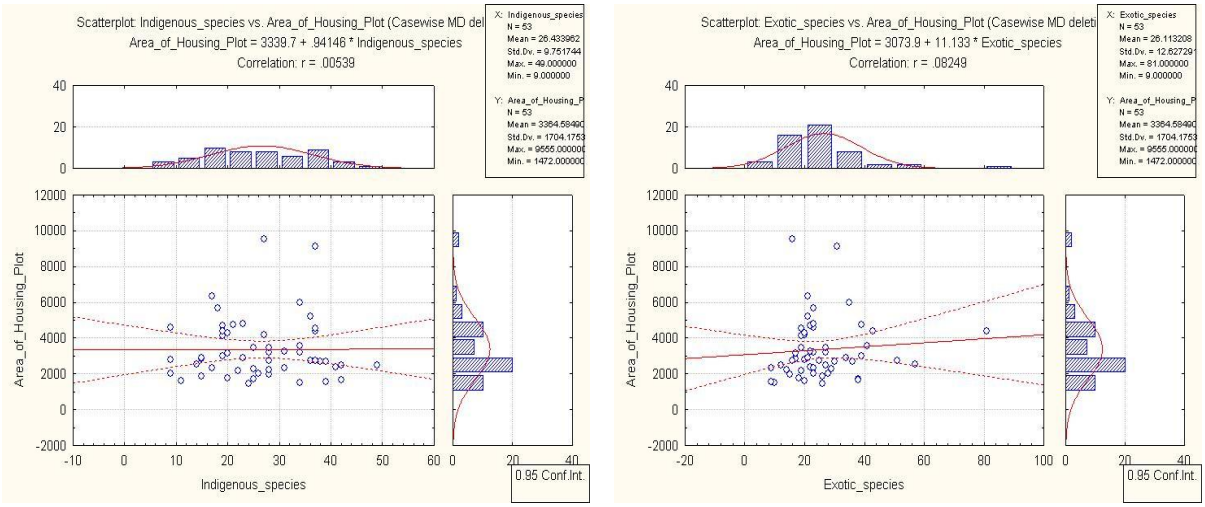
SES indicated a positive, but small to moderate level of correlation (Fig. 7.2). However, neither of these correlations are statistically significant.



A) **B)**

Figure 7.2: Scatterplots of the correlations between the SES and (A) the total number of species and (B) ornamental species composition. The red line is the least-squares line, which indicates the strength of correlation and the red dashed line indicates the 95% confidence intervals, which is computed for each graph.

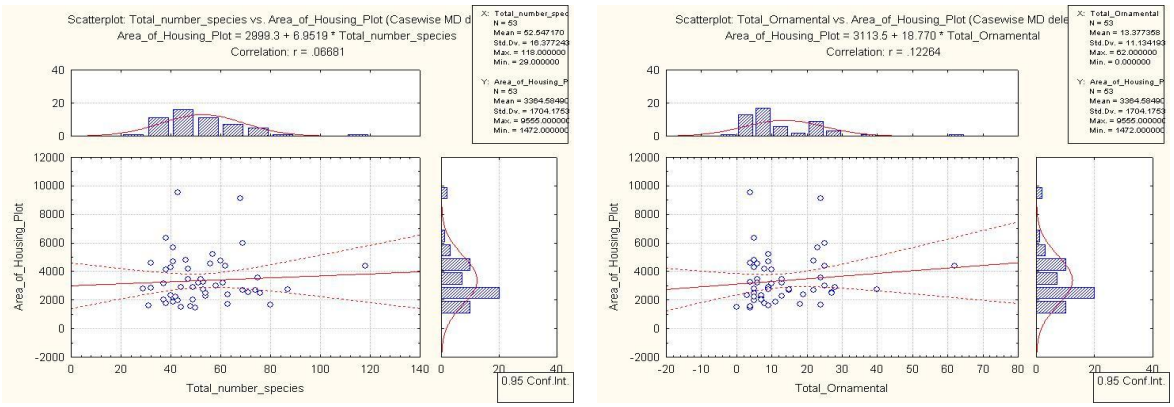
The correlation between the indigenous species composition and the area of housing indicated a positive, but small level of correlation (Fig. 7.3). Similarly, the correlation between the alien species composition and area of housing indicated a positive, but small level of correlation. However, neither of these correlations are statistically significant.



A) **B)**

Figure 7.3: Scatterplots of the correlations between the total area of the housing plots and (A) the indigenous and (B) alien species composition. The red line is the least-squares line, which indicates the strength of correlation and the red dashed line indicates the 95% confidence intervals, which is computed for each graph.

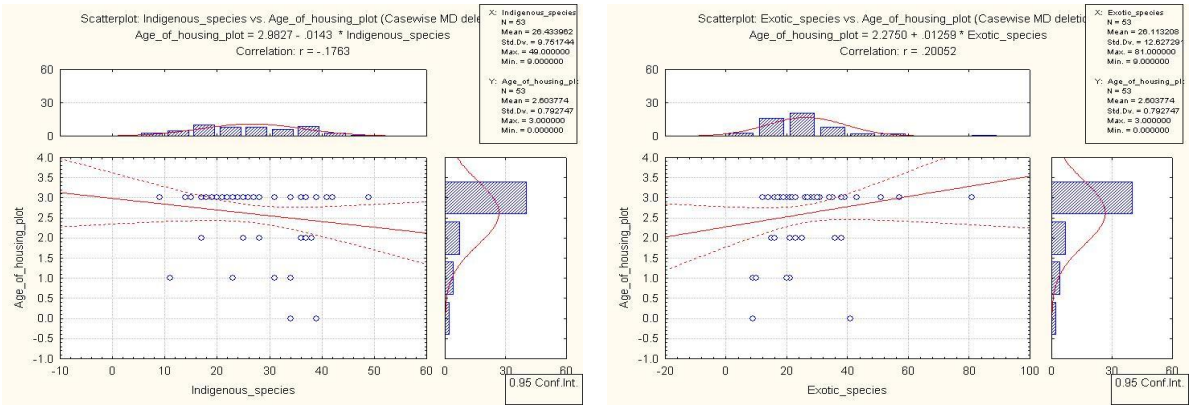
The correlation between the total number of species and the area of housing indicated a positive, but small level of correlation (Fig. 7.4). The correlation between the total number of ornamental species and area of housing indicated a positive, but small to moderate level of correlation. However, neither of these correlations are statistically significant.



A) **B)**

Figure 7.4: Scatterplots of the correlations between the total area of the housing plots and (A) the total number of species and (B) ornamental species composition. The red line is the least-squares line, which indicates the strength of correlation and the red dashed line indicates the 95% confidence intervals, which is computed for each graph.

Based on the correlation value (r) between the indigenous species composition and the age of housing plot, there is a negative, but small level of correlation (Fig. 7.5), while the correlation between the alien species composition and age of housing plot indicated a positive, but small to moderate level of correlation. Nevertheless, neither of these correlations are statistically significant.

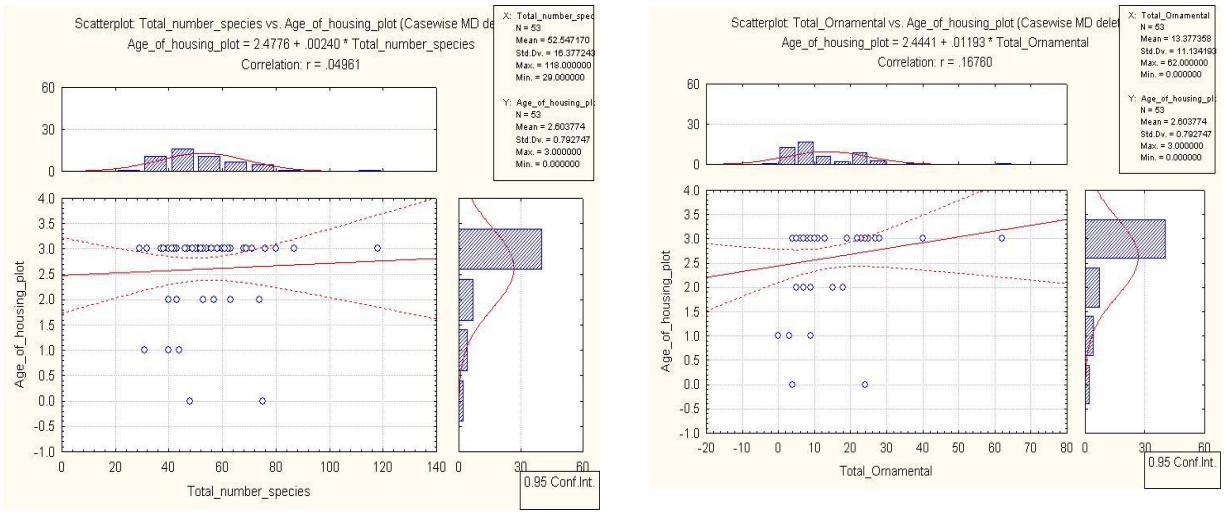


A) **B)**

Figure 7.5: Scatterplots of the correlations between the age of the housing plots and (A) the indigenous and (B) alien species composition. The red line is the least-squares line, which indicates the

strength of correlation and the red dashed line indicates the 95% confidence intervals, which is computed for each graph.

The correlation between the total number of species and the age of housing plot indicated a positive, but small level of correlation (Fig. 7.6). The correlation between the total number of ornamental species and age of housing indicated a positive, but small to moderate level of correlation. However, neither of these correlations are statistically significant.



A) **B)**

Figure 7.6: Scatterplots of the correlations between the age of the housing plots and (A) the total number of species and (B) ornamental species composition. The red line is the least-squares line, which indicates the strength of correlation and the red dashed line indicates the 95% confidence intervals, which is computed for each graph.

7.3.2 ANCOVA

Analyses of covariance (ANCOVA) were conducted on several dependent variables to compare the three levels of age of housing plots adjusted for the covariates 'Area of housing plot', SES, Education and monthly income. Pearson's eta-squared values (η^2) determine the practical significance of ANCOVA results (Steyn, 2009). The eta-squared value of SES for the total number of ornamentals are practically significant, but not statistically significant and therefore, SES does, to some extent, correlate for the number of ornamental species (Table 7.3). However, none of the other dependent and independent variable indicated statistical significance.

Table 7.3: The strength of association (η^2) is measured between several independent and dependent variables.

Independent variables:	Total Number of Species η^2	Indigenous species η^2	Alien species η^2	Tot. Number vegetables η^2	Tot. Number of Ornamentals η^2
Area of Housing Plot	0.002184	0.000028	0.003356	0.029467	0.009249
SES	0.050898	0.038966	0.097496	0.032927	0.119247
Education	0.088686	0.052711	0.172971	0.143181	0.156646
Age of Housing Plot	0.000025	0.0253	0.017034	0.036847	0.01528
Monthly Income	0.084535	0.135496	0.133485	0.098889	0.10319

7.4 Discussion

The studies of Hope *et al*. (2003 and 2006) and Martin *et al*. (2004) found that the plant diversity in urban areas increased across a gradient of low to high SES, with the most variation explained by median family income. Similarly, the study of Luck *et al*. (2009) indicated that the relationship between socioeconomic factors and vegetation appeared to become stronger over time. In Potchefstroom, similarly to developed countries, there is a strong positive correlation between SES and the total number of species (Cilliers *et al*., in press). However, in the current study the relationship between plant diversity and SES, for a rural settlement, was weak and not statistically significant, but the correlation graph did indicate a tendency for the plant diversity to be influenced by the SES, albeit at a lesser scale than in western cities. The main reason for this weak positive correlation could be explained by the sample size of only one settlement, annual income which represents poor economic classes only, and studying a single cultural group. This equates to working in a single neighbourhood of a city where one would not expect to find much variation in SES and plant diversity.

The study of Martin *et al*. (2004) found that the overall counts of native taxa in neighbourhoods in relation to the total neighbourhood abundance were little influenced by SES. However, when working across neighbourhoods, in Potchefstroom for instance, there are strong positive correlations between SES and the number of indigenous and alien species (Cilliers *et al*., in press). In Ganyesa however, the correlation between the indigenous species composition and SES was small and negative. However, the data does suggest that individuals with higher SES tend to have less indigenous species than individuals with a lower SES. In contrast, the correlation between the alien species composition and SES was positive and therefore, individuals with a higher SES tend to have more alien species in their gardens.

According to Hope *et al*. (2003 and 2006) plant diversity of developed urban sites was also related to age of housing, with higher diversity at sites with more recently developed housing.

In Ganyesa the correlation between the total number of species and the age of housing was not statistically significant, but the general tendency of the graph suggests that it may have an influence on plant diversity. However, the age of housing does seem to influence the indigenous and alien species composition on some level. In the case of the alien species composition there is a small but positive correlation with regards to the age of housing, which suggests that older homes may contain more alien species than newer homes. In contrast, the indigenous species composition has a negative correlation, albeit not significant, in relation to housing age. This could be explained by the remnants of natural vegetation that remain in the yards of newer houses. Tswana culture does not require homeowners to follow the western practise of clearing all indigenous natural vegetation from yards and replacing these with alien and indigenous garden ornamentals, although the area immediately surrounding the house is cleared of all vegetation, the lebala concept (Cilliers *et al*., 2009). However, gardens of older houses have shown that this does happen with time. As the SES of home owners increase, the more money is spent on beautifying the yard.

7.5 Summary

The lack of statistically significant data can be explained by a lack of variation in the data, as there were only 53 homegardens surveyed in this study and the differences in SES along the urbanization gradient were relatively small. In contrast, similar data in an urban area such as Potchefstroom was statistically significant (Cilliers *et al*., in press). The Potchefstroom survey was done on a larger scale with a steeper socioeconomic gradient and the area is far more heterogeneous than Ganyesa with respect to socioeconomic aspects and cultural groups (Cilliers *et al*., in press). In conclusion, even though the majority of our results presented in this chapter were not statistically significant there is still much to be learned from the data. The most important being that more repetition is needed in South Africa especially in varying degrees of urban to rural environments. It is therefore important to determine the SES categories of an urban area beforehand to judge the suitability of that environment to investigate urban biodiversity gradients as a function of socio-economics.

Chapter 8 - Concluding remarks

Determining the patterns of plant diversity in different land-use areas of a rural settlement and how socioeconomic status influences the plant diversity in the homegardens, formed the main themes of this dissertation. The themes were addressed in four main parts, namely the patterns of plant diversity (Chapter 4), floristic composition (Chapter 5), socioeconomic status of the residents (Chapter 6), and relationships between SES and plant diversity and plant species composition (Chapter 7). Concluding remarks on each of these sections are given below.

8.1 Patterns of plant diversity

Kent *et al*. (1999) produced one of the first studies to systematically record plant species data across an entire city. Similarly, the Ganyesa study was pioneering, as it is one of the first in South Africa to analyse the species diversity across an entire rural settlement, as well as comparing the alpha, beta and gamma diversity of different land-use types with one another. Clear differences were observed between the diversity measures inside and outside the settlement. The gamma diversity inside the settlement was higher due to the higher numbers of alien and naturalized species generally found in homegardens and institutional gardens. Therefore, homegardens greatly contribute to the overall plant species diversity of a settlement. The alpha diversity however, outside the settlement was higher than inside the settlement, suggesting richer species assemblages per unit area in untransformed sites. Conversely, the beta diversity was higher for homegardens than natural areas, which indicate a higher turn-over of species between the homegarden sample plots and suggest a repetitive, homogeneous flora in untransformed sites. The higher turnover of species in gardens is ascribed to the diverse preferences of gardeners, be it for livelihood or aesthetic reasons. The lower beta diversity in the natural areas are, however, misleading, as the homogenization effect that urban areas have on floras will result in comparatively higher beta diversity values for natural areas if the floras of many urban areas are compared.

Alpha diversity was graphically illustrated on kriging maps, while beta diversity was depicted with NMDS ordinations. Kriging is intuitive and provides useful visual comparisons (Williams, 2005) between the generated kriging maps and ordinations, while NMDS ordinations illustrate the level of species turn-over (beta diversity) between the different land-use types. The Ganyesa study is the first in South Africa, to explicitly distinguish between the alpha, beta and gamma diversity of different land-use types. Based on the results of this study there are clear differences between land-use types, especially between homegardens and the surrounding natural areas. However, the beta diversity between different urban areas will vary, since the surrounding natural areas will be more heterogeneous with respect to one another, while the

homegardens inside urban areas will become more homogenous. Therefore, data from several different urban areas should be incorporated in order to formulate a beta diversity theory.

8.2 An analysis of the floristic composition

The studies of both Blanckaert *et al*. (2004) and Das and Das (2005) emphasized the importance of homegardens as diverse agroforestry systems and as important *in situ* conservation sites. This is especially true in Ganyesa, since the residents cultivate a rich diversity of species for their multifunctionality, for example *Bulbine abyssinica* which is cultivated for both ornamental and medicinal purposes. Homegardens, not only, plays an important part in the livelihood of residents, but also in the conservation of endemic and endangered species. In Ganyesa, six of the nine recorded Red Data species and nineteen of the twenty-four recorded South African endemic species, were cultivated in homegardens. Therefore, homegardens greatly contribute to the protection of biodiversity in urban and rural environments, mainly through custodianship of useful species. However, cultivated alien and naturalized species greatly decreases the natural biodiversity of urban and rural areas. Native species are often removed to make way for alien taxa. It has been shown that the time that rural settlements have been exposed to western culture in South Africa, is directly proportional to the increase of alien species in the flora of urban areas (Cilliers *et al*., *in press*).

8.3 Socioeconomic survey and satisfaction with life

The study of Blanckaert *et al*. (2004) found that homegardens play an important role in the subsistence economy of families in San Rafael Coxcatlán, Mexico. Similarly, in Ganyesa the residents cultivate fruit and vegetables for their own consumption and as a means of generating an income. Homegardens in Ganyesa greatly contribute to the monthly income of the residents, since the majority of the residents rely on government grants and pension funds. The study of Shackleton *et al*. (2008) found that natural products can deliver a range of financial benefits. In conclusion, most of the residents are poor and are generally not satisfied with their lives or living conditions. Homegardens provide the people with a lifeline in difficult times as it provides food for consumption or additional income.

8.4 Socioeconomics and plant diversity

The studies of Hope *et al*. (2003 and 2006) and Martin *et al*. (2004) determined that the plant diversity in urban areas increased across a socioeconomic gradient. In Ganyesa however, the data was not statistically significant and therefore cannot confirm the results of these studies. This lack of statistically significant data can be attributed to a lack of variation in the data, since Ganyesa is mostly dominated by poor people and mostly one cultural group (Tswana) and was, therefore, too homogenous to describe an extensive SES gradient. However, the correlations did reveal certain tendencies. The plant diversity, for example, does seem to be influenced by the weak socioeconomic gradient in Ganyesa. In a more urbanized area such as Potchefstroom, the data was statistically significant, since the survey was done on a larger

scale and against a steeper socioeconomic gradient than that of Ganyesa (Cilliers *et al*., *in press*).

8.5 Recommendations for future research

The species diversity of different land-use types can be attributed to the level of human impacts and intervention, since homegardens are intensely managed by homeowners, while natural areas are characterized with relatively little human intervention. Even though correlation of diversity and SES-data showed no statistical significance, the results still indicate some correlations between species diversity and socioeconomic status and cultural aspects such as the ôebala conceptô(Cilliers *et al*., 2009). The Potchefstroom study, that is still ongoing, further verifies this (Cilliers *et al*., *in press*). However, more studies are needed, but on a larger scale in South Africa, to model the differences in urban biodiversity in developed and developing countries.

South Africa is committed to meeting the Millennium Development Goals, set out in the United Nations Millennium declaration of 2000 (Department of Environmental Affairs and Tourism, 2006). Since then, South Africa has paid increasing attention to current environmental problems, as well as improving the welfare of its people and especially poverty alleviation (Department of Environmental Affairs and Tourism, 2006). Homegardens can greatly contribute to poverty alleviation if they are managed in a sustainable manner. The homegardens in urban and rural settlements are totally understudied in South Africa, especially the homegardens in urban areas. Further research on the homegardens should be accompanied by SES surveys. The objectives of these studies should be poverty alleviation through the sustainable management of homegardens.

Furthermore, homegardens can greatly increase the natural biodiversity of urban areas, but to do so the public must first be educated on conservation issues through lectures at schools, and by means of pamphlets or newspaper articles. This is especially important since so many of the people living in urban habitats have become disconnected from nature and have so many misconceptions about the natural environment. Nevertheless, in order for ecologists to fully understand the role of homegardens in urban environments more integrative studies which take all the aspects of home gardens in both rural and urban habitats into consideration.

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Appendix 1: Climate data for the Ganyesa area

Table A1: The total and average rainfall data of the Ganyesa area from 2003 to 2009 (ARC-ISCW, 2009).

mm/day Rainfall

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
2003											24.4	6.8	**31.2**	**15.6**
2004	32.5	37.7	17.8	9.6	0	0.6	1.2	0.3	8.9	1.5	10.5	66	**186.6**	**15.6**
2005	60.3	16.9	44.9	81.7	6.3	1.8	0	0.8	0	17.6	17.7	23.3	**271.3**	**22.6**
2006	129.4	275.4	105.5	84.9	7.2	4.1	2.3	7.9	0	16	52.8	44.8	**730.3**	**60.9**
2007	18.1	2.1	54.1	28.1	2.6	8.6	0	0.6	54.7	16.4	54.2	27.5	**267**	**22.3**
2008		12.2	102.4	6.7	25.5	1.6	0	0.3	0	27.5	66.4	6.3	**248.9**	**22.6**
2009	74.9	31.7	33.4										**140**	**46.7**
Average	**63**	**62.7**	**59.7**	**42.2**	**8.3**	**3.3**	**0.7**	**2**	**12.7**	**15.8**	**37.7**	**29.1**	**337.2**	**28.1**

Table A2: The minimum daily relative humidity % of the Ganyesa area from 2003 to 2009 (ARC-ISCW, 2009).

% Minimum Daily Relative Humidity

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
2003											22.4	15.6	**37.9**	**19**
2004	34	29.8	35.6	35.4	20.2	26.9	22.8	19.7	17.6	18.9	15.1	23.4	**299.4**	**24.9**
2005	31.6	50.5	41.9	38.6	28.5	32.7	17.2	15.9	11.6	17.7	18.9	17.4	**322.4**	**26.9**
2006	41.3	50.8	42.6	40.1	27.8	24.9	27.8	27.5	14.8	23	26.5	25.3	**372.5**	**31**
2007	22.2	16.7	22.9	29.4	17.5	24.7	18.4	14.7	7.6	7.9	7.2	13.6	**202.7**	**16.9**
2008		6.6	19.7	19.4	20.9	17.1	16.2	12.1	6.9	5.5	5.8	2.4	**132.4**	**12**
2009										14.3	38.6	30.4	**83.3**	**27.8**
Average	**28.7**	**32.2**	**32.2**	**32.6**	**23**	**25.2**	**20.5**	**18**	**11.7**	**14.6**	**16**	**16.3**	**270.8**	**22.6**

Table A3: The maximum daily relative humidity % of the Ganyesa area from 2003 to 2009 (ARC-ISCW, 2009).

% Maximum Daily Relative Humidity

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
2003											76.2	68	**144.2**	**72.1**
2004	90.1	88.7	95.1	94	77.5	77.4	81.8	68.1	63.4	63.6	59.9	84.9	**944.6**	**78.7**
2005	83.6	83.6	87	94.7	84.1	73.9	69.6	69.1	53.6	65.2	70.4	77.7	**912.5**	**76**
2006	96	97.8	95.7	96.6	94.2	89.4	77.5	85.7	70.1	83.2	87.3	80.5	**1054**	**87.8**
2007	84.9	73.3	85.1	92.8	77.9	87	77.1	63.5	55.9	84.5	67.9	71.1	**920.9**	**76.7**
2008		54.7	91.5	86.6	86.5	84	74	60.1	60.3	59	62.7	38.1	**757.4**	**68.9**
2009										46.5	95.2	92	**233.6**	**77.9**
Average	**80.2**	**82.2**	**91.1**	**92.9**	**84**	**82.3**	**76**	**69.3**	**60.6**	**71.1**	**70.7**	**70**	**930.6**	**77.6**

Table A4: The average daily temperature (ºC) of the Ganyesa area from 2003 to 2009 (ARC-ISCW, 2009).

ºC Average Daily Temperature

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
2003											23.2	24.7	**47.9**	**24**
2004	23.4	23.1	20.9	17.5	15.4	10.5	8.2	13.8	15.7	20.9	25.2	24.5	**219.2**	**18.3**
2005	24.6	23.5	20.7	16.6	14.2	11.7	11.3	14.3	18.6	21.4	22.5	24.2	**223.4**	**18.6**
2006	23.3	21.4	19	16.2	10.7	9.5	11.1	11.1	16.2	20.3	21.9	24	**204.7**	**17.1**
2007	24.2	24.5	21.3	17.8	12.3	9.1	9	12.6	19.4	18.9	21.1	21.8	**212.1**	**17.7**
2008		23.1	19.5	15.7	14.9	10.6	9.9	14	15.6	21.7	23	25	**193**	**17.5**
2009										24.3	22.2	20.6	**67.1**	**22.4**
Average	**24**	**23**	**20.3**	**16.7**	**13.5**	**10.3**	**9.9**	**13.2**	**17.1**	**20.6**	**22.8**	**24**	**215.5**	**18**

Table A5: The maximum daily temperature (ºC) of the Ganyesa area from 2003 to 2009 (ARC-ISCW, 2009).

ºC Daily Maximum Temperature

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
2003											30.9	32.8	**63.7**	**31.8**
2004	30.6	31.3	28.7	26.2	25.7	19.8	18.4	23.7	24.8	29.1	33.5	32.6	**324.4**	**27**
2005	31.6	24.7	25.8	24.2	22.3	18.4	22.6	24.6	28.8	30.4	30.9	32.6	**317.2**	**26.4**
2006	30.3	28	26.5	24.3	20.6	20.8	18.9	20.2	26.5	29.3	30.3	32.5	**308.2**	**25.7**
2007	33.7	34.7	30.9	26.8	24	19.6	20.1	23.4	29.7	26.5	28.9	28.5	**326.9**	**27.2**
2008		30.3	26.4	24.8	22.7	21	19.9	23.9	26.5	30.5	31.1	32.9	**289.9**	**26.4**
2009										31.8	29.7	29.2	**90.8**	**30.3**
Average	**31.6**	**29.8**	**27.9**	**25.3**	**23.1**	**19.9**	**20**	**23.2**	**27.2**	**29.2**	**30.9**	**32**	**320.1**	**26.7**

Table A6: The minimum daily temperature (ºC) of the Ganyesa area from 2003 to 2009 (ARC-ISCW, 2009).

ºC Daily Minimum Temperature

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
2003											15.7	16	**31.7**	**15.9**
2004	17.2	16.6	14.8	10	6.3	2	-1.4	4.1	6.7	12.2	16.3	17.2	**122.1**	**10.2**
2005	17.9	17.8	15	10.1	6.9	4.1	1.2	4.1	8.4	12.2	14	15.8	**127.4**	**10.6**
2006	18.6	17	13.3	9.3	2	0.2	2	2.4	6.1	11.3	13.6	16.2	**111.9**	**9.3**
2007	15.6	14.5	12.6	9.9	2.1	-0.1	-1.3	2.1	9.1	12.2	13	15.7	**105.4**	**8.8**
2008		16.7	14.1	7.7	8.4	2	0.8	5.1	4.7	12.8	15.2	17.3	**104.7**	**9.5**
2009										17.9	16.6	13.9	**48.4**	**16.1**
Average	**17.4**	**16.5**	**14**	**9.4**	**5.2**	**1.6**	**0.3**	**3.5**	**7**	**12.1**	**14.6**	**16.4**	**118**	**9.8**

Appendix 2: Complete species list

All species with a collectors number are housed in the AP Goossens Herbarium (PUC), with duplicates in the Pretoria National Herbarium (PRE). All species names followed by PRE are of previously collected specimens housed at the Pretoria National Herbarium.

Land uses:

FF	**=**	**Fallow fields**
F	**=**	**Fragmented natural areas**
HG	**=**	**Home garden**
IG	**=**	**Institutional garden**
N	**=**	**Natural areas**
R	**=**	**Road verges**
W	**=**	**Wetlands**

* ***Alien species***

\# ***Indigenous species***

Unmarked species are native to the North-West Province

Acanthaceae

Barleria macrostegia Nees, *Davoren & Siebert 162*, Perennial, Prostrate herb, FF, F, HG, N.
Blepharis integrifolia (L.f.) E.Mey. ex Schinz var. *integrifolia*, *Davoren & Siebert 183*, Perennial, Prostrate herb, F, N.
Blepharis serrulata (Nees), Ficalho & Hiern, Perennial, Dwarf shrub, HG, N.
Monechma divaricatum (Nees) C.B.Clarke, *Davoren & Cilliers 54*, Perennial, Deciduous, Dwarf shrub, N.

Aceraceae

**Acer negundo* L., Perennial, Tree, HG, IG.

Agapanthaceae

#*Agapanthus praecox* Willd. subsp. *orientalis* (F.M.Leight) F.M.Leight, Perennial, Herb, HG, IG.

Agavaceae

**Agave americana* L. subsp. *americana* var. *americana*, *Davoren & Siebert 341*, Perennial, Evergreen, Succulent shrub, FF, HG.
**Agave decipiens* Baker, Perennial, Succulent shrub, HG.
**Agave filifera* Salm-Dyck, Perennial, Succulent herb, HG.
**Cordyline australis* (G.Forst.) Hook.f, Perennial, Tree, HG.
**Nolina recurvata* Hemsl., Perennial, Succulent shrub, HG.
**Yucca gloriosa* L. var. *gloriosa*, Perennial, Succulent shrub, HG.

Aizoaceae

Trianthema salsoloides Fenzl ex Oliv., *Davoren 364*, Annual, Prostrate herb, HG, N, W.
Zaleya pentandra (L.) Jeffrey, Annual, Herb, N, W.

Alliaceae

**Allium cepa* L., Annual, Herb, HG.
#Tulbaghia simmleri P.Beauv., Perennial, Geophyte, HG.

Amaranthaceae

**Achyranthes aspera* L. var. *aspera*, *Davoren & Siebert 68*, Perennial, Erect herb, W.
Aerva leucura Moq., *Davoren & Siebert 73*, Perennial, Erect herb, F, N, W.
**Alternanthera pungens* Kunth, Perennial, Herb, F, HG, IG, R, W.
**Amaranthus caudatus* L., Annual, Herb, HG.
**Amaranthus deflexus* L., Perennial, Herb, FF, HG, N.
** Amaranthus hybridus* L. subsp. *cruentus* (L.) Thell., Annual, Herb, HG.
**Amaranthus hybridus* L. subsp. *hybridus* var. *hybridus*, *Davoren 37*, Annual, Erect herb, HG, N.
Amaranthus thunbergii Moq., *Davoren & Siebert 270*, Annual, Erect herb, HG, R, W.
**Gomphrena celosioides* Mart., *Davoren & Siebert 278*, Perennial, Prostrate herb, FF, F, HG, IG, N, R, W.
**Guilleminea densa* (Willd. ex Roem. & Schult.) Moq., *Davoren & Siebert 276*, Perennial, Prostrate herb, FF, F, HG, IG, N, R, W.
**Iresine herbstii* Lindl., *Davoren & Siebert 62*, Perennial, Erect herb, HG, IG.
Kyphocarpa angustifolia (Moq.) Lopr., *Davoren & Siebert 182*, Annual, Erect herb, F, N.
Pupalia lappacea (L.) A.Juss. var. *lappacea*, *Davoren 345*, Annual, Scandent herb, N, R.

Amaryllidaceae

#*Amaryllis belladonna* L., IG
Ammocharis coranica (Ker Gawl.) Perennial, Herb geophyte, HG.
Boophone disticha (L.f.) Perennial, Herb geophyte, HG, N.
Brunsvigia sp., Davoren & Siebert 262, Perennial; Geophyte, N.
#*Clivia miniata* Regel var*. miniata*, Perennial, Herb geophyte, HG.
Crinum crassicaule Baker, Perennial, Herb geophyte, HG.
Crinum lugardiae N.E.Br., Perennial, Geophyte, HG.
**Hippeastrum puniceum* (Lam.) Kuntze, Perennial, Herb, HG.
**Hymenocallis littoralis* (Jacq.) J.F.Macbr., Perennial, Herb geophyte, FF, HG.
Nerine laticoma (Ker Gawl.) T.Durand & Schinz, *Davoren & Siebert 247*, Perennial, Geophyte, HG, N.
**Zephyranthes grandiflora* Lindl., Perennial, Herb geophyte, HG.

Anacardiaceae

Rhus lancea L.f., *Davoren & Siebert 75*, Perennial, Evergreen, Medium-sized tree, HG, N.
#*Rhus pendulina* Jacq., Perennial, Tree, IG, HG.
**Schinus molle* L., *Davoren & Siebert* 272, Perennial, Evergreen, Large tree, HG.

Anthericaceae

#*Chlorophytum comosum* (Thunb.) Jacq., Perennial, Herb, HG, N.
Chlorophytum fasciculatum (Baker) Kativu, *Davoren & Siebert 326*, Perennial, Rosette herb, N.

Apiaceae

**Apium graveolens* L., Perennial, Herb, HG.
**Daucus carota* L., Annual, Herb, HG.
**Foeniculum vulgare* Mill. var. *vulgare*, Perennial, Herb, HG.

Apocynaceae

**Catharanthus roseus* (L.) G.Don., Perennial, Shrub, HG, R.
Gomphocarpus fruticosus (L.) Aiton f. subsp. *decipiens* (N.E.Br.) Goyder & Nicholas, *Davoren & Siebert 115*, Perennial, Deciduous, Dwarf shrub, N, W.
Gomphocarpus physocarpus E.Mey., Perennial, Herb, N.
**Nerium oleander* L., Perennial, Shrub, HG, IG.

Orbea lutea (N.E.Br.) Bruyns subsp. *lutea*, *Davoren & Siebert 299*, Perennial, Succulent herb, HG.
Orthanthera jasminiflora (Decne.) Schinz, *Davoren & Siebert 91*, Perennial, Creeping herb, N, W.
Pergularia daemia (Forssk.) Chiov. var. *daemia*, *Davoren & Siebert 164*, Perennial, Scrambling herb, N, R, W.
Stapelia gigantea N.E.Br., Perennial, Succulent herb, HG.
Stomatostemma monteiroae (Oliv.) N.E.Br., Perennial, Shrub, HG, N.
**Vinca major* L., Perennial, Herb, HG.

Aponogetonaceae

Aponogeton junceus Lehm., *Davoren & Siebert 336*, Perennial, Geophyte, N, W.

Araceae

**Alocasia macrorrhiza* (L.) Schott., Perennial, Herb geophyte, HG.
**Monstera deliciosa* Liebm., Perennial, Shrub, HG.
**Philodendron selloum* K.Koch., Perennial, Shrub, HG.
**Syngonium podophyllum* Schott, Perennial, Herb, HG.
#*Zantedeschia aethiopica* (L.) Spreng., Perennial, Geophyte, HG.

Araliaceae

**Hedera helix* L. var. *helix*, Perennial, Shrub, HG.

Araucariaceae

**Araucaria araucana* (Molina) C.Koch, Perennial, Tree, HG.

Arecaceae

**Phoenix canariensis* Hort. ex Chabaud, Perennial, Tree, HG.
**Phoenix dactylifera* L., Perennial, Tree, HG.
**Trachycarpus fortunei* (Hook.) H.Wendl., Perennial, Tree, HG.

Asparagaceae

Asparagus cooperi Baker, Perennial, Dwarf shrub, N.

#*Asparagus densiflorus* (Kunth) Jessop, Perennial, Dwarf shrub, HG.
Asparagus laricinus Burch., *Davoren & Siebert 109*, Perennial, Deciduous, Shrub, N.
Asparagus plumosus Baker, Perennial, Dwarf shrub, HG.
Asparagus suaveolens Burch., *Davoren & Siebert 185*, Perennial, Deciduous, Dwarf shrub, FF, HG, N, W.

Asphodelaceae

#*Aloe arborescens* Mill., Perennial, Shrub succulent, HG.
Aloe cryptopoda Baker, Perennial, Shrub succulent, HG.
Aloe grandidentata Salm-Dyck, *Davoren & Siebert 84*, Perennial, Succulent herb, HG, N.
Aloe greatheadii Schonland var. *davyana* (Schonland) Glen & D.S.Hardy, Perennial, Succulent herb, N.
#*Aloe marlothii* A.Berger, Perennial, Shrub succulent, HG.
#*Aloe striata* Haw. x *A. maculata* All. Perennial, Shrub succulent, HG, N.
#*Aloe tenuior* Haw. Perennial, Shrub succulent, HG.
Bulbine abyssinica A.Rich., *Davoren & Siebert 61*, Perennial, Geophyte, FF, F, HG, IG, N, R, W.
#*Bulbine frutescens* (L.) Willd., Perennial, Succulent herb, HG.
Bulbine narcissifolia Salm-Dyck, *Davoren 403*, Perennial, Succulent geophyte, F, N.
#*Haworthia attenuata* (Haw.) Haw. var. *attenuata*, Perennial, Succulent herb, HG.
Trachyandra burkei (Baker) Oberm., Perennial, Herb geophyte, HG.
Trachyandra laxa (N.E.Br.) Oberm. var. *laxa*, *Davoren & Siebert 123*, Perennial, Rosette herb, HG, N.
Trachyandra saltii (Baker) Oberm. var.*saltii*, *Davoren & Siebert 283*, Perennial, Geophyte, FF, F, N.

Asteraceae

**Acanthospermum glabratum* (DC.) Wild., *Davoren & Siebert 343*, Annual, Prostrate herb, FF, F, HG, N, R.
**Acanthospermum hispidum* DC., *Davoren & Siebert 344*, Annual, Erect herb, F, HG, N, W.
**Achillea millefolium* L., Perennial, Herb, HG.
Arctotis arctotoides (L.f.) O.Hoffm., *Davoren & Siebert 284*, Perennial, Procumbent herb, HG, N, W.
Arctotis venusta Norl., *Davoren & Siebert 224*, Annual, Erect herb, N, R.
#*Artemisia afra* Jacq. ex Willd., Perennial, Bushy herb, HG.
**Aster laevis* L., *Davoren & Siebert 192*, Perennial, Rosette herb, HG.
**Baccharis pingraea* DC., Perennial, Herb, HG.
**Bidens bipinnata* L., *Davoren & Siebert 308*, Annual, Erect herb, F, HG, N, R, W.

**Centaurea cineraria* L., Annual, Herb, HG.

**Chrysanthemum morifolium* Ramat., Annual, Herb, HG.

Chrysocoma obtusata (Thunb.) Ehr.Bayer, *Davoren 11*, Perennial, Evergreen, Dwarf shrub, FF, F, HG, N, R.

**Conyza albida* Spreng., *Davoren & Siebert 64*, Annual, Erect herb, F, HG, N, R.

**Conyza bonariensis* (L.) Cronquist, Annual, Herb, F, HG, IG, N, R, W.

**Coreopsis grandiflora* Hogg, Perennial, Herb, HG.

**Cosmos bipinnatus* Cav., Annual, Herb, HG.

**Dahlia excelsa* Benth., Perennial, Herb geophyte, HG.

Dicoma macrocephala DC., *Davoren & Siebert 92*, Perennial, Procumbent herb, FF, F, N.

Dicoma schinzii O.Hoffm., *Davoren & Siebert 133*, Perennial, Prostrate herb, FF, F, HG, N, R.

#Euryops chrysanthemoides (DC.) B.Nord., Perennial, Shrub, HG.

Felicia muricata (Thunb.) Nees subsp. *cinerascens* Grau, Perennial, Shrub, HG, IG, N.

Felicia muricata (Thunb.) Nees subsp. *muricata*, *Davoren & Siebert 187*, Perennial, Evergreen, Dwarf shrub, FF, F, HG, IG, N, R, W.

**Flaveria bidentis* (L.) Kuntze, *Davoren 373*, Annual, Erect herb, F, IG, R.

**Gaillardia aristata* Purcsh, Perennial, Herb, HG.

**Gazania hybrida*, Perennial, Herb, HG.

Gazania krebsiana Less. subsp. *arctotoides* (Less.) Roessler, Perennial, Herb, HG

Gazania krebsiana Less. subsp. *serrulata* (DC.) Roessler, *Davoren & Siebert 206*, Perennial, Rosette herb, FF, F, HG, N, R.

Geigeria burkei Harv. subsp. *burkei* var. *zeyheri* (Harv.) Merxm., *Davoren & Siebert 86*, Perennial, Herb, FF, F, HG, N, W.

Geigeria burkei Harv. subsp. *fruticulosa* Merxm., *Davoren 9*, Perennial, Herb, F, N, R.

#Gerbera jamesonii Bolus ex Adlam, Perennial, Herb, HG.

Gnaphalium nelsonii Burtt Davy, *Davoren & Siebert 107*, Perennial, Decumbent herb, FF, F, HG, IG, N.

Helichrysum arenicola M.D.Hend., Perennial, Herb, HG, N.

Helichrysum argyrosphaerum DC., *Davoren & Siebert 386*, Annual, Decumbent herb, F, HG.

Helichrysum caespititium (DC.) Harv., *Davoren & Siebert 145*, Perennial, Creeping herb, FF, N.

Helichrysum cerastioides DC. var. *cerastioides*., *Davoren & Siebert 144*, Perennial, Erect herb, FF, F, HG, N.

Helichrysum lineare DC., Perennial, Herb, F, N.

Kleinia longiflora DC., Perennial, Shrub succulent, HG.

Litogyne gariepina (DC.) Anderb., *Davoren & Siebert 318*, Perennial, Evergreen, Dwarf shrub, W.

Nidorella resedifolia DC. subsp. *resedifolia*, *Davoren & Siebert 137*, Annual, Erect herb, FF, F, HG, N, R.

Nolletia ciliaris (DC.) Steetz, *Davoren & Siebert 127*, Perennial, Suffrutex, N.

Pentzia calcarea Kies, *Davoren & Siebert 82*, Perennial, Suffrutex, F, HG, IG, N, R, W.

Pentzia globosa Less., *Davoren & Siebert 99*, Perennial, Evergreen, Dwarf Shrub, F, HG, N, W.

Pseudognaphalium oligandrum (DC.) Hilliard & B.L.Burtt, Annual, Herb, F, HG.

Osteospermum muricatum E.Mey. ex DC. subsp. *muricatum*, *Davoren 406*, Perennial, Erect herb, HG, N, W.

**Schkuhria pinnata* (Lam.) Cabrera, *Davoren & Siebert 67*, Annual, Erect herb, FF, F, HG, IG, N, R, W.

#*Senecio barbertonicus* Klatt, Perennial, Shrub succulent, HG.

Senecio consanguineus DC., Annual, Erect herb, HG, IG.

Senecio oxyriifolius DC. subsp. *oxyriifolius*, Perennial, Succulent herb, HG.

Senecio scaposus DC. var. *scaposus*, Perennial, Succulent herb, HG.

#*Senecio tamoides* DC., *Davoren & Siebert 384*, Perennial, Evergreen, Climber shrub, Succulent, HG.

**Solidago canadensis* L., *Davoren & Siebert 193*, Perennial, Rosette herb, F, HG.

**Sonchus asper* (L.) Hill subsp. *asper*, Annual, Herb, HG.

**Sonchus oleraceus* L., *Davoren 382*, Annual, Erect herb, F.

**Sphagneticola trilobata* (L.) Pruski, Perennial, Herb, HG.

**Tagetes erecta* L., Annual, Erect herb, F, HG.

**Tagetes minuta* L., Annual, Erect herb, HG, N, W.

**Tagetes patula* L., *Davoren & Siebert 303*, Annual, Erect herb, HG.

Tarchonanthus camphoratus L., *Davoren & Siebert 189*, Perennial, Evergreen, Shrub, FF, F, HG, N, W.

Tripteris aghillana DC. var. *aghillana*, Perennial, Herb, N.

**Verbesina encelioides* (Cav.) Benth. & Hook. var. *encelioides*., *Davoren & Siebert 204*, Annual, Erect herb, FF, F, HG, IG, N, W.

Vernonia oligocephala (DC.) Sch.Bip. ex Walp., Perennial, Herb, F, N.

Vernonia poskeana Vatke & Hildebr. subsp. *botswanica* G.V.Pope, *Davoren & Siebert 397*, Annual, Erect herb, FF, HG, N.

Vernonia steetziana Oliv. & Hiern., *Davoren & Siebert 146*, Annual, Erect herb, F, N.

**Xanthium spinosum* L., *Davoren 348*, Annual, Erect herb, HG, IG, R, W.

**Xanthium strumarium* L., *Davoren & Siebert 266*, Annual, Erect herb, F, IG, N, R.

**Zinnia elegans* Jacq., Annual, Herb, HG.

**Zinnia peruviana* (L.) L., *Davoren & Siebert 161*, Annual, Erect herb, F, HG, N, W.

Begoniaceae

**Begonia semperflorens* Link & Otto, Annual, Herb, HG.

Berberidaceae

**Nandina domestica* Thunb., Perennial, Woody shrub, HG, IG.

Bignoniaceae

**Campsis grandiflora* (Thunb.) K.Schum., Perennial, Climber shrub, HG.
**Macfadyena unguis-cati* (L.) A.H.Gentry, Perennial, Climber shrub, HG, W.
#Tecoma capensis (Thunb.) Lindl., Perennial, Climber shrub, HG.

Boraginaceae

Ehretia rigida (Thunb.) Druce subsp. *nervifolia* Retief & A.E.van Wyk, Perennial, Woody shrub, HG, N.
Heliotropium ciliatum Kaplan, *Davoren 21*, Perennial, Erect herb, FF, F, HG, R.
Heliotropium lineare (A.DC.) Gürke., *Davoren & Siebert 139*, Perennial, Erect herb, FF, F, HG, N, R, W.
Heliotropium nelsonii C.H.Wright., *Davoren 38*, Perennial, Erect herb, N, R.
Lithospermum cinereum A.DC., *Davoren & Siebert 97*, Perennial, Erect herb, N.

Brassicaceae

Lepidium bonariense L.*, Annual, Herb, HG.
Lobularia maritima (L.) Desv.*, Annual, Herb, IG.

Cactaceae

**Cereus jamacaru* DC., Perennial, Succulent herb, FF, HG.
**Echinopsis spachiana* (Lem.) Friedrich & Rowley, Perennial, Succulent herb, HG.
**Opuntia ficus-indica* (L.) Mill., Perennial, Shrub succulent, HG, W.
**Opuntia humifusa* (Raf.) Raf., Perennial, Succulent herb, F, HG.
**Opuntia imbricata* (Haw.) DC., *Davoren & Siebert 328*, Perennial, Evergreen, Succulent shrub, N, W.
**Opuntia spinulifera* Salm-Dyck, Perennial, Shrub succulent, HG.

Campanulaceae

Wahlenbergia denticulata (Burch.) A.DC. var. *denticulata*, *Davoren & Siebert 157*, Perennial, Erect herb, FF, HG, N.

Wahlenbergia undulata (L.f.) A.DC., *Davoren & Siebert 106*, Perennial, Erect herb, FF, N, W.

Cannaceae

**Canna indica* L., Perennial, Herb geophyte, HG.

Capparaceae

Boscia foetida Schinz subsp. *minima* Tölken, *Davoren & Siebert 254*, Perennial, Deciduous, Dwarf Shrub, N.
Cleome gynandra L., *Davoren 377*, Annual, Erect herb, FF, HG, N, R.
**Cleome hassleriana* Chodat, Annual, Herb, HG.
Cleome rubella Burch., *Davoren & Siebert 269*, Annual, Erect herb, FF, F, N, W.

Caprifoliaceae

**Sambucus nigra* L. subsp. *nigra*, *Davoren & Siebert 294*, Perennial, Deciduous, Shrub, HG.

Caryophyllaceae

**Dianthus barbatus* L., Perennial, Herb, HG.
Herniaria erckertii Herm. subsp. *erckertii* var. *erckertii*, *Davoren & Siebert 337*, Perennial, Prostrate herb, N, W.
Pollichia campestris Aiton, *Davoren & Siebert 263*, Perennial, Erect herb, FF, F, HG, N, R, W.
**Saponaria officinalis* L., Perennial, Herb, FF, HG.

Casuarinaceae

**Casuarina cunninghamiana* Miq., Perennial, Tree, HG.

Celastraceae

**Euonymus japonicus* Thunb., Perennial, Woody shrub, FF, HG.

Celtidaceae

#*Celtis africana* Burm.f., Perennial, Tree, FF, HG, IG.
**Celtis sinensis* Pers., Perennial, Tree, HG, IG.

Chenopodiaceae

**Atriplex nummularia* Lindl. subsp. *nummularia*, *Davoren & Siebert 271*, Perennial, Evergreen, Shrub, HG.
Atriplex semibaccata R.Br. var. *typica* Aellen, *Davoren & Siebert 312*, Perennial, Scandent herb, HG.
**Beta vulgaris* L. subsp. *cicla* (L.) W.D.J.Koch., Annual, Herb, HG.
**Beta vulgaris* L. subsp. *vulgaris*, Annual, Herb, HG, W.
**Chenopodium album* L., Annual, Herb, HG.
**Chenopodium ambrosioides* L., Annual, Herb, W.
**Chenopodium carinatum* R.Br., Annual, Herb, FF, F, HG, IG, N, R, W.
**Chenopodium multifidum* L., *Davoren & Siebert 332*, Perennial, Erect herb, R.

Colchicaceae

Ornithoglossum dinteri K.Krause, *Davoren & Siebert 114*, Perennial, Geophyte, FF, F, HG, N.
Ornithoglossum vulgare B.Nord., *Davoren 47*, Perennial, Geophyte, N.

Combretaceae

#*Combretum erythrophyllum* (Burch.) Sond., Perennial, Tree, FF, HG, IG.
Terminalia sericea Burch. ex DC., Perennial, Tree, HG, N.

Commelinaceae

Commelina africana L. var. *barberae* (C.B.Clarke) C.B.Clarke., *Davoren 407*, Perennial, Erect herb, F, N.
**Commelina benghalensis* L., *Davoren & Siebert 338*, Perennial, Semi-erect herb, W.
Commelina livingstonii C.B.Clarke, *Davoren & Siebert 300*, Perennial, Semi-scandent herb, FF, F, HG, N, W.
**Tradescantia pallida* (Rose) Hunt, Perennial, Herb, HG.

Convallariaceae

**Ophiopogon jaburan* Lodd., Perennial, Herb, IG.
**Ophiopogon japonicus* (L.f.) Ker Gawl., Perennial, Herb, IG.

Convolvulaceae

Convolvulus sagitattus Thunb., Perennial, Herb, W.
**Ipomoea batatas* (L.) Lam., Perennial, Herb geophyte, HG.
Ipomoea bolusiana Schinz, *Davoren & Siebert 116*, Perennial, Scandent herb, N.
Ipomoea carnea Jacq. subsp. *fistulosa* (Mart. ex Choisy) D.Austin, Perennial, Scrambling herb, HG.
Ipomoea hochstetteri House, *Davoren 405*, Annual, Climbing herb, FF, N.
Ipomoea magnusiana Schinz, Perennial, Herb, N.
Ipomoea obscura (L.) Ker Gawl. var. *obscura*, *Davoren & Siebert 105*, Perennial, Scrambling herb, N, R.
Ipomoea ommaneyi Rendle, *Davoren & Siebert 89*, Perennial, Trailing herb, FF, HG.
**Ipomoea purpurea* (L.) Roth, Annual, Herb, F, HG, N.
Merremia kentrocaulos (C.B.Clarke) Rendle, Perennial, Climber shrub, HG, IG.
Merremia palmata Hallier f., Perennial, Herb, N.
Merremia verecunda Rendle, *Davoren & Siebert 257*, Annual, Scrambling herb, FF, F, HG, N.

Crassulaceae

**Bryophyllum delagoense* (Eckl. & Zeyh.) Schinz, Perennial, Succulent herb, HG.
#*Cotyledon orbiculata* L. var. *oblonga* (Haw.) DC., Perennial, Succulent herb, HG.
#*Cotyledon tomentosa* Harv. subsp. *tomentosa*, Perennial, Succulent herb, HG, IG, N.
#*Crassula capitella* Thunb. subsp. *capitella*, Perennial, Succulent herb, HG, W.
#*Crassula ovata* (Mill.) Druce, Perennial, Shrub Succulent, F, HG, N, W.
**Echeveria elegans* A.Berger, Perennial, Succulent herb, FF, HG.
**Kalanchoe blossfeldiana* Ploelln., Perennial, Succulent herb, HG, IG.
**Kalanchoe pinnata* Pers., Perennial, Succulent herb, HG.
Kalanchoe rotundifolia (Haw.) Haw., *Davoren 374*, Perennial, Succulent herb, F, HG, N.
#*Kalanchoe thyrsiflora* Harv., Perennial, Succulent herb, HG, W.
**Sedum morganianum* Walther, Perennial, Succulent herb, HG.

Cucurbitaceae

Acanthosicyos naudinianus (Sond.) C.Jeffrey, *Davoren & Siebert 141*, Perennial, Prostrate herb, FF, N.
Citrillus lanatus (Thunb.) Matsum. & Nakai, *Davoren & Siebert 121*, Annual, Prostrate herb, HG.
Coccinia sessilifolia (Sond.) Cogn., *Davoren & Siebert 71*, Perennial, Climbing herb, N, W.
Cucumis africanus L.f., Perenniall, Prostrate herb, HG.

Cucumis hirsutus Sond., Perennial, Herb, FF, N.
#*Cucumis melo* L. subsp. *agrestis* (Naudin) Pangalo, Annual, Herb, HG.
Cucumis myriocarpus Naudin subsp. *leptodermis* (Schweick.) C.Jeffrey & P. Halliday, *Davoren & Siebert 268*, Annual, Prostrate herb, N.
Cucumis myriocarpus Naudin subsp. *myriocarpus*, *Davoren & Siebert 111*, Annual, Prostrate herb, FF, HG, N.
**Cucurbita maxima* Duchesne ex Lam., Annual, herb, HG, N, W.
**Cucurbita pepo* L., Annual, Herb, HG.
Momordica balsamina L., *Davoren & Siebert 103*, Perennial, Climbing herb, N, R.

Cupressaceae

**Chamaecyparis obtusa* (Siebold & Zucc.) Endl., Perennial, Woody shrub, HG.
**Cupressus arizonica* Greene var. *arizonica*, Perennial, Tree, HG.
**Cupressus sempervirens* L. var. *sempervirens*, Perennial, Tree, F, HG.

Cycadaceae

**Cycas revoluta* Thunb., Perennial, Woody shrub, FF, HG.

Cyperaceae

Bulbostylis hispidula (Vahl) R.W.Haines subsp. *pyriformis* (Lye) R.W.Haines., *Davoren & Siebert 323*, Annual, Cyperoid herb, FF, F, HG, IG, N, R.
Bulbostylis humulis (Kunth) C.B.Clarke, *Davoren & Siebert 181*, Annual, Cyperoid herb, N, W.
Cyperus difformis L., *Davoren & Siebert 319*, Annual, Cyperoid herb, W.
Cyperus esculentus L. var. *esculentus*, Perennial, Herb, HG.
Cyperus indecorus Kunth var. *decurvatus* (C.B. Clarke) Kük., Davoren & Siebert 100, Perennial, Cyperoid herb, F, HG, IG, N, R.
Cyperus margaritaceus Vahl var. *margaritaceus*, *Davoren & Siebert 120*, Perennial, Cyperoid herb, FF, F, HG, N.
Cyperus marginatus Thunb., *Davoren & Siebert 287*, Perennial, Cyperoid herb, HG, W.
Cyperus textilis Thunb., Annual Cyperoid herb, W.
Kyllinga alba Nees, *Davoren & Siebert 180*, Perennial, Cyperoid herb, N, W.
Schoenoplectus muricinux (C.B.Clarke) J.Raynal, *Davoren & Siebert 316*, Perennial, Cyperoid herb, N, W.

Dracaenaceae

**Dracaena deremensis* Engl., Perennial, Herb, FF, HG.
Sansevieria aethiopica Thunb., *Davoren & Siebert 252*, Perennial, Succulent geophyte, FF, HG, N.
**Sansevieria trifasciata* Prain, Perennial, Herb goephyte, HG.

Ebenaceae

Diospyros austro-africana De Winter var. *microphylla* (Burch.) De Winter, Perennial, Woody shrub, HG, N.
Diospyros lycioides Desf. subsp. *guerkei* (Kuntze) De Winter, *Davoren & Siebert 70*, Perennial, Deciduous, Shrub, HG, N.

Elaeagnaceae

**Elaeagnus pungens* Thunb., Perennial, Woody shrub, HG, FF.

Eriospermaceae

Eriospermum porphyrium Archibald, *Davoren & Siebert 170*, Perennial, Geophyte, F, HG. N.

Euphorbiaceae

**Breynia disticha* J.R.Forst. & G.Forst., Perennial, Woody shrub, FF, HG.
**Euphorbia heterophylla* L., Annual, Herb, HG.
**Euphorbia inaequilatera* Sond. var. *inaequilatera*, Annual, Herb, FF, F, HG, N, R.
**Euphorbia prostrata* Aiton, *Davoren & Siebert 297*, Annual, Prostrate herb, FF, F, HG, IG, N, W.
**Euphorbia serpens* Kunth, *Davoren & Siebert 227*, Annual, Prostrate herb, FF, F.
#Euphorbia tirucalli L., Perennial, Shrub succulent, F, HG.
Phyllanthus maderaspatensis L., *Davoren & Siebert 154*, Annual, Erect herb, N.
Phyllanthus parvulus Sond. var. *garipensis* (E.Mey. ex Drège) Radcl.-Sm., *Davoren & Siebert 307*, Perennial, Erect herb, F, N.
Phyllanthus sp., *Davoren & Siebert 108*, Annual, Erect herb, N.

Fabaceae

Acacia caffra (Thunb.) Willd., Perennial, Tree, N.

Acacia erioloba E. Mey., *Davoren & Siebert 219*, Perennial, Evergreen, Tree, FF, F, HG, N, R.

#*Acacia galpinii* Burtt Davy, Perennial, Tree, HG, IG.

Acacia hebeclada DC. subsp. *hebeclada*, *Davoren 13*, Perennial, Deciduous, Shrub, FF, F, HG, N, R, W.

Acacia karroo Hayne, *Davoren & Siebert 176*, Perennial, Deciduous, Tree, FF, F, HG, N, W.

Acacia mellifera (Vahl) Benth. subsp. *detinens* (Burch.) Brenan, Perennial, Tree, HG, N.

Acacia robusta Burch. subsp. *robusta*, Perennial, Tree, HG.

Acacia tortilis (Forssk.) Hayne subsp. *heteracantha* (Burch.) Brenan, Perennial, Tree, F, N.

**Caesalpinia gilliesii* (Wall. ex Hook.) Benth., *Davoren 32*, Perennial, Deciduous, Shrub, HG.

**Ceratonia siliqua* L., Perennial, Tree, HG.

Chamaecrista biensis (Steyaert) Lock, *Davoren & Siebert 143*, Perennial, Erect Herb, HG, N.

Crotolaria barkae Schweinf. subsp. *barkae*, Annual, Herb, W.

Crotalaria burkeana Benth., Perennial, Herb, N.

Crotalaria lotoides Benth., *Davoren 350*, Perennial, Erect Herb, FF, F, HG, IG, N.

Crotalaria orientalis Burtt Davy ex I.Verd. subsp. *orientalis*, *Davoren & Siebert 87*, Perennial, Deciduous, Dwarf shrub, FF, N.

Crotalaria sphaerocarpa Perr. ex DC. subsp. *sphaerocarpa*, Davoren & Siebert 58, Annual, Erect herb, FF, F, HG, IG, N, R, W.

Elephantorrhiza elephantina (Burch.) Skeels, *Davoren & Siebert 90*, Perennial, Suffrfutex, FF, F, HG, N, R.

#*Erythrina lysistemon* Hutch., Perennial, Tree, F, HG.

**Gleditsia triacanthos* L., Perennial, Tree, HG.

Hoffmannseggia burchellii (DC.) Benth. ex Oliv. subsp. *burchellii*, Perennial, Shrub, HG, N.

Indigastrum argyraeum (Eckl. & Zeyh.) Schrire, Perennial, Herb, F, HG, IG, N.

Indigofera cryptantha Benth. ex Harv. var. *cryptantha*, *Davoren & Siebert 395*, Perennial, Deciduous, Dwarf shrub, W

Indigofera daleoides Benth. ex Harv. var. *daleoides*, *Davoren & Siebert 149*, Perennial, Erect herb, FF, F, HG, N, R.

Indigofera filipes Benth. ex Harv., *Davoren & Siebert 129*, Perennial, Erect herb, F, HG, N.

Indigofera heterotricha DC., *Davoren & Siebert 391*, Perennial, Deciduous, Dwarf shrub, F.

Indigofera rhytidocarpa Benth. ex Harv. subsp. *rhytidocarpa*, *Davoren & Siebert 279*, Annual, Erect herb, F, HG, N, W.

**Lathyrus latifolius* L., Perennial, Climber shrub, HG.

Lessertia pauciflora, Perennial, Herb, N.

Lotononis calycina (E.Mey.) Benth., *Davoren & Siebert 177*, Perennial, Erect herb, FF, F, HG, N.

Lotononis listii Polhill, *Davoren & Siebert 293*, Perennial, Creeping herb, N, W.

**Lotus subbiflorus* Lag. subsp. *subbiflorus*., *Davoren & Siebert 208*, Perennial, Erect herb, F.

**Medicago laciniata* (L.) Mill. var. *laciniata*, *Davoren & Siebert 289*, Annual, Prostrate herb, W.

**Melilotus alba* Desr., Annual, Herb, HG, W.

Melolobium calycinum Benth., *Davoren 380*, Perennial, Deciduous, Dwarf shrub, N.

Mundulea sericea (Willd.) A.Chev., *Davoren & Siebert 261*, Perennial, Deciduous, Shrub, HG.

**Parkinsonia aculeata* L., Perennial, Tree, HG.

**Prosopis glandulosa* Torr. var. *torreyana* (Benson) Johnst., *Davoren & Siebert 200*, Perennial, Deciduous, Tree, HG.

Requienia sphaerosperma DC., *Davoren 408*, Perennial, Trailing herb, FF, N.

Rhynchosia confusa Burtt Davy, *Davoren & Siebert 310*, Perennial, Climbing herb, F, N, R.

Rhynchosia minima (L.) DC. var. *minima*, *Davoren 30*, Perennial, Climbing herb, R, N.

**Robinia pseudoacacia* L., Perennial, Tree, HG.

**Senna corymbosa* (Lam.) Irwin & Barneby, Perennial, Woody shrub, HG.

Senna italica Mill. subsp. *arachoides* (Burch.) Lock, *Davoren 3*, Perennial, Deciduous, Dwarf shrub, FF, F, HG, N, R.

**Senna occidentalis* (L.) Link, Perennial, Woody shrub, HG.

**Styphnolobium japonicum* (L.) Schott, Perennial, Tree, HG, N.

Tephrosia burchellii Burtt Davy, *Davoren & Siebert 135*, Annual, Scandent herb, FF, F, HG, N, W.

Tephrosia lupinifolia DC., *Davoren & Siebert 124*, Annual, Trailing herb, FF, HG.

**Tipuana tipu* (Benth.) Kuntze, Perennial, Tree, F, HG.

Vigna unguiculata (L.) Walp., Annual, Herb, HG.

**Wisteria sinensis* (Sims) Sweet, Perennial, Climber shrub, FF, HG.

Zornia milneana Mohlenbr., *Davoren & Siebert 138*, Perennial, Erect herb, FF, F, HG, N, R.

Flacourtiaceae

#*Dovyalis caffra* (Hook.f. & Harv.) Hook.f., *Davoren 352*, Perennial, Deciduous, Tree, HG.

Gentianaceae

Sebaea grandis (E.Mey.) Steud., *Davoren & Siebert 118*, Annual, Erect herb, FF, F, HG, N.

Geraniaceae

**Geranium sanguineum* L., Annual, Herb, HG.

Monsonia angustifolia E.Mey. ex. A.Rich., *Davoren 360*, Annual, Erect herb, FF, F, HG, IG, N, R.
#*Pelargonium hortorum* L.H.Bailey, Perennial, Herb, HG.

Gisekiaceae

Gisekia africana (Lour.) Kuntze var. *africana*, *Davoren & Siebert 184*, Annual, Prostrate herb, N.
Gisekia pharnacioides L. var. *pharnacoides*, *Davoren & Siebert 201*, Annual, Prostrate herb, FF, F, HG, N, R.

Hyacinthaceae

Albuca abyssinica Jacq., Perennial, Geophyte, HG, N.
Dipcadi glaucum (Ker Gawl.) Baker, *Davoren 49*, Perennial, Geophyte, HG.
Dipcadi marlothii Engl., *Davoren & Siebert 298*, Perennial, Geophyte, FF, HG.
Dipcadi sp., *Davoren & Siebert 376*, Perennial, Geophyte, IG.
#*Drimia sanguinea* (Schinz) Jessop, Perennial, Herb geophyte, HG, N, R.
#*Drimiopsis maculata* Lindl., Perennial, Herb geophyte, HG.
Ledebouria macowanii (Baker) S.Venter, *Davoren 43*, Perennial, Geophyte, HG, N.
#*Lindneria clavata* (Mast.) Speta, Perennial, Herb geophyte, FF, F, HG, N, R.
Ornithogalum tenuifolium F.Delaroche subsp. *Tenuifolium,* Perennial, Herb geophyte, HG.
#*Schizocarphus nervosus* (Burch.) Van der Merwe, Perennial, Herb geophyte, F, HG.

Hypoxidaceae

Hypoxis hemerocallidea Fisch., C.A.Mey. & Ave-Lall., Perennial, Herb geophyte, HG.

Iridaceae

Eleutherine bulbosa (Mill.) Urb., *Davoren & Siebert 295*, Perennial, Geophyte, HG.
#*Gladiolus dalenii* Van Geel, Perennial, Herb geophyte, HG.
Gladiolus permeabilis D.Delaroche subsp. *edulis* (Burch. ex Ker Gawl.) Oberm., *Davoren & Siebert 152*, Perennial, Geophyte, FF, N.
**Iris germanica* L., Perennial, Herb geophyte, HG.
Lapeirousia plicata (Jacq.) Diels subsp. *longifolia* Goldblatt, *Davoren 304*, Perennial, Geophyte, HG, W.
Lapeirousia plicata (Jacq.) Diels subsp. *plicata*, *Davoren 370*, Perennial, Geophyte, FF, N.

Juglandaceae

**Carya illinoiensis* (Wangenh.) K.Koch, Perennial, Tree, F, HG.

Lamiaceae

Acrotome inflata Benth., *Davoren & Siebert 195*, Annual, Erect herb, F, HG, N.
**Coleus thyrsoideus* Baker, Perennial, Herb, HG.
Leucas capensis (Benth.) Engl., *Davoren & Siebert 306*, Perennial, Deciduous, Dwarf shrub, FF, F, N.
**Mentha spicata* L., Perennial, Herb, HG.
Ocimum angustifolium Benth., *Davoren & Siebert 260*, Perennial, Erect herb, HG.
#*Plectranthus madagascariensis* (Pers.) Benth., Perennial, Herb, HG.
#*Plectranthus neochilus* Schltr., Perennial, Succulent herb, HG.
#*Plectranthus pentheri* (Guerke) Van Jaarsv. & T.J.Edwards, Perennial, Succulent herb, HG, N.
#*Plectranthus saccatus* Benth. var. *saccatus*, Perennial, Herb, HG, IG.
Salvia disermas L., *Davoren & Siebert 285*, Perennial, Erect herb, W.
**Salvia leucantha* Cav., Perennial, Herb, F, HG, N.
**Salvia microphylla* Kunth., *Davoren & Siebert 383*, Perennial, Evergreen, Dwarf shrub, HG.
Salvia runcinata L.f., *Davoren & Siebert 96*, Perennial, Erect herb, HG, N, R, W.
#*Stachys linearis* Burch. ex Benth., Perennial, Herb, FF, HG, W.
#*Stachys spathulata* Burch. ex Benth., Perennial, Herb, FF, HG, N.
Teucrium trifidum Retz., *Davoren & Siebert 389*, Perennial, Erect herb, W.

Lauraceae

**Cinnamomum camphora* (L.) Nees & Eberm., Perennial, Tree, HG.
**Persea americana* Mill. var. *americana*, Perennial, Tree, HG.

Loranthaceae

Agelanthus lugardii (N.E.Br.) Polhill & Wiens, Perennial, Shrub, HG, N.
Erianthemum ngamicum (Sprague) Danser, Perennial, Shrub, HG, N.

Malvaceae

**Alcea rosea* L., Annual, Herb, HG.
Hibiscus pusillus Thunb., *Davoren 346*, Perennial, Erect herb, F, N, W.

Hibiscus trionum L., *Davoren & Siebert 213*, Annual, Erect herb, F, N, W.
**Malva verticillata* L. var. *verticillata*., *Davoren 379*, Annual, Erect herb, HG.
Pavonia burchellii (DC.) R.A.Dyer., *Davoren & Siebert 163*, Perennial, Deciduous, Dwarf shrub, N, W.
Sida acuta Burm.f. var. *acuta*, *Davoren & Siebert 212*, Annual, Erect herb, HG, N, W.
Sida chrysantha Ulbr., *Davoren & Siebert 282*, Perennial, Decumbent herb, FF, F, HG, N.
Sida cordifolia L., *Davoren & Siebert 98*, Perennial, Deciduous, Dwarf shrub, FF, F, HG, IG, N, R, W.

Marsileaceae

Marsilea macrocarpa C.Presl, *Davoren & Siebert 317*, Perennial, Hydrophytic fern, N, W.

Meliaceae

**Melia azedarach* L., Perennial, Tree, HG, IG.

Menispermaceae

Antizoma angustifolia (Burch.) Miers ex Harv., *Davoren & Siebert 168,* Perennial, Scrambling herb, F, HG, N.

Mesembryanthemaceae

#*Aptenia cordifolia* (L.f.) Schwantes, Perennial, Succulent herb, HG.
#*Carpobrotus dimidiatus* (Haw.) L.Bolus, Perennial, Succulent herb, HG.
#*Lampranthus aureus* (L.) N.E.Br., Perennial, Succulent herb, HG, IG, N.
#*Lampranthus glaucus* (L.) N.E.Br., Perennial, Succulent herb, HG.
#*Lampranthus roseus* (Willd.) Schwantes, *Davoren & Siebert 197*, Perennial, Decumbent succulent herb, HG, W.
#*Ruschia canonotata* (L.Bolus) Schwantes, Perennial, Succulent herb, N.
#*Ruschia perfoliata* (Mil.) Schwantes, Perennial, Succulent herb, HG.

Molluginaceae

Hypertelis arenicola Sond., Annual, Herb, HG, N, R.
Hypertelis salsoloides (Burch.) Adamson var. *mossamendesis* (Welw. ex Hiern) Gonc., *Davoren & Siebert 313*, Perennial, Succulent herb, HG.

Limeum fenestratum (Fenzl) Heimerl var. *fenestratum*, *Davoren & Siebert 140*, Annual, Erect herb, FF, N.
Limeum sulcatum (Klotzsch) Hutch. var. *sulcatum.*, *Davoren & Siebert 205*, Annual, Erect herb, HG, R.
Limeum viscosum (J.Gay) Fenzl subsp. *viscosum* var. *glomeratum* (Eckl. & Zeyh.) Friedrich, *Davoren & Siebert 202*, Annual, Creeping herb, HG.
Limeum viscosum (J.Gay) Fenzl subsp. *viscosum* var. *kraussii* Friedrich, *Davoren & Siebert 393*, Annual, Erect herb, F, HG, N.
Mollugo cerviana (L.) Ser. ex DC. var. *cerviana.*, *Davoren & Siebert 151*, Annual, Rosette herb, HG, IG.

Moraceae

**Ficus carica* L., Perennial, Woody shrub, HG, IG.
**Morus alba* L. var. *alba*, Perennial, Tree, HG, IG.

Musaceae

**Musa sapientium* Kuntze, Perennial, Tree, HG, IG.

Myrtaceae

**Callistemon citrinus* (Curtis) Stapf, Perennial, Tree, HG.
**Callistemon viminalis* (Sol. ex Gaertn.) Cheel, Perennial, Tree, HG.
**Eucalyptus camaldulensis* Dehnh., Perennial, Tree, F, HG, N.
**Eucalyptus cladocalyx* F.Meull., Perennial, Tree, HG, N.
**Eucalyptus sideroxylon* A.Cunn., Perennial, Tree, FF, HG.
**Eucalyptus* sp., *Davoren & Siebert 334*, Perennial, Evergreen, Tree, IG.
**Melaleuca linariifolia* Sm., Perennial, Tree, HG.
**Myrtus communis* L. var. *communis*, Perennial, Woody shrub, HG, IG.

Nephrolepidaceae

**Nephrolepis exaltata* (L.) Schott, Perennial, Herb geophyte, HG, W.

Nyctaginaceae

**Boerhavia cordobensis* Kuntze, *Davoren & Siebert 150*, Annual, Decumbent herb, HG, R.

**Boerhavia diffusa* L. var. *diffusa*, *Davoren & Siebert 190*, Perennial; Decumbent herb, F, HG, R.

**Boerhavia erecta* L., Annual, Decumbent herb, HG, N.

**Bougainvillea glabra* Choisy, *Davoren & Siebert 191*, Perennial, Deciduous, Climbing shrub, HG, IG.

**Mirabilis jalapa* L., *Davoren & Siebert 301*, Perennial, Deciduous, Dwarf shrub, HG.

Olacaceae

Ximenia caffra Sond. var. *caffra*, Perennial, Tree, N.

Oleaceae

**Fraxinus angustifolia* Vahl, Perennial, Tree, HG.

**Fraxinus pennsylvanica* Marsh, Perennial, Tree, HG.

**Fraxinus velutina* Torr. var. *velutina*, Perennial, Tree, HG.

**Ligustrum ibota* Siebold & Zucc., Perennial, Woody shrub, HG, W.

**Ligustrum lucidum* Aiton, Perennial, Woody shrub, HG.

Menodora africana Hook., Perennial, Woody shrub, W.

#Olea europaea L. subsp. *africana* (Mill.) P.S.Green, Perennial, Tree, HG.

Ophioglossaceae

Ophioglossum costatum R.Br., *Davoren & Siebert 236*, Perennial, Geophytis fern, N.

Orchidaceae

Habenaria epipactidea Rchb.f., *Davoren & Siebert 85*, Perennial, Geophyte, FF, N.

Orobanchaceae

Striga gesnerioides (Willd.) Vatke ex Engl., *Davoren & Siebert 128*, Perennial, parasitic herb, FF, N.

Oxalidaceae

**Oxalis corniculata* L., *Davoren & Siebert 80*, Annual, Prostrate herb, FF, F, HG, N, W.

Oxalis depressa Eckl. & Zeyh., *Davoren & Siebert 305*, Perennial, Geophyte, HG, N.

**Oxalis latifolia* Knuth, Perennial, Herb geophyte, HG.

Papaveraceae

**Argemone orchroleuca* Sweet subsp. *ochroleuca*, *Davoren 12*, Annual, Erect herb, HG.

Pedaliaceae

Ceratotheca triloba (Bernh.) Hook.f., Annual, Herb, HG.
Dicerocaryum eriocarpum (Decne.) Abels, *Davoren & Siebert 215*, Perennial, Prostrate herb, N.
Harpagophytum procumbens (Burch.) DC. ex Meisn. subsp. *procumbens*, *Davoren 16*, Perennial, Prostrate herb, FF, F, HG, N, R.
Holubia saccata Oliv., Perennial, Succulent herb, N.
Pterodiscus speciosus Hook., Perennial, Suffrutex, N.
Sesamum alatum Thonn., Annual, Erect herb, FF, F, HG, N.
Sesamum capense Burm.f., *Davoren & Siebert 203*, Annual, Erect herb, HG, R.
Sesamum triphyllum Welw. ex Asch. var. *triphyllum*, *Davoren & Siebert 210*, Annual, Erect herb, FF, HG, R.

Phytolaccaceae

**Phytolacca dioica* L., Perennial, Tree, HG.

Pinaceae

**Pinus elliottii* Engelm. var. *elliottii*, Perennial, Tree, HG.
**Pinus halepensis* Mill., Perennial, Tree, HG.

Plumbaginaceae

#Plumbago auriculata Lam. Perennial, Woody shrub, HG.

Poaceae

Anthepora pubescens Nees, *Davoren 44*, Perennial, Graminoid, N, R.
Aristida canescens Henrard subsp. *canescens*, Perennial, Graminoid, IG, N.
Aristida congesta Roem. & Schult. subsp. *barbicollis* (Trin. & Rupr.) De Winter, *Davoren & Siebert 228*, Perennial, Graminoid, FF, F, HG, IG, N, R, W.
Aristida diffusa Trin. subsp. *burkei* (Stapf) Melderis, *Davoren & Siebert 225*, Perennial, Graminoid, FF, F, N.

Aristida meridionalis Henrard, *Davoren & Siebert 231*, Perennial, Graminoid, FF, N.

Aristida stipitata Hack. subsp. *graciliflora* (Pilg.) Melderis, *Davoren & Siebert 243*, Perennial, Graminoid, FF, F, HG, N, R, W.

**Arundo donax* L., Perennial, Graminoid, HG.

Brachiaria eruciformis (Sm.) Griseb., *Davoren & Siebert 290*, Annual, Graminoid, W.

Brachiaria marlothii (Hack.) Stent., *Davoren & Siebert 209*, Annual, Graminoid, HG, N.

Brachiaria nigropedata (Ficalho & Hiern) Stapf, *Davoren & Siebert 232*, Perennial, Graminoid, FF, F, HG, N, W.

Centropodia glauca (Nees) Cope, Perennial, Graminoid, HG, IG, N.

Chloris virgita Sw., *Davoren & Siebert 333*, Annual, Graminoid, F, HG, IG, N, R, W.

Cynodon dactylon (L.) Pers., *Davoren & Siebert 245*, Perennial, Graminoid, FF, F, HG, IG, N, R, W.

Cynodon hirsutus Stent, *Davoren & Siebert 329*, Perennial, Graminoid, F, HG, IG, N, R, W.

Cynodon transvaalensis Burtt Davy, Perennial, Graminoid, HG

Dactyloctenium aegyptium (L.) Willd., *Davoren & Siebert 385*, Annual, Graminoid, HG.

Dactyloctenium giganteum Fisher & Schweick., Perennial, Graminoid, HG.

Digitaria eriantha Steud., *Davoren & Siebert 237*, Perennial, Graminoid, FF, F, HG, N, R, W.

**Digitaria sanguinalis* (L.) Scop., Annual, Graminoid, FF, HG, N, W.

Echinochloa holubii (Stapf) Stapf, *Davoren & Siebert 398*, Perennial, Graminoid, W.

Eleusine coracana (L.) Gaertn. subsp. *africana* (Kenn.-O'Byrne) Hilu & De Wet, Annual, Graminoid, HG, IG, N, R.

Enneapogon cenchroides (Roem. & Schult.) C.E.Hubb., *Davoren 45*, Annual, Graminoid, N, R.

Eragrostis aspera (Jacq.) Nees, *Davoren 349*, Annual, Graminoid, FF, HG, R.

Eragrostis biflora Hack. ex Schinz, *Davoren & Siebert 235*, Annual, Graminoid, F, N.

Eragrostis chloromelas Steud., Perennial, Graminoid, FF, HG, N.

Eragrostis curvula (Schrad.) Nees, Perennial, Graminoid, HG, N.

Eragrostis gummiflua Nees, Perennial, Graminoid, HG, N.

Eragrostis lehmanniana Nees var. *lehmanniana*, *Davoren & Siebert 241*, Perennial, Graminoid, FF, F, HG, IG, N, R, W.

Eragrostis micrantha Hack., Perennial, Graminoid, HG, N.

Eragrostis pallens Hack., Perennial, Graminoid, HG, IG, R.

Eragrostis x pseud-obtusa De Winter, *Davoren & Siebert 291*, Perennial, Graminoid, F, N, W.

Eragrostis superba Peyr., Perennial, Graminoid, HG, N.

Eragrostis trichophora Coss. & Durieu, *Davoren 23*, Perennial, Graminoid, FF, F, HG, IG, N, W.

Eragrostis viscosa (Retz.) Trin., *Davoren & Siebert 325*, Annual, Graminoid, FF, HG, N.

Heteropogon contortus (L.) Roem. & Schult., *Davoren & Siebert 394*, Perennial, Graminoid, N.

Melinis repens (Willd.) Zizka subsp. *grandiflora* (Hochst.) Zizka, *Davoren & Siebert 233*, Annual, Graminoid, FF, N.

Melinis repens (Willd.) Zizka subsp. *repens*, *Davoren 27*, Annual, Graminoid, FF, F, HG, N, W.
Microchloa caffra Nees, Perennial, Graminoid, HG, N.
Panicum coloratum L. var. *coloratum*, *Davoren & Siebert 288*, Perennial, Graminoid, FF, HG, N, W.
Paspalum distichum L., *Davoren & Siebert 322*, Perennial, Graminoid, W.
**Pennisetum clandestinum* Hochst. ex Chiov., Perennial, Graminoid, HG, IG.
**Pennisetum villosum* R.Br. ex Fresen., Perennial, Graminoid, HG.
Perotis patens Gand., Annual, Graminoid, N.
**Poa annua* L., Annual, Graminoid, HG.
Pogonarthria squarrosa (Roem. & Schult.) Pilg., *Davoren & Siebert 230*, Perennial, Graminoid, FF, N.
**Saccharum officinarum* L., Annual, Graminoid, HG, N, W.
Schmidtia pappophoroides Steud., *Davoren & Siebert 239*, Perennial, Graminoid, FF, F, HG, N, R.
Setaria pumila (Poir.) Roem. & Schult., *Davoren & Siebert 388*, Annual, Graminoid, N, W.
Setaria sphacelata (Schumach.) Moss var. *sphacelata*, Perennial, Graminoid, HG, N.
Setaria verticillata (L.) P.Beauv., Annual, Graminoid, HG, W.
Sorghum bicolor (L.) Moench subsp. *arundinaceum* (Desv.) de Wet & Harlan, Annual, Graminoid, HG, R.
Sorghum bicolor (L.) Moench subsp. *bicolor*, Annual, Graminoid, HG.
Sporobolus africanus (Poir.) A.Robyns & Tournay, Perennial, Graminoid, W.
Sporobolus fimbriatus (Trin.) Nees, Perennial, Graminoid, N, W.
Themeda triandra Forssk., Perennial, Graminoid, HG, N.
Tragus koelerioides Asch., *Davoren & Siebert 250*, Perennial, Graminoid, FF, F, HG, IG, N, R.
Tragus racemosus (L.) All., *Davoren & Siebert 242*, Annual, Graminoid, FF, F, HG, N, W.
Trichoneura grandiglumis (Nees) Ekman, Perennial, Graminoid, FF, HG, N.
Triraphis schinzii Hack., *Davoren 367*, Perennial, Graminoid, N.
Urochloa mosambicensis (Hack.) Dandy, Perennial, Graminoid, FF, F, HG, IG, N, R, W.
Urochloa panicoides P. Beauv., Annual, Graminoid, FF, F, HG, R.
**Zea mays* L., Annual, Graminoid, HG.

Polygalaceae

Polygala leptophylla Burch. var. *leptophylla*, *Davoren & Siebert 130*, Perennial, Erect herb, FF, N, R.

Polygonaceae

Emex australis Steinh., *Davoren & Siebert 56*, Annual, Erect herb, HG, R.

Oxygonum dregeanum Meisn. subsp. *canescens* (Sond.) Germish. var. *canescens*, *Davoren & Siebert 126*, Annual, Erect herb, N, R.
**Polygonum capitatum* Buch-Ham. ex D.Don, Perennial, Herb, HG, W.

Portulacaceae

Portulaca grandiflora Hook., *Davoren & Siebert 223*, Annual, Prostrate succulent herb, F, HG, N.
Portulaca kermesina N.E.Br., *Davoren & Siebert 246*, Annual, Prostrate succulent herb, FF, F, HG, N, W.
**Portulaca oleracea* L., *Davoren 363*, Annual, Prostrate succulent herb, F, HG, N, R.
Portulaca quadrifida L., *Davoren & Siebert 77*, Annual, Prostrate succulent herb, FF, F, HG, IG, N, R, W.
Talinum arnotii Hook.f., *Davoren 368*, Annual, Prostrate succulent herb, FF, HG, N.
Talinum crispatulum Dinter ex Poelln., *Davoren & Siebert 221*, Annual, Prostrate succulent herb, HG, N.

Proteaceae

**Grevillea robusta* A.Cunn. ex R.Br., Perennial, Tree, HG.
**Grevillea rosmarinifolia* A.Cunn., Perennial, Herb, IG.

Punicaceae

**Punica granatum* L., Perennial, Woody shrub, F, HG.

Ranunculaceae

Clematis brachiata Thunb., *Davoren & Siebert 400*, Perennial, Climbing herb, N, W.

Rhamnaceae

Ziziphus mucronata Willd. subsp. *mucronata*, *Davoren 14*, Perennial, Deciduous, Tree, F, HG, N, R, W.
Ziziphus zeyheriana Sond., *Davoren & Siebert 55*, Perennial, Deciduous, Dwarf shrub, F, N.

Rosaceae

**Cotoneaster frigidus* Wall. ex Lindl., Perennial, Woody shrub, HG.

*_Cydonia oblonga_ Mill., Perennial, Woody shrub, HG.
*_Fragaria ananassa_ Duchesne, Perennial, Herb, HG.
*_Malus sylvestris_ Mill., Perennial, Tree, F, HG, N.
*_Prunus armeniaca_ L., Perennial, Tree, HG, N.
*_Prunus persica_ (L.) Batsch. var. _persica_, Perennial, Tree, FF, F, HG, IG, N, W.
*_Pyracantha angustifolia_ (Franch.) C.K.Scheid., Perennial, Woody shrub, HG.
*_Rosa banksiae_ R.Br., Perennial, Climber shrub, IG.
*_Rosa chinensis_ Jacq., Perennial, Woody shrub, HG, IG.
*_Rosa rubiginosa_ L., Perennial, Climber shrub, HG.

Rubiaceae

Anthospermum hispidulum E.Mey. ex Sond., _Davoren & Siebert 267_, Perennial, Erect herb, N.
Anthospermum rigidum Eckl. & Zeyh. subsp. _rigidum_., _Davoren & Siebert 94_, Perennial, Erect herb, N, R.
*_Gardenia augusta_ (L.) Merr., Perennial, Woody shrub, HG.
Kohautia subverticillata (K.Schum.) D.Mantell subsp. _subverticillata_, _Davoren & Siebert 327_, Perennial, Erect herb, FF, N, R.
Spermacoce senensis (Klotzsch) Hiern, _Davoren 39_, Annual, Erect herb, N, R.

Rutaceae

*_Citrus limon_ (L.) Burm.f., Perennial, Tree, HG.
*_Citrus reticulata_ Blanco, Perennial, Tree, HG.
*_Citrus sinensis_ (L.) Osbeck, Perennial, Tree, HG.
*_Ruta graveolens_ L., Perennial, Evergreen, Dwarf shrub, HG.

Salicaceae

*_Populus deltoideus_ Bartram ex Marsh subsp. _wislizenii_ (S.Watson) Eckenw., Perennial, Tree, HG.
*_Populus nigra_ L. var. _italica_ Moench., Perennial, Tree, HG, N, W.

Santalaceae

Thesium utile A.W.Hill, Perennial, Herb, FF, F, N.

Sapindaceae

Dodonaea viscosa Jacq. var. *viscosa*, *Davoren 33*, Perennial, Evergreen; Shrub, F, HG.

Scrophulariaceae

Aptosimum elongatum Engl., *Davoren & Siebert 65*, Perennial, Prostrate herb, FF, F, HG, N.
Jamesbrittenia atropurpurea (Benth.) Hilliard subsp. *atropurpurea*, *Davoren & Siebert 340*, Perennial, Erect shrub, N, W.
Jamesbrittenia aurantiaca (Burch.) Hilliard, *Davoren & Siebert 286*, Perennial, Erect herb, F, HG, N, W.
Selago mixta Hillard, *Davoren & Siebert 110*, Perennial, Erect herb, FF, F, HG, N, R, W.
Selago welwitschii Rolfe var. *australis* Hilliard, *Davoren & Siebert 392*, Perennial, Suffrutex, W.
**Viola odorata* L., Perennial, Herb, HG.

Simaroubaceae

**Ailanthus altissima* (Mill.) Swingle, Perennial, Tree, HG.

Solanaceae

**Capsicum annuum* L. var. *glabriusculum* (Dunal) Heiser & Pickersgill, Perennial, Herb, HG.
**Capsicum frutescens* L., Perennial, Herb, HG.
**Cestrum nocturnum* L., Perennial, Herb, W.
**Cestrum parqui* L'Her., Perennial, Woody shrub, HG.
**Datura inoxia* Mill., *Davoren & Siebert 199*, Annual, Erect herb, HG.
**Datura stramonium* L., Annual, Erect herb, HG.
Lycium cinereum Thunb., *Davoren 381*, Perennial, Deciduous, Dwarf shrub, N.
Lycium horridum Thunb., *Davoren & Siebert 156*, Perennial, Deciduous, Dwarf shrub, F, HG, N.
**Lycopersicon esculentum* Mill. var. *cerasiforme* Hort., Annual, Erect herb, HG.
**Lycopersicon esculentum* Mill. var. *esculentum*, Annual, Erect herb, HG, N.
**Nicotiana glauca* Graham, *Davoren & Siebert 194*, Perennial, Evergreen, Shrub, F, HG, IG.
**Petunia hybrida* Hort., Annual, Herb, IG.
**Physalis angulata* L., Annual, Herb, F, HG.
**Physalis viscosa* L., Perennial, Herb, HG.
**Solanum elaeagnifolium* Cav., Perennial, Shrub, F, HG, N.
**Solanum nigrum* L., *Davoren & Siebert 214*, Annual, Erect herb, N, W.
Solanum panduriforme E.Mey., *Davoren 365*, Perennial, Erect herb, N.
** Solanum rantonnetii* Carri Ġre., *Davoren 402*, Perennial, Evergreen, Shrub, HG.

Solanum supinum Dunal var. *supinum*, *Davoren & Siebert 76*, Perennial, Erect herb, N.
**Solanum tuberosum* L., Perennial, Herb geophyte, HG.

Sterculiaceae

**Brachychiton populneus* (Schott & Endl.) R.Br., Perennial, Tree, HG.
Hermannia comosa Burch. ex DC., *Davoren & Siebert 57*, Perennial, Erect herb, HG, N.
Hermannia linnaeoides (Burch.) K.Schum., *Davoren & Siebert 292*, Perennial, Prostrate herb, W.
Hermannia modesta (Ehrenb.) Mast., *Davoren & Siebert 296*, Perennial, Erect herb, F, HG, N.
Hermannia quartiniana A.Rich., *Davoren & Siebert 256*, Perennial, Prostrate herb, F, HG, N.
Hermannia stellulata (Harv.) K.Schum., *Davoren 25*, Perennial, Prostrate herb, FF, F, HG, N.
Hermannia tomentosa (Turcz.) Schinz ex Engl., *Davoren 20*, Perennial, Trailing herb, FF, F, HG, N, R.
Melhania acuminata Mast. var. *acuminata*., *Davoren & Siebert 216*, Perennial, Erect herb, N.
Waltheria indica L., *Davoren & Siebert 390*, Annual, Erect herb, N.

Tamaricaceae

**Tamarix ramosissima* Ledeb., Perennial, Shrub, HG.
#*Tamarix usneoides* E.Mey. ex Bunge, Perennial, Shrub, HG, N.

Thymelaeaceae

Gnidia burchellii (Meisn.) Gilg, *Davoren & Cilliers 51*, Perennial, Deciduous, Dwarf shrub, N.
Gnidia polycephala (C.A.Mey.) Gilg, *Davoren & Cilliers 50*, Perennial, Deciduous, Dwarf shrub, FF, F, HG, N, W.

Tiliaceae

Corchorus asplenifolius Burch., Perennial, Herb, HG, N.
Grewia bicolor Juss., Perennial, Shrub, W.
Grewia flava DC., *Davoren & Siebert 172*, Perennial, Deciduous, Shrub, FF, F, HG, N.
Grewia occidentalis L. var. *occidentalis*, Perennial, Shrub, N.

Tropaeolaceae

**Tropaeolum majus* L., Annual, Herb, HG.

Urticaceae

**Boehmeria nivea* (L.) Gaud., Perennial, Herb, IG.

Vahliaceae

Vahlia capensis (L.f.) Thunb. subsp. *vulgaris* Bridson var. *linearis* E.Mey. ex Bridson, *Davoren & Siebert 321*, Annual, Erect herb, N, W.

Verbenaceae

**Duranta erecta* L., Perennial, Shrub, HG.
**Lantana camara* L., Perennial, Dwarf shrub, HG, W.
Lantana rugosa Thunb., *Davoren & Siebert 66*, Perennial, Deciduous, Dwarf shrub, N, W.
Lippia scaberrima Sond., *Davoren & Siebert 259*, Perennial, Erect herb, N.
**Verbena aristigera* S.Moore, Perennial, Herb, HG.
**Verbena bonariensis* L., *Davoren & Siebert 320*, Annual, Erect herb, N, W.
**Verbena hybrida* Voss ex Rumpler, Perennial, Herb, HG

Vitaceae

**Parthenocissus quinquefolia* (L.) Planch., Perennial, Climber shrub, HG.
**Vitis vinifera* L., Perennial, Climber shrub, HG.

Zygophyllaceae

Tribulus terrestris L., *Davoren & Siebert 330*, Annual, Prostrate herb, F, HG, IG, N, R, W.

Appendix 3: Social survey questionnaire

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

Q Nr: _____

GPS: _____

PLANT DIVERSITY and SES SURVEY:

GANEYSA (Bophirima District, North-West Province)

IMPORTANT NOTES TO FIELDWORKERS

IMPORTANT NOTES TO FIELDWORKERS

- Please **introduce yourself** to the respondent;
- Tell the respondent that you are **doing research** in this area;
- and then ask the respondent if you can ask him/her some questions about their garden/yard (patlelo) and their socio-economic status.

THENé

- ***Please thank the respondent for his/her participation****;*
- *tell him/her that there are **no right or wrong answers** to the questions;*
- *and that you are **going to write down all the answers** to the questions on this questionnaire (remember to write the answer as close as possible to the respondents own wording**, in English**).*

Before starting the interview ***please thank the respondent for his/her participation****; tell him/her that there are* ***no right or wrong answers****; and that you are* ***going to write down all the answers*** *to the questions on this questionnaire (remember to write the answer as close as possible to the respondents own wording****, in English****).*

1. What is a garden the way you understand it?

2. Do you think that it is important to have a garden? (Ask them to please tell you why).

3. Please tell me more about your garden/yard (***Patlelo***)?

4. What is the occupation (work/job), age and gender of the main gardener?

5. Who helps (works) in the garden / yard (***Patlelo***); and list what does each person/s do?

6. What is the age/s and gender of the persons helping in the garden / yard (***Patlelo***)?

7. Why do you grow ornamental flowers (*plants you can't eat or use in any other way*)?

8. Which of the following activities takes place in your garden / yard (***Patlelo***)?

	ã	How often?
Water the garden		
Fertilise the garden		
Weed the garden		
Sweep the garden		
Prune your hedges / trees		
Remove any dead material		
Any method of pest control		

Key to terminology:

- **Watering** the garden refers to watering specific plants with a hosepipe, bucket or any other container that contains a water base fluid;
- **Fertilising** refers to the use of compost (decomposed plant material such as leaves) or manure (the dung of livestock, such as cattle, sheep or chickens) or chemicals and/or granules;
- **Weeding** refers to removing unwanted (alien or problem) plants;
- **Sweeping the garden** refers to sweeping an area around the house that are cleared of vegetation (plants);
- **Pruning** refers to the cutting of unwanted branches, twigs, etc. so that the plant has a distinctive shape;
- **Pest control** refers to applying some action to remove or prevent unwanted insects from destroying vegetation (plants) that are considered apart of the garden.

9. Would young people/children like to learn more about gardening?

(1) Yes	(2) No

10. Would you like to learn more about gardening?

(1) Yes	(2) No

11. How long have you lived on this plot?

(1) 0-2 years	(2) Between 2 and 5 years	(3) 5-10 years	(4) More than 10 years

12. How many people live here on a permanent basis?

_____

_____

_____

_____

_____

13. How many of the people living here on a permanent basis are males and how many are females, and what are their ages?

Males		**Females**	
How many	Age	How many	Age

14. How many of these people generate an income through part-time work or permanent jobs/work?

_____

_____

_____

_____

_____

15. Are there persons in your household that are of income earning age (between the ages of 18-60, who can work), but that cannot find any work/jobs?

_____

_____

_____

16. In what type of structure do you live?

Informal house (Zinc structure)	1
Traditional house (Mud structure)	2
Formal house	3

17. How many rooms does your house have?

_____

18. Do you own or rent this house?

Rent	1
Own	2

19. Do you have a toilet or sanitation (a place to wash yourself) facility available and where is it?

None	0
Outside your home	1
Inside your home	2

20. Which of the following energy resources do you use to help you to see at night?

Wood fire	1
Candles	2
Paraffin (lamps)	3
Electricity	4
Other	

Please specify other?

_____

21. Which of the following energy resources do you use to stay warm when it is cold?

Wood fire	1
Paraffin (heater)	2
Electricity (electrical heater)	3
Other	

Please specify other?

_____

22. Which of the following energy resources do you use to cook your food on?

Wood fire	1
Paraffin (stove)	2
Electricity (stove)	3
Other	

Please specify other?

_____

23. Where do you get your water from, specifically the water for your own use to drink and to cook your food?

Natural source (River/Stream or Dam/Pan)	1
Communal water tap	2
Water tap in your yard	3
Water tap in your home	4

24. Where do you get the water that you use in your garden?

Natural source (River/Stream or Dam/Pan)	1
Rain water	2
Communal water tap	3
Bore hole/well on property	4
Water tap in your yard	5
Water tap in your home	6

25. How far away is your water source, that you use in your garden?

More than 1 km	1
500m ï 1 km	2
100 ï 500m	3
Less than 100m	4

26. How do you transport the water you use in your garden, if you don't have a tap in your yard?

Carry in buckets	1
Wheelbarrow	2
Donkey car	3
Other	

Please specify other

_____

27. Do you buy food or do you produce your own fruit/vegetables?

Produce/grow	1
Buy and grow	2
Buy	3

28. For what reason do you grow your own fruit/vegetables?

For own consumption	1
For own consumption and to sell	2
To sell	3

29. If you grow vegetables, where do you get your vegetables seeds/seedlings from?

Buy	1
Produce	2
Get for free	3

30. Do you use any plants from the veldt (**naga**)?

(1) Yes	(2) No

31. If yes, what do you use these plants for?

_____

_____

_____

32. Which of the following animals do you own/

Chicken/Geese/Ducks/Turkey	1
Pig	2
Goats/Sheep	3
Donkey	4
Cattle	5

33. What is the highest level of education in your household? Please fill in the number of household members with a specific level of qualification ***(People living here permanently).***

Level of education	Male	Female
(1) None		
(2) Primary school		
(3) Secondary school (excluding Grade 12)		
(4) Grade 12		
(5) A tertiary qualification		

34. How do you earn your money / how do you get your money?

Support form others/family members	1
Piece work/odd jobs (skrop werk)	2
Government grant	3
Informal business	4
Own business	5
Permanent job	6
Other	

Please specify other

_____

35. Does any member of your household have access to any of the following modes of transport?

Bicycle	1
Donkey car	2
Own motor car	3

36. What is the combined total monthly income of all the working household members?

R o ï 500	1
R 500 ï 1000	2
R 1000 ï 2000	3
R 2000 ï 5000	4
More than R 5000	5

37. On what do you spend <u>most</u> of your money? Please rank in order of expenditure.

(1) Food	
(2) Housing	
(3) Medical expenses	
(4) Transport	
(5) Clothing	
(6) School	
(7) Insurance	
(8) Remittances/support to others elsewhere	
(9) Other	

In case of ñotherò please specify _____

38. Satisfaction of life scale

Statement	Yes	No
Are you satisfied with your life?		
Are you satisfied with your living conditions?		
Do you have the basic resources needed for you to make a living?		
Do the people in your community support each other and work together?		
My health and the health of my family is good?		

39. How often do you feel happy, calm and peaceful?

Always	Sometimes	Never

40. Do you have some one to turn to in times of stress?

Always	Sometimes	Never

Appendix 4: Thematic context analysis

Perception question 1: What is a garden you the way you understand it?

1. Gardens represent life:	*"A garden is life"*
2. A place where you can grow fruit and vegetables:	*"A place where you can help yourself by planting vegetables and fruit"* *"A place where we can plant vegetables and flowers"* *"It is a place where we plant trees and vegetables"*
3. To generate an income:	*"You can make money by selling what you planted"* *"You can generate an income from your garden"* *"You can even make a living by planting and selling"*
4. To prevent erosion:	*"You can help prevent soil erosion by planting more trees"* *"Planting trees can help you deal with the erosion of the soil"*
5. Taking care of your environment:	*"It represents a way of taking care of your environment"*

Perception question 2: Do you think that it is important to have garden?

1. A garden is important:	*"Yes, a garden is important"* *"Yes, a garden is very important"*
2. In order to grow food:	*"We can plant some vegetables to eat"* *"You can save money by planting your own vegetables"* *"Because you can eat everything you like to eat without having to buy it from the shop"*
3. To generate an income:	*"You can earn some money by selling the vegetables you grow"* *"We can sell the vegetables for money"* *""you can make a living from it by selling the vegetables"*
4. To prevent soil erosion:	*"A garden keeps the soil and helps to prevent soil erosion"*
5. It helps to build bodies:	*"A garden helps to build our bodies"*

Perception question 3: Please tell me more about your garden/yard?

1. Cleaning the garden	*"I keep the garden clean everyday"* *"I keep my yard clean"*
2. Soil for growing fruit and vegetables	*"The soil is very fertile for growing something"* *"The soil is ok for planting"*
3. To plant fruit and vegetables	*"I use my garden to plant vegetables and fruit"* *"The vegetables I plant help my children at school"*
4. To plant ornamental flowers	*"Sometimes I plant flowers"* *"It is important to grow flowers because the yard is going to look smart"*
5. To make friends	*"The vegetables we plant help us to make friends"* *"A garden can attract people"*

Perception question 4: Why do you grow ornamental flowers?

1. To make the yard look beautiful	*"To make my yard attractive"* *"To make my yard look smart"*
2. For shade	*"To sit under shadow"* *"For shade in the summer"*
3. Doesnâ t plant ornamental flowers	*"I've got no ornamental flower, I don't have enough water"* *"We don't grow ornamental flowers"*
4. Plants provide oxygen	*"Plants give us oxygen"* *"Plants give oxygen"*
5. To prevent soil erosion	*"To help prevent erosion"* *"To prevent soil erosion"*
6. Decoration for the house	*"It also helps me with the decoration of my house"* *"To make your house beautiful"*
7. To protect the house from wind	*"Some of the trees protect my house against the wind"* *"To help us during the wind"*
8. To attract people	*"It attracts people"*