An assessment of the useful plant diversity in homegardens and communal land of Tlhakgameng, North-West

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Dedicated to my family

You believed in me during hard times

Special dedication to my mother Lydia Molebatsi and my daughter Phemelo






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Declaration

I hereby declare that the work contained in this dissertation is my own work and has not previously in its entirety or in part been submitted at any university for a degree.

Signature: ________________________

Date: _______________________

Abstract

For decades homegardens have shown to be significant to rural inhabitants by providing a wide range of useful products such as fruits, vegetables, medicine and building material. Several studies have emphasized that homegardens are diverse agroforestry systems and regard them as an important *ex situ* conservation sites. The main aim of this study was to assess the floristic diversity of useful plants in homegardens and communal land of Tlhakgameng. Other objectives of the study were to determine how different land-use types affect the patterns of plant diversity, garden layout of the Batswana, its function, and Indigenous Knowledge Systems (IKS) used by different socio-economic classes to manage their gardens. A survey was conducted in Tlhakgameng rural village, which is situated 30 km away from Ganyesa in the North-West Province. Using Geographic Information Systems (GIS) techniques, a grid was placed over the settlement with sample points approximately 500m apart from each other. During the survey, different land-use types were identified and sampled, namely 16 fallow fields, 51 homegardens, 34 natural areas and 17 wetlands. A total of 460 species was recorded in all land-use types, however indigenous species was found to be the highest in all land-use types with 44% of indigenous species, followed by alien cultivated species (31%), indigenous cultivated species (13%) and naturalized species (12%).

In all land-use types found in the study area, homegardens were found to have higher species richness in comparison with other land-use types. Cultivated species in homegardens were found to have five main use categories namely ornamental (57%), food (21%), shade (8%) and 7% hedge and medicinal. The high percentage of ornamentals indicated that rural inhabitants have been influenced by European culture, irrespective of the people's socio-economic class. Alpha, beta and gamma diversity were measured for all land-use types, however homegardens were found to have higher alpha, beta and gamma diversity in comparison with other land-use types. NMDS (non-metric multidimensional scaling) ordination method was used to measure beta diversity. Alpha diversity was visualized with IDW (inverse distance weighting), which indicated a clear difference between land-use types based on alien cultivated, indigenous, indigenous cultivated and naturalized species patterns. For all land-use types the following indices were measured, Shannon-Wiener Diversity, Pieolou's Evenness, Margalef's Species Richness and Simpson's Index of diversity. In all the indices homegardens had the highest value in comparison with other land-use types followed by natural areas. Questionnaires were used to gather information regarding indigenous knowledge used by residents to manage their homegardens and to determine the different socio-economic classes in the study area. The majority of the population was still utilizing indigenous knowledge to manage their homegardens. However, there was some disparity whether or whether not indigenous knowledge has been lost.

This study confirms that homegardens contribute significantly to household diet and income especially for the people living in rural areas due to the production and diversity of cultivated edible species. This is the case despite a high percentage of ornamentals being cultivated. Although the extent of household dependency on homegardens varies considerably, its contribution is quite significant towards the livelihood of the people because it requires minimal investment and is easily accessible. Homegardens also serve as sites for the conservation of rare, vulnerable, endangered and endemic species.

Keywords: communal land, homegarden, IKS, management, patterns, socio-economic class, species diversity, Tlhakgameng, useful plants.

Opsomming

Huistuine het al dekades lank getoon dat dit waardevol is vir landelike gemeenskappe deurdat dit ‘n wye verskeidenheid van waardevolle produkte lewer soos vrugte, groente, medisyne en boumateriaal. Heelwat studies het al beklemtoon dat huistuine diverse agronomiese stelsels is en dat dit belangrike persele is vir *ex situ* bewaring. Die hoofdoel van hierdie studie was om die floristiese diversiteit van nuttige plante in huistuine en dorpsmeent van Tlhakgameng te bepaal. Ander doelstellings van hierdie studie was om te bepaal hoe verskillende landsgebruike die patrone van plantdiversiteit beinvloed, die uitleg en funksie van die Batswana se huistuine te dokumenteer, en te bepaal hoe verskillende sosio-ekonomiese klasse Inheemse Kennis Stelsels (IKS) gebruik om hul tuine te onderhou. ‘n Ondersoek was geloots in die landelike dorpie Tlhakgameng, 30 km oos van Ganyesa, Noordwes Provinsie. Deur middel van ‘n Geografiese Inligting Stelsel (GIS) is ‘n ruit oor die dorpie geplaas met opnamepunte 500 m uitmekaar. Gedurende die ondersoek is verskillende landsgebruike geidentifiseer vir opnames, naamlik 16 oulande, 51 huistuine, 31 natuurlike gebiede en 17 vleilande. In totaal is 460 plantspesies aangeteken in alle landsgebruike waarvan inheemse spesies die hoogste was met 44%, gevolg deur uitheemse tuinspesies (31%), inheemse tuinspesies (13%) en genaturaliseerde spesies (12%).

Van alle landsgebruike in die studiegebied het huistuine navore gekom met die hoogste spesierykheid in vergelyking met ander landsgebruike. Die studie het bevind dat gekweekte spesies in huistuine tot vyf hoof verbruikskategorieë behoort, naamlik sier (57%), voedsel (21%), skadu (8%) en 7% heining en medisinaal. Die hoë persentasie sierplante is ‘n aanduiding dat landelike inwoners deur die Europese kultuur beinvloed is, ongeag die mense se sosio-ekonomiese klas. Alfa, beta en gamma diversiteit is vir alle landsgebruike bepaal, maar huistuine het die hoogste diversiteit getoon in vergeleke met die ander landsgebruike. Die NMDS (Nie-Metriese Multidimensionele Skalering) metode van ordening was gebruik om die mate van beta diversiteit te toon. Alfa diversiteit is weer getoon met behulp van OAB (Omgekeerde Afstandsbelading), wat ‘n duidelike verskil tussen landsgebruiktipes uitgewys het gebaseer op sierplante, inheemse plante, inheemse sierplante en genaturaliseerde patrone. Vir alle tipes landsgebruike was die volgende indekse bepaal, Shannon-Wiener se Diversiteit, Pieolou se Gelykmatigheid, Margalef se Spesie Rykheid en Simpson se Index. Huistuine het in alle gevalle die hoogste waardes opgelewer in vergeleke met ander landsgebruike, spesifek gevolg deur natuurlike gebiede. Vraelyste was gebruik om inligting in te samel wat betref inheemse kennis wat gebruik word om deur inwoners om hul huistuine te bestuur en om die verskillende sosio-ekonomiese klasse te bepaal. Die meerderheid van die bevolking gebruik steeds inheemse kennis om hul tuine te bestuur. Daar was egter onenigheid oor inheemse kennis en die verlies daarvan.

Hierdie studie bevestig dat huistuine ryklike bydraes lewer tot huishoudelike dieet en inkomste, veral vir mense wat in landelike gebiede woon as gevolg van die produksie en diversiteit van gekweekte eetbare spesies. Hierdie tendens is sigbaar ten spyte van ‘n hoë persentasie sierplante wat gekweek word. Alhoewel die huishouding se afhanklikheid van die huistuin grootliks varieër, is die bydra nogmaals van belang as bestaansmiddel vir die mense omdat dit minimale infestering benodig en toeganklik is. Huistuine dien ook as terreine vir die bewaring van skaars en bedreigde spesies.

Sleutelwoorde: bestuur, huistuin, dorpsmeent, IKS, nuttige plante, patrone, sosio-ekonomiese klas, spesiediversiteit, Tlhakgameng.

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List of abbreviations

GIS	-	Geographic Information System
IDW	-	Inverse Distance Weighting
IKS	-	Indigenous Knowledge Systems
NMDS	-	Non-metric Multidimensional Scaling
PRE	-	Pretoria National Herbarium
PRECIS	-	Pretoria Computerized Information System
PUC	-	AP Goossens Herbarium
SANBI	-	South African National Biodiversity Institute
NWP	-	North-West Province

Chapter 1

Introduction

1. Introduction and Motivation

High and Shackleton (2000) reported that in southern Africa most of the research effort around the use of wild resources for livelihoods of rural communities has been oriented towards the utilization of indigenous woodlands, especially the communal areas surrounding rural villages and homesteads (e.g. Bradley & McNamara, 1993; Campbell, 1996). Furthermore, several authors have reported a wide array of use and values of the wild resources (e.g. Bishop & Scoones, 1994; Shackleton, 1996; Campbell *et al*., 1997; Shackleton, 1998; Shackleton *et al*., 1999), as a consequence of (i) different objectives (for instance to quantify the value used per household, or the potential use value per unit area of woodland), (ii) the adoption of different methodologies, and (iii) the exclusion of some products in some studies. There has been relatively little research attention in southern Africa on the value and use of the wild resources from the more intensively impacted and managed areas within rural settlements, i.e. homegardens, road verges and small-scale arable plots. It is known that resources such as wild fruits, edible herbs (leafy vegetables), thatch grass and the like are harvested from areas such homegardens, road verges and small scale arable plots (McGregor, 1995).

According to Fernandes and Nair (1986) little research has been done to improve homegarden systems, and there is a dire need for research to be done to understand these systems. In their study, Fernandes and Nair (1986) found that structural complexity, species diversity, multiple output nature, and tremendous variability from garden to garden, are some of the main characteristics that make the homegardens extremely difficult models to work with according to the currently available research procedures. Although researchers have looked for patterns, the general conclusion was that homegarden structures vary greatly from one system to another (Barrera, 1980; Rico-Gray *et al*., 1990; Caballero, 1992; Millat-e-Mustafa *et al*., 1996). Nair (2001) stated that even though homegardens have been extensively described, there is lack of quantitative data about their benefits. According to Nair (2001) the main reason that homegardens have not been studied that rigorously is because there are no standard applicable methodologies that can be used and those that have been developed for single-species systems are not applicable to such complex systems (Nair, 2001). Vogl *et al*. (2004) proposed tools and methods to overcome these difficulties and to study homegardens from both botanical and anthropological perspectives.

Past studies have highlighted the social and economical aspects of homegardens, their structure, composition, organization, as well as their nutritional importance (Caron, 1995; Rugalema *et al*., 1994a, b). According to Mohan (2004), homegardens are unique agroforestry systems that have been often described in detail, but whose biophysical and socio-economic characteristics have not been extensively studied. Modi *et al*. (2006) reported that the value of wild edible vegetables and fruit in food security has not been given sufficient attention especially in South Africa. According to Paumgarten *et al*. (2005), villagers in Eastern Cape and Limpopo Province were utilizing trees for fruits and shade. As a result, there are no formal interventions that seek to encourage people to use traditional vegetables. Such interventions could provide important information for development of policies on the sustainable exploitation of natural resources for human sustenance (Modi *et al*., 2006).

According to Maunder and Meaker (2007), there have been studies in South Africa investigating nutrient intakes in households with gardens as intervention to improve nutrients intakes. There has been some controversy in the South African literature with some authors (Schmidt & Vorster, 1995) questioning the impact of gardens on nutrient intake (Webb, 2000). However, Faber *et al*. (2002), found in an experimental study that homegardens together with nutrition education and growth monitoring, led to increased vitamin A, riboflavin, vitamin B6, and vitamin C intakes in children in the experimental group, compared to the nutrient intakes of children in the control group. This alludes to the importance of linking science to indigenous knowledge systems to optimize the value of homegarden systems.

According to Smith and Eyzaguirre (2007), traditional African dark-green leafy vegetables are underutilized and neglected in areas where people consider them inferior to commercially-produced conventional vegetables of the western diet. Many studies reported that leafy vegetables are regarded as important dietary sources of minerals, trace elements (iron, zinc and selenium) and phytochemicals with health-protective and immune-strengthening properties (Borek, 2003; Philpott & Ferguson, 2004; Van der Walt *et al*., 2009). These studies also showed that (iron, zinc & selenium) and antioxidant molecules in green leafy vegetables can lower the risk of cancer and cardiovascular diseases (Borek, 2003; Philpott & Ferguson, 2004).

Mulyoutami *et al*. (2009) mentioned that for many years social scientists have studied the knowledge systems underlying the management of natural resources by indigenous people. In recent years, natural scientists have also looked at local or indigenous knowledge from a different perspective to find ways to manage natural resources with minimal environmental degradation (Mulyoutami *et al*., 2009). There are vigorous debates ongoing in the literature on the nature, role, validity and politics of indigenous people and their knowledge. Dove (2006) argues that while modernity has helped popularize indigenous knowledge and practices, it can also hamper progress and development of this indigeneity. There is now recognition that Indigenous Knowledge Systems (IKS) are keys to sustainable development (Crevello, 2004) and that sound local environmental knowledge should form an important basis for a sustainable natural resource management in many developing countries. Oniang'O (2004) articulated that IKS fulfils a vital role for many poor rural communities and is often the only asset for those communities to sustain, and its significance increases as other resources disappear.

According to the South African National Biodiversity Institute (SANBI), Tlhakgameng is one of the floristically most under sampled areas in North-West Province (Bester *et al.*, 2008). Hence, very little is known about the wild and domestic useful plants occurring in the region. This further signifies the importance of gathering baseline data on homegardens is to provide future researchers with information on species diversity in different land-use types, patterns of plant diversity and how different socio-economic classes manage their gardens using IKS.

1.1 Aims and objectives

Key aim:

Assess the useful plant diversity of homegardens and communal land of Tlhakgameng, North-West.

General objectives to undertake this study in Tlhakgameng are to:

- Spatially analyse the plant diversity patterns across different land-uses and homegardens;
- Quantitatively assess the floristic diversity of plants, specifically useful species;
- Graphically describe the homegarden system in the context of the Batswana;
- Quantitatively relate plant uses and garden management systems to socio-economics.

1.2 Hypotheses

Hypothesis 1: Plant diversity patterns of rural settlements are dependent on the type of land-use and homegardens have the highest diversity.

Hypothesis 2: Homegardens and communal land harbor a wide array of useful and potentially useful plants.

Hypothesis 3: Inhabitants of poor rural areas keep cultural homegardens to provide a wide array of services to sustain their livelihoods.

Hypothesis 4: Homegardens are intricate indigenous knowledge systems which are kept according to traditional gardening practices.

1.3 Layout of dissertation

Chapter 1 introduces and motivates the study, it sets the scene for the other chapters, along with the main aim, objectives and hypotheses.

Chapter 2 presents a literature overview of the research field, with various features, focusing on useful plants, Indigenous Knowledge System (IKS), homegardens and communal land.

Chapter 3 presents a complete overview of the study area such as the Tswana culture and history, environmental data of the Ganyesa area which is 30km away from Tlhakgameng, topography, geology, soil, climate, vegetation, economic activities and conservation data.

Chapter 4 analyses the patterns of plant diversity for the entire study area (Tlhakgameng) whereby the floristic diversity of different land use types is compared with each other. In prep for submission to *South African Journal of Botany* as ‘Patterns of plant diversity in a rural settlement in South Africa: towards a general theory of beta diversity in urban environments’.

Chapter 5 evaluates the floristic composition of homegarden and communal land in Tlhakgameng to highlight the difference between indigenous and alien species composition relating to different land-use types, and to document the useful plant diversity and conservation in homegardens. Submitted to and accepted for publication in *Plant Ecology and Evolution* as part of the proceedings of the XIXth AETFAT Congress, Madagascar, 25-30 April 2010 as ‘Alien and indigenous plant species diversity of homegardens of a rural settlement in the eastern Kalahari, South Africa’.

Chapter 6 describes the layout of and services provided by homegardens to the Tswana people in rural areas of North-West Province. It defines the *tshimo* whereby the first, thorough attempt is made to describe a type of indigenous garden for South Africa. Published in part in *African Journal of Agricultural Research*, 5(21):2952–2963 as ‘The Tswana *tshimo*: a homegarden system of useful plants with a specific layout and function’.

Chapter 7 investigates how IKS plays a vital role in people’s lives, relating it to socio-economic status, and how this has a direct influence on homegarden management and use. In prep for submission to *African Journal of Agricultural Research* as ‘Garden management systems of the Batswana in the eastern Kalahari, South Africa’.

Chapter 8 concludes by summarizing the results from various features discussed in the dissertation and also provides recommendations for future studies.

Chapter 2

Literature review

2.1 Homegardens

A homegarden has been described as an important social and economic unit of rural households, in which crops, trees, shrubs, herbs and livestock are managed to provide food, medicine, shade, cash, poles and socio-cultural functions (Christanty, 1990; Campbell *et al*., 1991; Rugalema *et al*., 1994a; Shackleton *et al*., 2008). In many tropical countries home gardening has been long established. According to Nair (1993), tropical homegardens also consist of an assemblage of plants, which may include trees, shrubs, vines and herbaceous plants growing in or adjacent to a homestead or home compound. Fernandes and Nair (1986) reported that homegardens are therefore considered as intensively cultivated agroforestry systems managed within the compounds of each household. Homegardens are not static, but have evolved over centuries due to the adaptive abilities of farmers in response to changing rural and livelihood conditions (Michon & Mary, 1994; Kumar & Nair, 2004).

Silwana (2000) defined a homestead as an operational farming unit in which a number of crops (including tree crops) are cultivated and livestock and poultry produced, all for the purpose of satisfying the farmer's basic needs. Mixed farming practiced by traditionally African people involves the production of both crops and animals on three types of land, namely residential, arable and commonage. According to Silwana (2000), residential land is used for home gardening, while arable allotments are used to produce staple food crops such as maize, dry beans, pumpkins and melons which are often produced by using a mixed cropping system. During the fallow periods, arable lands play a significant role in livestock production by providing fodder to animals in the form of crop residues and weeds (Bennett, 2002) and as a source of wild leafy vegetables (McAllister, 2001). The commonage is used for the production of small and large livestock, mainly cattle, goats and sheep and also for the collection of plant materials for various uses including food in the form of fruit, edible herbs and firewood (Schackleton *et al*., 2000; Schackleton, 2003).

Vogl *et al*. (2003) mentioned that homegardens can be distinguished from other types of domestic gardens, such as urban gardens (a vegetable garden plot at significant distance from a house in a city), a rural garden (a field at 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, institutional gardens and community gardens. According to Nair (1993), there are many forms of domestic gardens which vary in how intensively they are cultivated and their location with regard to the home. ‘Domestic’ derives from the Sanskrit *damah*, the Avestan *demana*, and the Greek *domos*, all meaning 'house'. Traditional homegardens are therefore a type of domestic garden or ‘house’ garden. The difference however lies in the purpose and use of the garden by the individual. Nair (1993) stated that a domestic garden is mainly used for relaxation, outdoor eating, children’s play and the cultivation of ornamental and edible plants. Homegardens could be used for similar functions, but its main purpose belies in its support of livelihoods, primarily food production, medicine and spirituality. Homegardens are very common in developing countries. For the purpose of this study we therefore define a homegarden as a land-use form on private or communal land surrounding individual houses with a definite fence, in which several tree species are cultivated together (intercropped) with annual and perennial crops, often with the inclusion of small livestock (Nair, 1993). Homegardens have shown to be stable systems that maintain high levels of productivity and stability (Michon *et al*., 1983; Soemarwoto & Conway 1992).

2.1.1 Importance of the homegarden

The importance of homegardens to rural livelihoods is highly valued throughout the world, especially in developing countries, including southern Africa (Fernandes & Nair, 1986; Soemarwoto, 1987; Torquebiau, 1992; Jose & Shanmugaratnam, 1993). According to Wenhold *et al*. (2007), smallholder farming can potentially impact on human nutrition by providing a variety of foods in sufficient quantities to enable all household members to eat a nutritionally adequate diet.

The significance of a homegarden in the developing world is that the marketing of its products by rural households and small-scale farmers has been identified as a potential means of reducing poverty (Garrity, 2004; Shackleton *et al*., 2008).

Homegardens have played a vital role in solving poverty problems by stimulating small-scale farming activities which sustain the poor rural inhabitants (Rogerson, 1996). According to Soemarwoto and Conway (1992) the major functions of homegardens in rural areas are subsistence production and income generation which improve family's financial status.

Homegardens also provide shade near living areas while reducing erosion in high rainfall regions (Jose & Shanmugaratnam, 1993). Watson and Eyzaguirre (2002) stated that homegardens are regarded as ideal production systems for *in situ* conservation of genetic resources because of their large diversity of crop species and cultivated varieties. Tropical homegardens are important sites of high plant species diversity, which may act as reservoirs of crop germplasm and serve to conserve rare or threatened species and varieties (Clarke & Thaman, 1993; Smith, 1996). Traditionally, homegardens mainly served to produce vegetables, fruits and other crops which supplemented the staple food produced on open croplands (Soemarwoto, 1987; Kumar & Nair, 2004).

2.1.2 Homegarden structure

According to Soemarwoto (1987), structure of homegardens varies from one place to the other depending upon the socio-economic status of the people and ecological conditions. The number of vegetation layers which determines the age and size of homegardens often differs (Kehlenbeck & Maass, 2004) from one household to the other. The vegetation structure in tropical homegardens is mainly influenced by the age of the garden and its management (Kumar & Nair, 2004). Tropical homegardens exhibit a complex structure, both vertically and horizontally (Fernandes & Nair, 1986). The horizontal structure of the vegetation generally changes in relation to distance from the house. Vertically the homegarden is generally stratified and consists of different layers (Fernandes & Nair, 1986; Millat-e-Mustafa *et al*., 1996), creating a forest-like, multistorey structure in more mesic environments (Singh, 1987). According to Mohan (2004), rural gardens usually have more layers which make them more complex than urban gardens.

According to Kumar and Nair (2004) the size and shape of tropical gardens, and the nature of cropping are dynamic, thus complicating the structural pattern further.

Blanckaert *et al*. (2004) mentioned that the oldest garden shows a rich herbaceous layer almost covering the entire soil, which is characterized by many trees and shrubs filling every gap in the vegetation. However, the youngest garden is characterized by a less dense structure with gaps in the vegetation cover. In tropical homegardens, medicinal and ornamental species are typically cultivated in small areas or in pots surrounding the house, and vegetables in areas adjacent to the kitchen (Kumar & Nair, 2004). Multipurpose tree and shrub species are usually planted on boundaries and used as live fences regardless of the household size, however trees may be scattered throughout the homestead or at a specific point to provide shade (Kumar & Nair, 2004).

According to Kumar and Nair (2004), the vertical stratification in tropical homegardens provides a gradient in light and humidity which creates different niches for enabling various species groups to exploit. In tropical homegardens, crops that tolerate shade constitute the lower stratum and those which are shade intolerant are found at the top layer. Species with varying degrees of shade tolerance are located in the intermediate strata (Kumar & Nair, 2004).

Homegardens in Austria differ from others in terms of location, area, layout and size they are usually separated from the surrounding areas by fences (Vogl *et al*., 2003). They are commonly found next to the house and consist of a series of structured and raised beds with small paths that allow the gardener to reach every part of the cultivated area for planting, watering, weeding and harvesting (Vogl *et al*., 2003). The beds in the center of gardens are dedicated to food crops, mostly annuals or biennials species. Food crop species are usually not mixed i.e. the area covered by each species is clearly separated from areas designated for other species (Vogl *et al.*, 2003).

2.1.3 Species diversity in homegardens

Christanty *et al*. (1986) stated that species diversity in the garden varies according to ecological or socio-economic factors and/or characteristics of gardens or gardeners. Species diversity in tropical homegardens was reported to be very high due to species having different life forms, height and canopy structure (Babu *et al*., 1982; Soemarwoto & Conway 1992). Species number and diversity were shown to be influenced by altitude of homegardens in tropical areas (Karyono 1990; Quiroz *et al*., 2002).

2.1.4 Homegarden management

Nair (2001) stated that homegardens have traditionally been managed and adapted by gardeners rather than through agroforestry research. This could be expected but resulted in an interesting question, whether all gardeners are following similar homegarden development trends, or whether they are following different pathways in maintaining their homegardens. The recent advances in using statistical methods for classification of homegarden systems provides a good basis to assess the differences between homegarden types and evaluating whether different types follow different development trends (Peyre *et al.*, 2006).

It has been shown that the composition and management of homegardens vary from one household to another, and this variation is influenced by factors such as type and fertility of the soil, slope of the garden, size of the holding, size of the household, resource endowment and individual farmer's preference (Rugalema *et al*., 1994a). According to Vogl *et al*. (2003), the management and composition of these homegardens reflects a body of knowledge gained through adaptive management of natural resources by communities, and which is based on the communities' long-term experience with their local environment.

One example of adaptive management is that, Austrian women use simple tools like small hoes, rakes, spades, forks and watering cans to perform their garden duties, which are made locally on the farm i.e. built from the recycled material no longer being used (Vogl *et al*., 2003). Modern equipment such as rotary cultivators, tillers or flame weeders are not used at all. The only modern tool used by Austrian women farmers is a sprinkler irrigation system. Most of the time women irrigate with watering cans or hosepipes, because this saves water and allows the irrigation of each species according to its needs (Vogl *et al*., 2003).

In the Bukoba, district of North-western Tanzania soil fertility was maintained mainly through the application of various types of organic matter such as crop residues, tree litter, banana trash, grass mulch, household refuse and animal manure (Rugalema *et al*., 1994a), while in Austria it is maintained by the use of cattle, sheep, horse or chicken manure (Vogl *et al*., 2003). In the Bukoba district it was found that farmers who used cattle manure in their homegardens had higher crop yields when compared to those who did not use it.

Zobolo *et al.* (2008) found that farmers in KwaZulu-Natal, South Africa, who did not apply cattle manure, but used sugar cane compost (green manure) instead, had higher crop yields. In Austria green manure or water extracts from plants or compost are not used at all (Vogl *et al*., 2003). Paumgarten *et al*. (2005) found that most household gardens in the Eastern Cape and Limpopo provinces, South Africa were using manure such as organic matter and vegetative material to fertilize and improve their soil quality.

Mulching was practiced in some homegardens during autumn by Austrian women to protect the soil and/or perennial plant species from frost in wintertime. It is also done to suppress weeds in the pathways between the beds. During digging, manure is set in and the topsoil turned. The loosening of the topsoil without turning it over is done only when plant species are already planted. Most plant species in the beds are rotated every year taking into account special demands e.g. nutrients for subsequently grown species. No written plan exists for managing the garden with regard to crop rotation, because usually it is done without noting the activities by Austrian women (Vogl *et al*., 2003).

According to Austrian women gardeners, diseases and pests occurring in gardens never threatens the entire range of cultivated plant species (Vogl *et al*., 2003). If certain plant part is attacked by pests they are removed by hand. Austrian women utilize homemade remedies such as teas of nettle (*Urtica dioica*), horsetail (*Equisetum* species), soft soap or lime to protect plants against diseases and pests. Practices such as control of diseases are significantly more frequent in gardens on organic farms. The weeding process is done by hand on all farms with simple tools (Vogl *et al*., 2003).

In Kerala (India), management practices in homegardens involve pruning, weeding, fertilization and crop spacing (Nair & Sreedharan, 1986). In particular, cash crops are subjected to a variety of management practices. Some species are intensively managed including use of chemical fertilizers and insecticides, systematic weeding, organic fertilization and row arrangement of trees. Cash crops are managed more, because they are protected from competitors and are the only crops that receive watering. Fruit trees and timber species receive less attention in comparison to the cash crops (Nair & Sreedharan, 1986).

For the past 3-4 decades, the use of synthetic pesticides have been promoted in the Lake Victoria Base (Tanzania), farmers in the region add them into their insect pest management systems due to the subsistence nature of production and high poverty levels (Ogendo *et al*., 2003a, b). This makes them to rely on indigenous knowledge (IK) systems to meet their daily needs (Mugisha-Kamatenesi, 2004) which are most relevant to the rural poor and marginalized population. The high costs of synthetic pesticides and associated toxicity risks discourage to integrate into insect pest management systems (Mihale and Kishimba, 2004; Ogendo *et al*., 2004). Farmers in the tropics still use traditional methods to preserve their stored agricultural products and the noble promise for the development of suitable, simple, natural and environmental friendly pesticides products has provided impetus for the scientific improvement and packaging of the existing IK base and practices. The realization that a farmer's IK holds the key to the success of any pest focus and approach. Despite the enormous potential that has existed for generations, the plant based indigenous pest control practices have remained largely unexploited with limited regional research intervention and resources (Mihale *et al*., 2009). IK that farmers used as a pest control was in the form of general ash, specific plant ash or whole plant for pest control.

2.1.5 Sustainability of homegardens

According to Soemarwoto and Conway (1992), the sustainability of the homegarden is its ability to maintain long-term production at a desired level. It is thus a function of the intrinsic structure of the homegarden and of the forces of disturbance that emanate from the surrounding biophysical and socioeconomic environment. Sustainability of homegardens depend on contributing factors such as (i) the dependence on solar and human labor power; (ii) the completely closed biogeochemical cycling of minerals, which together with a minimal rate of soil erosion, ensures that soil fertility is maintained; and (iii) a rich genetic resource that minimizes pest and disease problems and enables the system to respond to a wide variety of changing demands (Soemarwoto & Conway, 1992).

During the long period of their existence, homegardens have been subjected to severe disturbance of many kinds, e.g. pests and diseases, large-scale clear cutting and erosion, population growth and economic development. One of the most important essential features of the Javanese homegarden is its ability to withstand the natural forces of soil erosion (Soemarwoto & Conway, 1992).

Many authors regard homegardens as a sustainable production system especially in the tropical areas, where they contribute to biodiversity conservation (e.g. Kehlenbeck and Maass, 2004; Torquebiau, 1992; Fernandes & Nair, 1986).

According to Torquebiau (1992), for an agricultural system to be sustained, it should fulfill some of the important requirements such as: (i) soil conservation, including erosion control and fertility maintenance; (ii) the efficient use and conservation of existing resources (water, light, energy, genetic resources, labour); (iii) the use of biological interactions between the different elements of the agricultural system (e.g. mulching, the association of climbing plants and support, nitrogen fixation, biological control of weeds and diseases); (iv) the use of inputs that are easily available and of inputs and practices that ensures both human health and environmental conservation. Torquebiau (1992) mentioned that, in the case of gardeners who depend both on cash crops and subsistence crops, a sustainable system must fulfill requirements such as, meeting the farmer's energy needs (fuel, heat, labour); meet the farmer's needs for subsistence, so that they may be assured of having an adequate and balanced diet; strengthen cooperation between local community members; ensure that social equity, cultural integrity, ethnic and gender issues are adequately considered. Torquebiau (1992) emphasized that these requirements can assist households to withstand difficult periods caused by climatic or economic stress, improve living conditions in rural areas while bridging the gap between production seasons, taking care of various social concerns and ensuring the survival of traditional rural systems.

The shift from subsistence-oriented agriculture to market economy often implies drastic structural and functional modifications to the homegarden, including a homogenization of the structure and use of external inputs (Soemarwoto, 1987; Kumar & Nair, 2004). The question remains whether homegardens are becoming dissolute or even extinct (Kumar & Nair, 2004).

The expressed fears is that the traditional, diverse and ecological sustainable homegardens will gradually dissolve into nonspecific agricultural systems with uncertain sustainability that are in stark contrast to the earlier ideas on homegardens as having a promising future (Soemarwoto, 1987). Nair (2006) stated that homegardens, as part of a household livelihood strategy, has gained status as a natural asset through which sustainable use of resources, particularly for the poor may be achieved. As stated previously, plants grown in homegardens and agricultural fields provide rural communities with income, nutritious vegetables and fruit, fodder etc. These assist communities to achieve self-sufficiency (Maroyi, 2009).

2.2 Indigenous Knowledge Systems

According to Domfeh (2007), Indigenous Knowledge System (IKS) refers to the complex systems acquired over generations by communities as they interact with the environment. It includes spiritual relationships, relationships with the natural environment and the use of the natural resources, and relationships between people, and is reflected in the local language, social organization, values, institutions and laws. Indigenous knowledge and practices are important aspects of a society’s culture and its technology (Domfeh, 2007). They include accumulated knowledge, as well as skills and technology of the local people, usually derived from their direct interaction with their local environment (Domfeh, 2007).

According to Ellen and Harris (1996), IKS can be recognized when:

- It is local in that it is rooted in a particular community and situated within the broader cultural traditions; it is a set of experiences generated by people living together.
- It is tacit knowledge and therefore not easily codifiable.
- It is transmitted orally or through imitation and demonstration. Codifying may lead to the loss of some of its properties.
- It is experiential rather than theoretical. Experience and trial and error, tested in the rigorous laboratory of survival of local communities constantly reinforce IK.
- It is learnt through repetition, which is a defining characteristic of tradition even when new knowledge is added. Repetition aids in the retention and reinforcement.

- It is constantly changing, being produced as well as discovered and lost, though it is often perceived by external observers as being somewhat static.

Oniang's *et al*. (2004) stated that IKS needs to be fully understood because it contributes significantly to food security, especially in African communities. According to Warren and Cashman (1998), traditional agriculture in Africa has been seen as an indigenous agricultural system which developed over centuries with cropping patterns based on an agricultural knowledge system that is expressed in local language and viewed to be in dynamic equilibrium with the environment. Traditional agricultural practices provide valuable lessons to be learned from local farmers who have the knowledge of managing their farms to yield high productivity (Oniang'O *et al*., 2004). Kabuye (2002) mentioned that practices like fallow, mixed farming, and intercropping were contained within IKS long before the introduction of the Green Revolution. These practices provide advantages that are now recognized for ensured fertility of soil, pest control and a variety of food sources. In subsistence agriculture, farmers grow and use traditional food plants, they select varieties to meet the needs and constraints of their environment, and harvest and select seed from their own land races to produce a reliable crop (Kabuye, 2002).

Domfeh (2007) mentioned that IK continues to be largely overlooked in development planning and its contribution to society in general has not been exploited, although it plays a major role in biodiversity management. According to Domfeh, (2007) indigenous knowledge is being lost under the impact of modernization and of ongoing globalization processes. Warren (1991) emphasized that there is a need to protect and further develop the knowledge generated and perpetuated by local communities through awareness raising, training programmes, international property rights arrangements, and validation procedures. Indigenous knowledge has cultural value and is also beneficial for the institutions who are interested in improving conditions in rural areas (Domfeh, 2007).

2.3 Useful plants

One of the major activities emanating from IKS is the use of plants by rural communities to improve their livelihoods (Oniang'O *et al*., 2004).

In time of food scarcity the use of wild sources for food was seen as significant, especially for nomadic tribesmen or travelers (Heneidy & Bidak, 2004). In general, food availability from wild sources depends upon the natural distribution of the plants involved.

There is a wide range of plants that are used in domestic affairs. This ranges from cordage, tanning, dyeing, and soap making to toothbrushes, fish poisons, oils, and gums.

Halophytes, either native or exotic, are liable to many different economic uses in land reclamation and rehabilitation, planted grazing as fodder reserves, sand binding and sand dune stabilization, fuel plantations, amenity plantations, street and roadside trees, site protection around cities, villages, airports, in headwaters and watersheds, ground cover, hedging, gardening, low maintenance turfs and golf courses, windbreaks, beekeeping, and even timber production (Le Houérou, 1993; Heneidy & Bidak, 1996; Heneidy & Bidak, 2001).

Throughout the history of human civilization, wood has been the main source of fuel i.e. firewood. The majority of rural inhabitants depend on wood as a fuel to cook their food (McMahon, 2006). Alternative sources of fuel or firewood reserves are usually available for the established urban areas, but there is a need for stronger awareness of the requirements of smaller settlements. In general there are three major categories, namely pole timber for building frames, timber for local domestic uses (such as doors, furniture, boxes etc.), and commercial timber for mining, railway sleepers, bridge and wharf construction (Wickens, 1980). Tree crops are also commonplace in homegardens. In Indonesia, six useful tree species are cultivated in homegardens mainly for food and timber (Minchon *et al*., 1986). In southern Mozambique, it was shown that trees play a major role in birth, initiation, burial rites and natural resources especially for local communities (Izidine *et al*. 2008).

According to Wickens (I980) the two main uses of trees and shrubs in agriculture are (i) to provide shade for plantation crops and (ii) for the protection of crops generally by means of live or dead fences. Trees and shrubs also provide small-scale ecosystems that minimize nutrient drain due to leaching and soil erosion, restore nutrients lost from the ecosystem, and perform other key environmental services (Wickens, 1980).

In the former Ciskei, South Africa, Cocks and Wiersum (2003) found that the local people living in that area was using wild plants for a variety of purposes such as kraal construction, fuelwood, rituals, fencing, wild fruit, traditional medicines, timber, wild vegetables, sticks, tools, and fodder.

2.3.1 Leafy vegetables

Useful plants found around the house in homegardens of South Africa have been shown to be linked to IKS (Zobolo & Mkabela, 2006). In South Africa, leafy vegetables has been used for centuries by the Khoi-San people who have lived in southern Africa for the past 120 000 years and relied on wild plants for their survival (Fox & Norwood Young, 1982; Parsons, 1993). Bantu speaking tribes that settled in South Africa about 2000 years ago also relied on wild vegetables for endurance (Bundy, 1998). During crop failures and livestock decimation, people usually hunt and collect edible plants (Peires, 1981). Collecting and cultivating green leafy vegetables continue to be a common activity among African people in South Africa (Bhat & Rubuluza, 2002; Jansen van Rensburg *et al.*, 2004; Husselman and Sizane, 2006; Modi *et al*., 2006) even though western tradition have influenced people's food preference and pattern of consumption.

An indigenous leafy vegetable may be defined as a plant species which is either genuinely native to a particular region or which was introduced to that region for long enough to have evolved through natural processes or farmer selection (Schippers, 2002). Vorster *et al.* (2002) stated that the majority of poor households tend to use leafy vegetables from the natural area due to a lack of money to buy vegetables and inability to travel long distances to markets. During periods of drought, or when the breadwinner in the household becomes unemployed, the only option for the affected rural household is wild food collection for survival (Shackleton *et al*., 1999; Dovie *et al*., 2002; Shackleton, 2003).

In poor rural communities, consumption of wild food such as leafy vegetables is particularly important for women and children (Shackleton *et al*., 2002a; Vorster *et al*, 2005). It was found that the most widely used leafy vegetable species harvested from the wild, or as weeds in homegardens, were *Amaranthus hybridus, Bidens pilosa, B. biternata, Cleome gynandra,* *Corchorus tridens* and *Chenopodium album* (Shackleton *et al*., 1999; Twine *et al*., 2001; Magasela *et al*., 2001; Shackleton *et al*., 2002a; Shackleton *et al*., 2007; Jansen van Rensburg *et al*., 2007). However, the importance of leafy vegetables differs between communities in South Africa (Jansen van Rensburg *et al.*, 2007). In Africa the production, trade and consumption of indigenous and naturalized leafy vegetables is increasing (Schippers, 2000; 2002 & 2006).

Indigenous leafy vegetables play a significant role in the nutrition and health status of the under privileged in both urban and rural settings (Gackowski *et al*., 2003). Kimiywe *et al*. (2007) reported that indigenous leafy vegetables have medicinal value i.e. some of the vegetables can cure more than one illness.

The most common illnesses cured were malaria, diarrhea, anemia, colds and coughs, skin infections, malnutrition, diabetes and high blood pressure (Kimiywe *et al*., 2007). Olembo *et al*. (1995) also states that traditional vegetables have medicinal properties for the management of HIV/AIDS symptoms, stomach-related ailments and other diseases. Kimiywe *et al*. (2007) found that the major factors that affect consumption and utilization of these vegetables are ethnicity, occupation, gender, income and education level.

2.3.2 Important South African leafy vegetables

2.3.2.1 Amaranth (*Amaranthus* species)

Amaranth species are erect, annual herbaceous plants that belong to the family Amaranthaceae. The height of the mature plants varies between 0.3 and 2 m. The height of the plant depends on the species, growth habit and environment. Amaranth is a C4 plant that grows optimally under warm conditions (day temperatures above 25^oC). Various amaranth species are tolerant to drought and adverse climatic conditions. Amaranth is rarely cultivated in South Africa because people believe it only occurs naturally. The leaves of most *Amaranthus* species are used as vegetables. Several of these species are collected from the natural areas for subsistence (Schippers, 2000; Van Wyk & Gericke, 2000).

Amaranthus thunbergii is an indigenous leafy vegetable in southern Africa. It has stems furnished with long crisp hairs with a long crista, and leaves broadest above the middle (Maundu *et al*., 2009). It grows throughout the summer season. In southern Africa people collect it from natural areas. People in Botswana mix it with either sorghum or maize, while in Namibia cooked leaves are eaten with porridge made from pearl millet. Leaves of *A. thunbergii* are bitter compared to other amaranth species. It is also appreciated by Asian people living in South Africa (Schippers, 2002).

Amaranthus spinosus is rarely cultivated in southern Africa. It is called "spiny amaranth" because of spines on its stem. It is commonly used in parts of east and southern Africa (Maundu *et al*., 2009). *A. spinosus* is drought tolerant. Its leaves are better known for its medicinal properties than its nutritive qualities (Schippers, 2002).

Amaranthus deflexus is commonly called "large fruit amaranth" and is a perennial or annual plant growing up to 0.5 m in height. The species grows best as a weed in disturbed habitats (Grubben & Denton, 2004).

Amaranthus hypochondriacus is an ornamental plant commonly known as "Prince-of-Wales-Feather". In Africa it is known as a valued source of food (Grubben & Denton, 2004).

Amaranthus viridus is a small amaranth, which is commonly found in urban areas. It is consumed in both southern and western Africa (Maundu *et al*., 2009). It is commonly called "slender amaranth". The species is also eaten as a vegetable in southern India, especially in Kerala (Grubben & Denton, 2004).

Amaranthus hybridus is the most widely distributed and consumed amaranth in Africa. The species has dark green stems and leaves, and is mostly cultivated in urban and peri-urban areas to be sold fresh at city markets. It is also relatively common as a weed. Several forms are either collected from natural areas or are cultivated in homegardens. Some forms grow up to 2 m high and these are referred to as "tree spinach". In South Africa, *A. hybridus* is even locally cultivated for commercial purposes (Schippers, 2002).

2.3.2.2 Black-jacks (*Bidens pilosa* and *B. bipinnata*)

Bidens pilosa and *B. bipinnata* belong to the family Asteraceae and are common throughout the tropics where it is indigenous to South America. *Bidens pilosa* is frequently found as a troublesome weed which is difficult to eradicate. As a ruderal crop, which thrives in disturbed soils, it grows very fast and people can harvest their first crop in three weeks from sowing. In Tanzania, villagers collect shoots during weeding.

Black-jacks are also collected from the wild throughout south-east Africa, in Zambia, Malawi, and Mozambique, in Zimbabwe's Eastern Highlands and South Africa.

Leaves and shoots of *B. bipinnata* are not only collected from the wild, but are also cultivated on a small scale in West Africa from Sierra Leone to Nigeria and in southern Africa (Schippers, 2002).

2.3.2.3 Jew's Mallow (*Corchorus olitorius* and *C. tridens*)

The genus *Corchorus* consists of some 50-60 species in the family Tiliaceae, of which about 30 are found in Africa. *Corchorus* is mainly known for its fiber product, jute, and as a leafy vegetable. Several species of *Corchorus* are used as vegetables, of which *C. olitorius* is mostly cultivated. *C. tridens* is woodier and mainly seen in the warmer and drier areas of Africa. This species is recognized by its oblong to lanceolate non-shiny leaves and a thin three-valved capsule with three small, spreading horns at the apex. The leaves are often light to yellow-green and its stipules are glabrous. It tastes more bitter than *C. olitorius*. Plants generally do not exceed 1 m in height (Schippers, 2002).

Corchorus is an erect, annual herb that grows up to 1.5 m in height and is a member of the Tiliaceae. The stems are angular with simple, oblong to lanceolate leaves that have serrated margins and distinct hair-like teeth at the base. Flowers are small, bright yellow in colour and fruits are straight angular capsules. *Corchorus* prefers high temperatures (30^{o}C during the day and 25^{o}C at night), humid conditions and performs well in areas with high rainfall (600 to 2 000 mm). It is also harvested from the natural area like nightshade, but people are starting to cultivate it in the north and east of the country (Jansen Van Rensburg *et al*., 2007). The leaves are cooked and eaten with porridge.

2.3.2.4 Spider-flower or Spider-wisp (*Cleome gynandra*)

Cleome belongs to the family Capparaceae and is an herbaceous, erect, mainly branched plant. The height of the plant depends on the environment where it grows, and it can vary between 0.5

and 1.5 m. Leaves are compound and palmate with three to seven leaflets. Stems and leaves of this plant are hairy.

Amongst the species, *C. gynandra* is the most widely used leafy vegetable in comparison to *C. monophylla* and *C. hirta* which are occasionally used. *Cleome* grows best under warmer conditions than cold ones where the temperature drops below 15^{o}C.

Cleome performs well on well-drained medium textured soils as compared to poorly drained or heavy clay soils. It performs poorly when shaded. It grows best with ample water, but is also drought tolerant. Application of fertilizers containing nitrogen delays the flowering, while increasing the number and size of leaves. Northern parts of South Africa are environmentally suitable to cultivate *Cleome*. People in southern Africa find *Cleome* to be more bitter than amaranth (Jansen Van Rensburg *et al*., 2007). According to Schippers (2002), the spider-wisp or spider plant in most African countries is no longer considered a weed and regarded to be a valuable food plant and that provides income.

2.3.2.5 Chinese cabbage (*Brassica rapa* subsp. *chinensis*)

Chinese cabbage is a member of the family Brassicaceae. Chinese cabbage forms a compact to elongated head with green crinkled leaves and white midribs. Non-heading Chinese cabbage has dark green leaves which are supported by light green to white petioles forming a rosette. It is an annual, flowering vegetable which takes a period of six to eleven weeks from sowing to harvest when the plants reach a height of 150-300 mm. Chinese cabbage is a cool season crop which requires sufficient water and plant nutrients for optimal growth. Black people in South Africa prefer non-heading *B. rapa* subsp. *chinensis*. All *Brassica* species have glucosinolate compounds, which are converted by the enzyme myrosinase to give bitter-tasting and gitrogenic substances, such as isothiocyanates, nitriles and goitrin (Pierce, 1987; Rubatzky & Yamaguchi, 1997). These compounds contribute to the flavour and odour, but they also inhibit thyroxin production and cause thyroid enlargement (goitre) when consumed in large quantities (Schippers, 2000). Vhembe (Limpopo Province) is the location where non-heading Chinese cabbage was first cultivated in South Africa, before spreading to the other provinces (Jansen Van Rensburg *et al*., 2007).

2.3.2.6 Night shade (*Solanum nigrum* complex)

Nightshades are members of the family Solanaceae, they are erect, branched, annual or biennial herbaceous plants that can grow up to 750 mm tall. The leaves are alternate and bright green in colour but purple pigmentation may be present. The small flowers are about 4 to 10 mm in length with white petals and conspicuous yellow anthers that are arranged in a drooping umbel-like inflorescence.

It has small, shiny, black-purple fruits which are used to make jam (Fox and Norwood Young, 1982). These plants prefer fertile soil with a high nitrogen and phosphorus content (Van Averbeke & Juma, 2006b). The optimal growing temperature ranges between 20 and 30^{o}C, but most species can tolerate temperature ranges from 15 to 35^{o}C. During summer season shading of up to 60 % can be beneficial (Edmonds & Chweya, 1997). When used as a leafy vegetable the leaves and shoots are cooked (Van Averbeke & Juma, 2006a), but Fox & Norwood Young (1982) reported people even eating the raw leaves. Nightshade is mostly harvested from natural areas in South Africa, while it has being cultivated in the Vhembe district (Van Averbeke & Juma, 2006a).

2.3.2.7 Pumpkin (*Cucurbita* species)**, melons and indigenous cucurbits**

All members of the family Cucurbitaceae are vine-like, annual, herbaceous plants. Some species have leaves and stems that are covered in sharp, stiff translucent hairs that can irritate human skin. Leaves vary in shape, size and colour. Flowers are monoecious, yellow or white, and vary in size. Some cucurbit species grow in natural areas where they are harvested. The most popular cucurbit species are bitter watermelon (*Citrullus lanatus*); melon (*Cucumis melo*); bottle gourd or calabash (*Lagenaria siceraria*), and pumpkins and squashes (*Cucurbita pepo*, *C. maxima* and *C. moschata*). *Cucurbita maxima* and *C. pepo* are drought tolerant as they require little water, but they respond well to irrigation in dry climates (Chigumira Ngwerume & Grubben, 2004; Messiaen & Fagbayide, 2004). *Cucurbita moschata* is a pumpkin that tolerates both heat and drought (Chigumira Ngwerume & Grubben, 2004). Cucurbits respond well to fertilizers, particularly farm manure. Members of the Cucurbitaceae are popular leafy vegetables and are amongst the few cultivated vegetables. The leaves, flowers and young fruit are picked and cooked. The seeds are roasted and eaten as a snack. In desert areas the fruit of bitter water melon and other indigenous cucurbits are known to be a valuable water source (Fox & Norwood Young, 1982; Van Wyk & Gericke, 2000). To control weeds in South Africa, pumpkins and melons are often grown as a minor crop with maize to shade the soil surface (Jansen Van Rensburg *et al*., 2007).

2.3.2.8 Cowpeas (*Vigna inguiculata*)

Cowpeas belong to the family Fabaceae. They are annual or perennial herbaceous plants with tri-foliate leaves. They are indigenous to Africa and have been cultivated on the continent for a long time (Fox & Noorwood Young, 1982; Schippers, 2000; Vorster *et al*., 2002; Hart & Vorster, 2006). Cowpeas are heat-loving, drought tolerant crops that require low soil fertility as compared to other crops. They derive their nitrogen requirements from the atmosphere (Schippers, 2000). They are resistant to bacteria, fungi, viruses and parasites which cause diseases (Singh, 2006). They are primarily grown for grain but young leaves and growth points are used as leafy vegetables. They are often grown amongst taller crops such as maize (Jansen Van Rensburg *et al*., 2007).

2.3.2.9 White Goosefoot (*Chenopodium album*)

This member of the family Chenopodiaceae is a cosmopolitan weed which is widely distributed in southern Africa and is one of the most important and popular wild spinach (*morogo*) plants. The young twigs are boiled and eaten as spinach on their own or with other foods. It may be dried and stored for later use. Two other closely related species, *C. murale* and *C. glaucum*, are also used by people as *morogo* (Van Wyk & Gericke, 2000).

2.3.3 Socio-economic importance of indigenous vegetables

According to Schippers (2002), indigenous vegetables play a significant role in income generation and subsistence for many households. It has been mentioned that they are important commodities for poor households, because anyone can afford to buy, collect or cultivate them as compared to other food items (Schippers, 2002). Selling of indigenous vegetables also provide employment for those outside the formal sector in peri-urban areas of many African cities, because of their generally short labour-intensive production systems, low levels of financial input and high yields. The production of these vegetables is increasingly targeted as a livelihood strategy as the level of urban unemployment rises. African indigenous vegetables contribute to a more balanced diet for many people and a significant improvement in food security for the community at large (Schippers, 2002).

Schippers (2000) mentioned that the price of vegetables tends to drop in the wet season because it is the main production period and a time when most rural households can cultivate or collect their own vegetables. According to Schippers (2002) the retail prices of indigenous vegetables remain constant but the volume varies between seasons, i.e. the size of the bundles of leafy vegetables is reduced in the dry season. Currently most countries have focused their research on major food crops or cash crops, and have largely ignored indigenous vegetables.

The reason for indigenous vegetables not being considered for research support is that people categorize them as minor crops (Schippers, 2002).

The production systems for many different African indigenous vegetables crops, which may be found throughout the continent (Africa), are very similar despite the geographical distance. Mixed cropping systems are the norm for all subsistence and semi-subsistence farmers whereas most commercial production, especially under irrigation in the dry season, is mono-cropped. Women have been seen as key players in the production, processing and marketing of the indigenous vegetables (Schippers, 2002).

2.3.4 Main constraints facing African leafy vegetable cultivation

2.3.4.1 Lack of technical advice

Schippers (2002) mentioned that extension officers are often trained to only give advice on exotic vegetables, but not on production systems for indigenous vegetables. Generally improved agronomic packages provided to farmers are for staple and cash crops and often have little or nothing to do with indigenous vegetables. There is also lack of published information about indigenous vegetables. Therefore, most producers have to rely on traditional technologies (Schippers, 2002).

2.3.4.2 Lack of seed/planting materials

Schippers (2002) stated that most farmers produce their own seed and some buy seedlings at their local markets. Other farmers obtain their seeds from specialists within their village. According to Schippers (2002) farmers regularly express a desire to experiment with other varieties, but have no access to a good seed supply. Uniform varieties hardly exist and most plots are planted with a landrace which could be heterogeneous, but these landraces are able to withstand most of the local stress factors such as drought or very wet conditions, a low level of soil fertility, and pressure brought about by pests and diseases. The viability of seeds produced on-farm is not tested before planting so that farmers tend to reduce the risk of poor seeds by producing and sowing more than they actually need. Little seed are kept for longer than one season (Schippers, 2002).

2.3.4.3 Misuse of insecticides and polluted water

According to Schippers (2002) many farmers need advice on the selection and use of crop protection chemicals and on the dosage and appropriateness of the substance being used. Major problems which affect the production of vegetable are associated with pests, such as snails that eat the leaves of *Vernonia*, or aphids that cause the leaves of African nightshades to fold up, or flea beetles that destroy an early *Hibiscus* crop. This problem has resulted in the misuse of insecticides by farmers. The manufacturer's instructions as far as timing of application is concerned are often ignored. The misuse of pesticides has led to some consumers preferring to buy produce which shows evidence of insect damage, thus indicating the absence of toxic chemicals on the leaves (Schippers, 2002).

2.4 Useful plant diversity and their availability

The most commonly occurring and used *morogos* in homegardens of Limpopo Province are *Corchorus tridens*, *Amaranthus hybridus*, *Momordica balsamina* and *Cleome gynandra*, along with pumpkin leaves (*Cucurbita* species), *Bidens bipinnata* and *B. pilosa* (High and Shackleton, 2000). Fifteen types of *morogo* was recorded for this study, of which twelve were wild, two were domestic (pumpkin and *madanda*, *Hibiscus esculentus*), and one was a dried *morogo* mixture of several species. Pumpkin is usually planted to supply leaves and flowers for *morogo*, rather than for its fruit (High & Shackleton, 2000). Most of the *morogo* species are available for four to six months, while *Momordica balsamina* and *Bidens* species can be found throughout the year. Even though these two species were available throughout the year, people did not favour them because of their taste. According to High and Schackleton (2000) most of the *morogo* consumed and traded were regarded as weedy species in agricultural sense and some were not indigenous to South Africa. Mulberry (*Morus alba*) leaves, maize (*Zea mays*) stalks and grass species are used for livestock fodder. Other plants were used as snuff, mosquito repellent, fibres for hat making and kindling (High & Shackleton, 2000).

Gardens keep some tree output that could be used for long-term production and sale for profit. Various trees and shrubs are retained in homegardens for their uses and functions such as fuelwood, wind breaks, propping poles, staking poles, fencing poles, timber, shade, medicine and livestock fodder (Rugalema *et.al*, 1994a). For instance, palms in Kerala (India) homegardens are traditionally of significant importance in small farm management as sources of edible fruits, oil, green vegetables, fiber, thatch, construction wood, fuel wood and other useful products (Johnson, 1988). The main function of the homegardens in Indonesia is to supply the gardener's families with non-staple food, chiefly fruits, vegetables and spices (Kehlenbeck & Maass, 2004).

In Kerala state (India) bamboo (*Bambusa arundinacea*) is commonly known as the 'poor man's timber'. This multipurpose plant plays an important role in providing building material for the poor people in villages, where they are widely used as posts and rafters in building construction, and bamboo thorns are used for fencing. Bamboo mattresses are used as partition walls in the homes and also for drying grains. Bamboo poles are used as a physical support for bananas, and rural cottage industries like basket making (Nair & Sreedharan, 1986). In Nhema (Zimbabwe), people use plants for building, timber, firewood, construction material, fruit trees, ornamentals, hedging, shade, medicinal, cereals, tubers, oil crops, food and miscellaneous uses (Maroyi, 2009).

2.5 Medicinal plants and importance

Plants have been used as a primary source of medicine for centuries and still provide mankind with new remedies (Van Wyk *et al*., 1997). Medicinal plants (locally called *muthi* in Zulu, *amayeza* in Xhosa and *setlhare* in Tswana) are still widely used in the health-care system of

South Africa, particularly by the African population. According to Mander and Le Breton (2005) there are up to 100 million traditional remedy consumers in southern Africa and as many as 500 000 traditional healers. Medicinal plants are often a basic requirement for the treatment of certain conditions irrespective of an individual's status (Cocks & Dold, 2000). The use of traditional medicine is not confined to rural, low-income groups but also prevails in urban areas. The use and trade of plants for medicine is no longer restricted to traditional healers, but has entered both the informal and formal entrepreneurial sectors of the African economy, resulting in an increase in the number of herbal gathers and traders (Cunningham, 1989; Dauskardt, 1990, 1991 & Cocks *et al*., 2004).

Wiersum *et al*. (2006) found in their study that over 100 plant species were used as *amayeza* in Amatola region (South Africa). The *amayeza* not only have a utilitarian value for healing physical illnesses, but also have important cultural values. The Xhosa people generally do not differentiate between the causation of diseases and misfortunes (Cocks & Moller, 2002), and *amayeza* can be used both for healing and for protection against misfortunes with natural and supernatural causes. The use of medicinal plants for protection against misfortune may involve protection against evil spirits, treatment of sorcery impacts and use of *amayeza* as luck charms. *Amayeza* may also be used in traditional ancestral-related ceremonies. This mostly concerns the species *Olea europaea* subsp. *africana* (umnquma), *Ptaeroxylon obliquum* (umthathi), *Rubia petiolaris* (impendulo) and *Silene undulata* (unozitholana) (Cocks & Moller, 2002).

According to Veale *et al*. (1992), the majority of plants in South Africa are used to enhance fertility, especially by women who experience complications and disorders associated with their female reproductive and genital organs. Thirteen of the plant species identified by Veale *et al*. 1992) as being used in obstetrics are also used in gynaecology, specifically for the treatment of infertility: *Clivia miniata, Asclepias fruiticosa, Callilepsis laureola Vernonia tigna, Gladiolus perpensa, Gladiolus sericeovillosus, Bowiea volubilis, Eulophia clavicornis, Eulophia tenella, Pentanisia prunelloides, Grewia occidentalis, Typha capensis* and *Rhoicissus tridentata. Catharanthus roseus* has been documented as being used in the treatment of breast and uterine cancer (Van Wyk *et al*., 1997). Even entire taxonomic groups above species level are medicinal, such as the family Menispermaceae with its rich diversification of biologically active bisbenzylisoquinoline alkaloids (De Wet & Van Wyk, 2008).

Women grow various types of medicinal plant species including shrubs, herbs and creepers in their homesteads. People depend greatly on indigenous medicinal plants even though modern medical facilities are accessible (Zobolo & Mkabela, 2006). When indigenous medicine fail, then people consult a medical doctor. The study done by Zobolo and Mkabela (2006) revealed that Zulu women had a tremendous knowledge of vernacular names of plants and their uses in traditional healthcare practice, especially in the treatment of coughs, headaches, stomach aches, toothaches, diarrhoea, wounds, asthma and diabetes.

2.6 Women's role in agriculture to overcome poverty

Since poverty and unemployment is high in South Africa, women tend to rely on small-scale farming to generate income to support their families by selling vegetables at roadside markets (Zobolo *et al*., 2008). Zobolo *et al*. (2008) reported that poverty problems could be reduced by increasing the crop yield. Successful cropping with high crop yields requires sufficient fertilization of the soil. However, poor rural communities do not have money to buy fertilizers (Zobolo *et al*., 2008). Traditional methods of manure fertilization are no longer possible because most rural communities have no cattle, which results in lower crop yields. The only alternative for poor rural communities is to use sugarcane as manure to increase their crop yield, which has already been reported by Zobolo *et al*. (2008).

Ghosh (2004) mentioned that poverty can be overcome by introducing intercropping systems that improves crop protection and increases productivity and profitability. It has been shown that intercropping with plants of differing maturities and/or canopy heights reduces weed growth, lower soil temperatures, controls erosion and maximizes growth resources (Olasantan *et al*., 1996). In areas where garden cropping is a well-developed culture, it is the responsibility of the woman to take care of the garden plots. Such plots usually comprise diverse plants used for food (such as fruits, vegetables, root crops), and non-food plants (spices, medicinal, ornamentals, etc.). Some of these plants are collected from the wild and domesticated by the women farmers for immediate use and occasionally for marketing. Even if women are involved in agricultural food production, researchers in the past used to refer to them as 'non-productive'. Hence, their contribution was often neglected as marginal (Tsegaye, 1997).

Women farmers play a crucial role in safeguarding food security at the household level. They have particular responsibilities and store grains separately for various purposes: seed, consumption and sale. Seeds for planting are given special care and are kept in the best available storage facility to ensure food and livelihood security (Tsega, 1994). Women play an important role in food production and management of plant genetic resources. As tenders of crops, the particular roles of women in the development or conservation of crop genetic resources include: decision on what to grow (plant), planting, selection, seed cleaning/sorting, storage, introduction of new materials and exchange of information (Tsega, 1994). Each of these duties is interrelated and interdependent on the other. They take part in completion of most homestead activities. They play an important role in domestic duties such as washing utensils, cleaning house compounds, livestock and poultry management and feeding, as well as post-harvest activities, guest entertainment, decision making and technology adoption (Tsega, 1994)

2.7 Women's knowledge of plants

According to Tsegaye (1997), women farmers have a tremendous wealth of knowledge in the identification and characterization of the various crop plants they are dealing with. The differentiating criteria commonly used by women include: grain colour, size, taste, cooking quality, hardiness or softness for grinding, storage life, nutritious quality and the like. For instance, although women farmers in Ethiopia do not read and write, they do possess a tremendous wealth of knowledge about the different qualitative attributes and utilities of crop plants (Tsegaye, 1997). This informal knowledge is well developed and based on what they learn from society i.e. from each other's experience by exchanging information. The traditional knowledge of women, however, is not documented and remains only in the memories of the current generations (Tsegaye, 1997).

Zobolo and Mkabela (2006) revealed that elderly women possessed more knowledge on plant uses as compared to young women. The reason for this is that younger generations regard indigenous knowledge as primitive and outdated, and they are therefore not interested. Kothari

(2003) stated that indigenous women have extensive knowledge of medicinal plants due to their role as mothers. They are also knowledgeable about nutrition and storage of food (Kelkar, 1995). The recognition and restoration of indigenous women's knowledge through support of their efforts to pass it to future generations would enhance sustainable use of natural resources (Mikkelsen, 2005). In South Africa, rural women have played a significant role in sustaining, managing and using biodiversity for decades. They have managed most of the resources that are used and grown around the house (Howard, 2003).

Chapter 3

Study area

3.1 Introduction

The study area is Tlhakgameng (26°28'00" South, 24°21'00" East), a rural settlement situated 30 km east of Ganyesa in the North-West Province, South Africa. The North-West Province (NWP) is one of the smallest provinces in South Africa and is completely land-locked by four other South African provinces, namely Northern Cape (west), Free State (south), Gauteng (east) and Limpopo (north-east), and Botswana as a neighbouring country to the north (De Villiers and Mangold, 2002; Anon, 2004). According to De Villiers and Mangold (2002) the NWP occupies a total land area of 116 320 km^2 which is approximately 9.5% of the total area of South Africa and is geographically located between 25 and 28° E latitude and 22 and 28° S longitude. Mafikeng serves as the capital city of the province and some of the most important towns include Brits, Klerksdorp, Potchefstroom, Rustenburg, and Vryburg (Anon, 2008).

The estimated human population resident in the South African urban environment is 53.7% of the total population, while the majority (65%) lives in rural towns and only 35% in urban areas (Tladi *et al*., 2002b). An increase in the rate of urbanization is due to people migrating from rural to urban areas to seek employment (Tladi *et al*., 2002b). In the NWP a total of 60.7% of the population is currently regarded as economically active (15 years and older), but of this potential labour force of approximately 1.2 million people, only 62.3% are employed (Tladi *et al*., 2002b). It is estimated that unemployment rate in the province is 38%, which makes it the fourth highest in South Africa (Tladi *et al*., 2002b).

According to Tladi *et al*. (2002b), NWP consists of four regions, namely Bojanala, Bophirima, Central and Southern. It also has four district municipalities, namely Bojanala Platinum, Dr. Ruth Segomotsi Mompati, Ngaka Modiri Molema and Dr. Kenneth Kaunda respectively (Fig. 3.1). These district municipalities are subdivided further into 21 local municipalities. Bojanala Platinum district has the highest population, while the semi-arid Dr. Ruth Segomotsi Mompati district is sparsely populated (Anon, 2004). Approximately 3.4 million people live in NWP, which encompasses 8.3% of the population of South Africa (Tladi *et al*., 2002b).

The annual growth rate of the province is approximately 3.1% per annum and the main languages spoken are Setswana, Afrikaans and isiXhosa, with English as a second language (Anon, 2004). Due to lack of large cities in the province, the distribution of smaller settlements has been influenced by policies of colonialism and as a result very few of these settlements are self-sustainable (Anon, 2004).

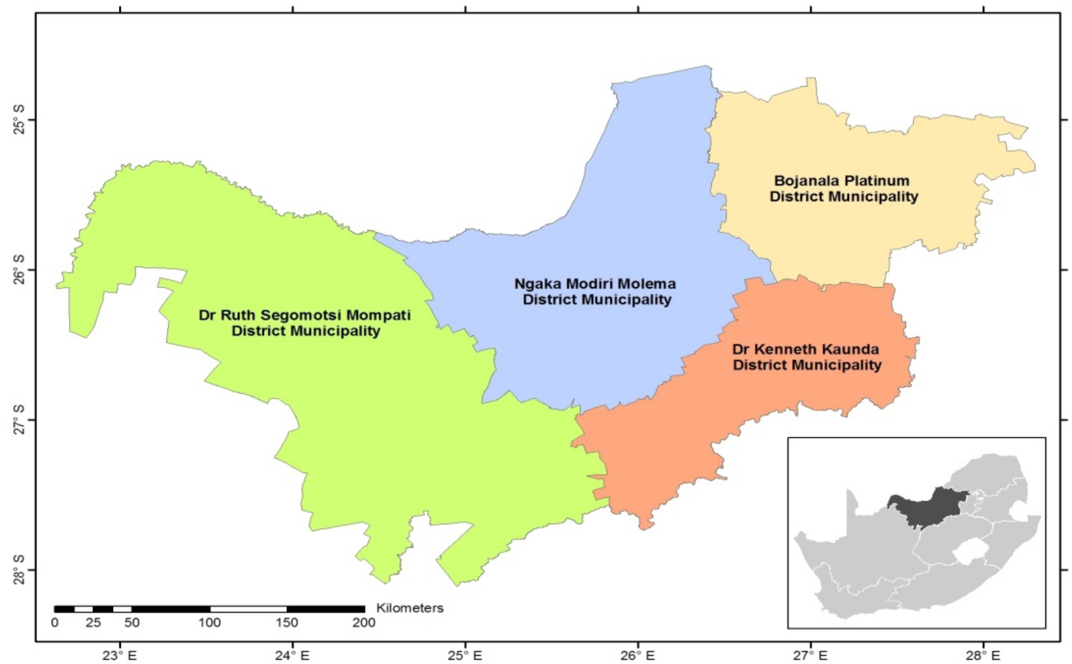


Figure 3.1: Map of North-West Province indicating the four district municipalities.

3.2 Bophuthatswana and the Tswana people

The dominant cultural group in Tlhakgameng is the BaTswana. According to Norman-Smith *et al*. (1977) the BaTswana have always consisted of a conglomerate of various mutually dependent tribes, regardless of several temporary ad hoc alliances, they were usually inclined to divide rather than to assimilate. Tswana society is pluralistic and the word Tswana most probably means 'the little ones who break away' and a reflection of the Tswana's tendencies to fragment rather than integrate 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 BaTswana date back to 1300-1600 AD when the first Sotho ethno-linguistic group moved southwards from the Great Lakes of East Africa, and settled in the enormous open spaces of what were later called Botswana, Eastern Kalahari, Western 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 or sections, and only five Tswana tribes had more than 30 000 members (Norman-Smith *et al*., 1977). As none of these areas had any large cities or towns, the period between 1973 and 1975 was seen by the Bophuthatswana government as the opportunity to claim Mafikeng, Brits, Rustenburg, Zeerust, Lichtenburg and Vryburg (Tladi *et al*., 2002a). The republic of Bophuthatswana became independent on the 6th of December 1977 when the Tswana people were given independence (Norman-Smith *et al*., 1977). South Africa entered a period of new regionalization after the general elections in 1994 and as a result these areas all became part of what is now known as the NWP (Tladi *et al*., 2002a).

3.2.2 Culture

3.2.2.1 Social system

Kinship and descent play a significant role in the social system of the Tswana people which is communal in nature (Norman-Smith *et al*., 1977). Norman-Smith *et al*. (1977) mentioned that most important social groupings are determined by using kinship criteria such as family, lineage, totem group and 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). Kinship and descent also play a major role in the determination of marriagerial partners. Marriage between cousins in Tswana society is an ordinary thing, which further contributes to the endogamous character within the society (Norman-Smith *et al*., 1977). In Tswana society marriage is viewed as an agreement, not only between bridegroom and bride, but between the families concerned. Therefore it is expected that bride-price (*bogadi*) be delivered at the solemnization of the marriage (Norman-Smith *et al*., 1977).

3.2.2.2 Tribal authority structure

The Tswana tribal area is comprised 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 unites the tribe with his advisory council, he is the highest political authority within the tribe. All members of the tribe accept his right to make laws which must be obeyed by everyone (Norman-Smith *et al*., 1977). The chief's decisions are communicated 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 subjected to the extreme authority of the state.

3.2.2.3 Agriculture

Agriculture has played a major role in the history, culture and tradition of the BaTswana people (Norman-Smith *et al*., 1977). Crop production and animal husbandry both play a significant role in the daily lives of traditional Tswana families and like most African people, the Tswana regard cattle as an indication of wealth and status (Norman-Smith *et al*., 1977). In the past cattle were used to exchange for a bride, especially for the bride-price (*bogadi*). Cattle are usually kept at cattle posts, where they range freely over the surrounding pastures that are normally not fenced off (Norman-Smith *et al*., 1977). The owners of cattle posts often share the grazing with others, however, no one is allowed to bring cattle to the posts without permission from the chief (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 worn out he would simply obtain new land from his headman. The cultivation of crops used to be basically a female activity, and the area cultivated by a household depended on the number of woman available and they weren't allowed to go near the cattle (Norman-Smith *et al*., 1977). BaTswana cultivate crops such as corn meal (sorghum), certain types of vegetables and predominately maize which forms a critical part of their culture (Norman-Smith *et al*., 1977). In Tswana culture there is a belief that the area around the homestead should be open and devoid of any vegetation (Fig. 3.2), which is an indication of the tidiness of the household ('*lebala concept*') (Cilliers *et al*., 2009). This resulted in large areas of bare ground, which increases the level of soil erosion around their homes.

Figure 3.2: A distinctive bare yard in Tlhakgameng illustrating the '*lebala concept*' where vegetation is cleared around the home (Photo by: SJ Siebert).

3.3 Dr Ruth Segomotsi Mompati district

The study area falls under the Dr Ruth Segomotsi Mompati district municipality which mainly consists of poor rural areas and the majority of its population (450 000) are Tswana speakers (Anon, 2006). The larger part of the Dr Ruth Segomotsi Mompati district municipality is known as Stellaland and the main town is Vryburg, which forms the centre of a large agricultural hub (Anon, 2006). During a survey of the different areas in this district to find a deep rural village, Tlhakgameng was chosen as the study area (Fig. 3.3). Approximately 20 000 people live in or around Tlhakgameng (Anon, 2006). Tlhakgameng is approximately 20.82 km^2 (2082.43 ha) and is located between 26°28'00" S and 24°21'00" E.

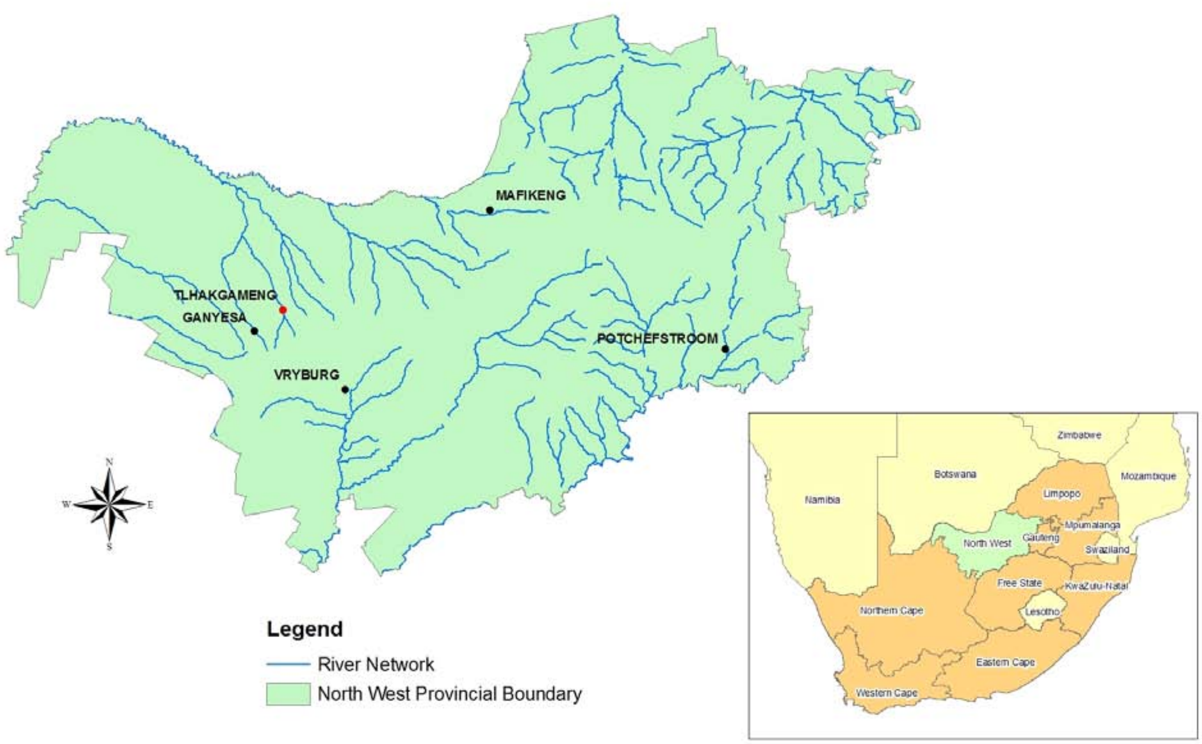


Figure 3.3: Map of the North-West Province indicating the location of Tlhakgameng and the main river network of the province.

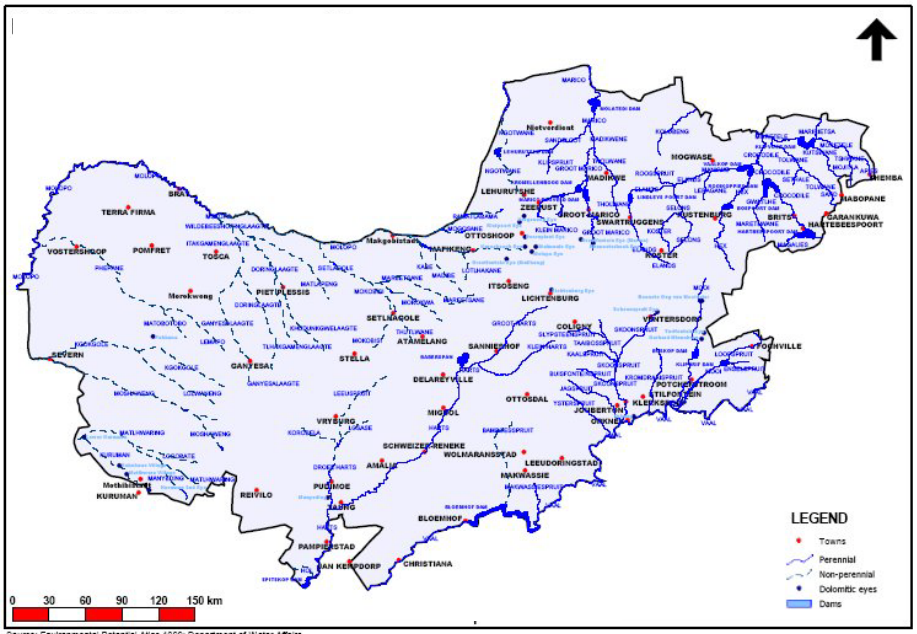
3.4 Topography

According to De Villiers and Mangold (2002), the province is believed to have the most homogeneous landscape of all the South African provinces, with an altitude ranging between 920-1782 m above sea level. The study area lies in the central to western regions that are characterized by flat or gently undulating plains, while the dunes, associated with the arid environment of the Kalahari, mainly occur further west (De Villiers & Mangold, 2002). According to Mucina and Rutherford (2006), Tlhakgameng forms part of the Mafikeng Bushveld vegetation unit in the Eastern Kalahari Bioregion. This vegetation lies west of Mafikeng and south of Botswana, at an altitude of approximately 1 100-1 400 m above sea level (Mucina & Rutherford, 2006).

3.5 Hydrography

3.5.1 Rivers

NWP is mainly a semi-arid region with very few perennial rivers (De Villiers & Mangold, 2002). However, sections of three of the six major drainage basins in South Africa fall within the boundaries of the NWP, namely the Limpopo, Orange and Vaal River basins. Tlhakgameng is located within the Orange River drainage basin by means of the Molopo River (De Villiers & Mangold, 2002). The Molopo River has a number of tributaries that fall within the province, namely Setlagolespruit, Ramatlabamaspruit and Ganyesaspruit, all of which are non-perennial. The Tlhakgamenglaagte flows into the Ganyesaspruit, a tributary which connects with the Molopo River (Fig. 3.4). The Molopo River rises from the Molopo eye near Mafikeng and flows westwards to form the northern border of the NWP with Botswana (De Villiers & Mangold, 2002). The Molopo River used to be a tributary of the Orange River system before it was blocked by high dunes (De Villiers & Mangold, 2002).



Source: Environmental Potential Atlas 1999; Department of Water Affairs

Figure 3.4: Map of the secondary, tertiary and quaternary catchments in the North-West Province (De Villiers and Mangold, 2002).

3.5.2 Wetlands and pans

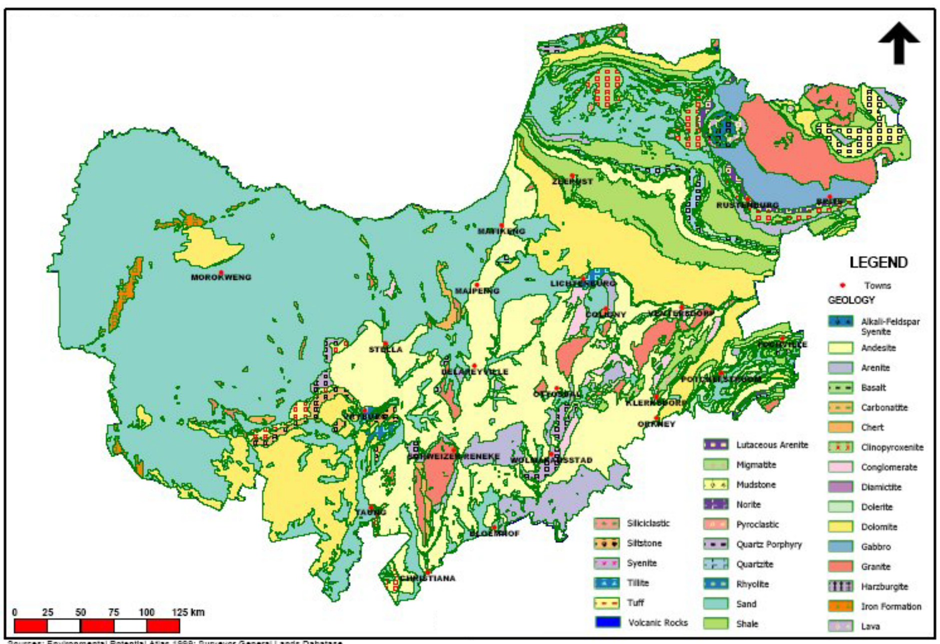
According to Schuyt (2005), wetlands in Africa are an important source of water and nutrients that are essential for biological productivity. Currently, wetlands are considered to be the most endangered habitat types worldwide (De Villiers & Mangold, 2002). De Villiers and Mangold (2002) stated that wetlands play an important role in natural filtration and purification of water as well as providing a habitat for various 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 province forms part of the western Plateau Wetland Group, which has the greatest concentration 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 and a total of 636 pans are located in the western Plateau Wetland Group (De Villiers & Mangold, 2002). Tlhakgameng has four different wetland areas.

3.6. Geology and soil

3.6.1 Geology

According to De Villiers and Mangold (2002), the province is underlain by an attractive and ancient geological heritage which is rich in minerals and paleontological artifacts. Tlhakgameng is located on the Kalahari group, which is the most extensive body of terrestrial sediment of the Cenozoic age in South Africa (Patridge *et al*., 2006). The Cenozoic age comprises the last 65 million years of the earth's history and is divided into two periods, namely the Tertiary and Quaternary periods (Snyman, 1996). The main rock types that can be found in Tlhakgameng area are sand and chert (Fig. 3.5), along with rock types such as limestone, calcrete, clay and siltstone which are features of the larger Kalahari group (De Villiers & Mangold, 2002). Tlhakgameng is also characterized by Archaean Granites, which are the oldest rock formations in the province and mostly forms flat to slightly undulating landscapes (De Villiers & Mangold, 2002).



Sources: Environmental Potential Atlas 1999; Surveyor General Lands Dabatase

Figure 3.5: Map of the geology and rock types of the North-West Province (De Villiers and Mangold, 2002).

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 forms (Mucina & Rutherford, 2006). Different authors reported on the soil of Kalahari Thornveld in different ways, e.g. Acocks (1988) and Low and Rebelo (1996) described the Kalahari soil as loose sandy soils and De Villiers and Mangold (2002) classifiedit as freely drained, arid to semi-arid, red and yellow soils with a clay content of approximately 15%, which have developed calcareous crusts in the Tlhakgameng area (Fig. 3.5). According to Van der Walt and Le Riche (1999) the sandy soils of the Kalahari are characterized by a sand content of 86-90% and a grain cross section of 0.02-2 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 a substantial area. According to De Villiers and Mangold (2002) the climatic conditions in NWP varies considerably from west to east. The western region is arid, while the eastern region is mainly temperate and the central region is dominated by typically semi-arid conditions (De Villiers & Mangold, 2002). The eastern and south-eastern region of NWP receives over 600 mm rainfall per annum (Fig. 3.6), while the central region receives approximately 550 mm per annum and the western region less than 300 mm per annum (De Villiers & Mangold, 2002). According to Acocks (1988) the rainfall in the Kalahari Thornveld veld types ranges from 400-500 mm per annum, falling mostly in summer. The mean annual rainfall for the Kalahari Plains Thorn Bushveld vegetation type is 300 mm, which falls in the summer and early autumn (Low & Rebelo, 1996).

The Mafikeng Bushveld vegetation unit is characterized by summer rainfall with very dry winters (Mucina and Rutherford, 2006). 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 mid-October (Low & Rebelo, 1996; Van der Walt & Le Riche, 1999; Mucina & Rutherford, 2006). Four years prior to this study, the Tlhakgameng region experienced an above average rainfall year (Fig. 3.7). In 2006 the total rainfall for Tlhakgameng was 730.3 mm and the mean monthly rainfall was 60.9 mm (Fig. 3.7), while in 2007 it was 267.0 mm and the mean monthly rainfall only 22.3 mm. In 2008 which was a year before our survey, the study 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).

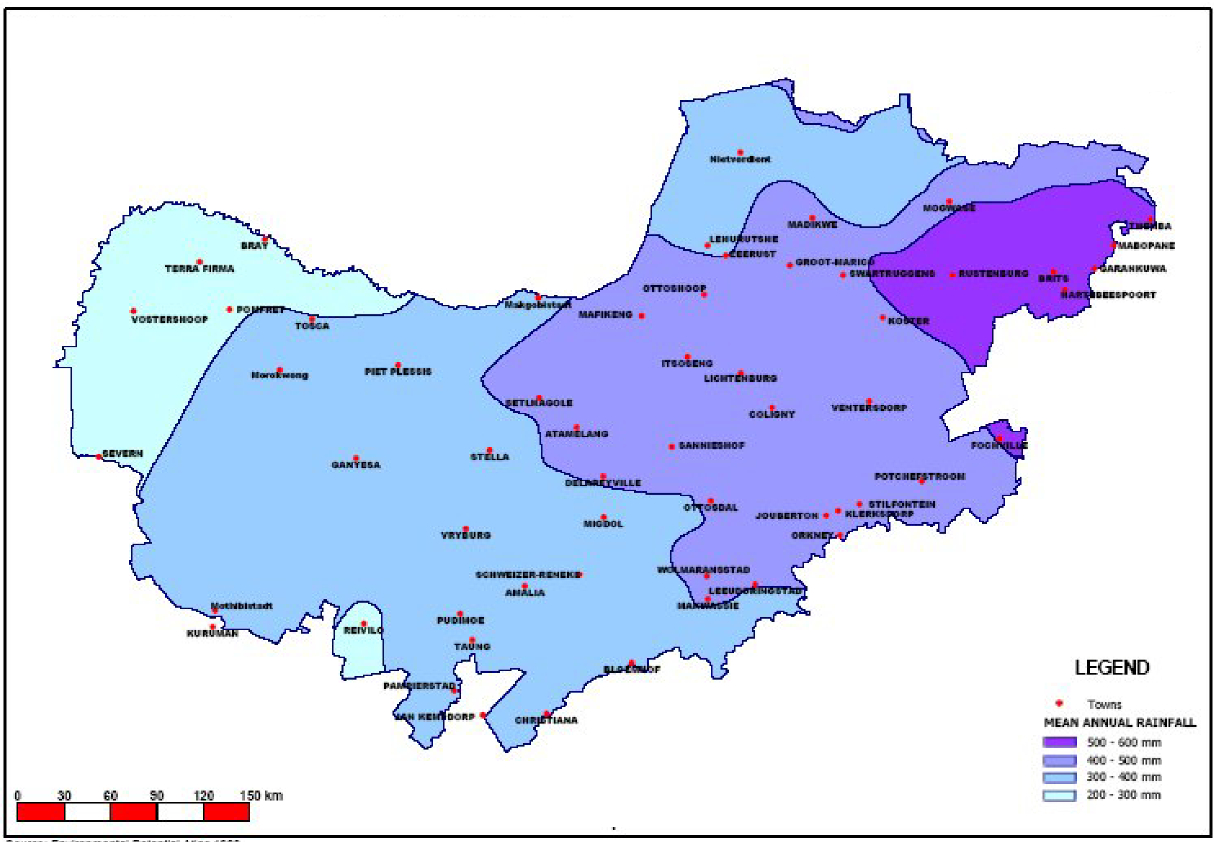


Figure 3.6: Mean annual rainfall zones for North-West Province (Mangold *et al.*, 2002).

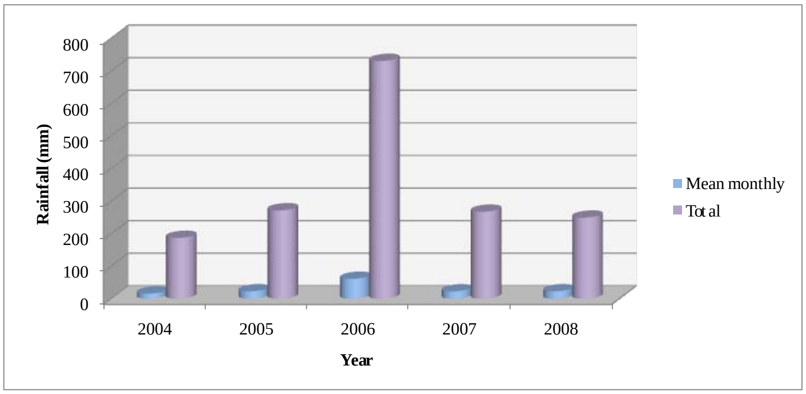
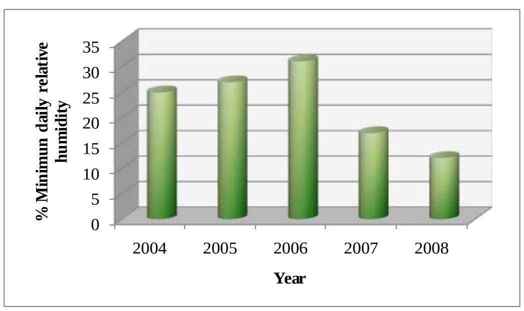


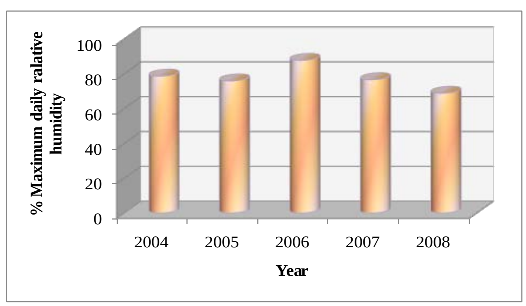
Figure 3.7: The total and mean monthly rainfall for Tlhakgameng for the period 2004-2008 (ARC-ISCW, 2009).

3.7.2 Humidity

According to De Villiers and Mangold (2002) the relative humidity is typically low throughout NWP, being below 28% in the northern part of the province in July and between 28-30% for the central and eastern regions. February has the highest humidity with the northern and eastern parts of the province ranging between 66 and 68%, while the rest of the province ranges between 64 and 66% (De Villiers & Mangold, 2002). Such relatively high humidity values for the province are a result of high evapo-transpiration rates by the flora of the region (De Villiers & Mangold, 2002). Based on the humidity data from the Louwna weather station, the minimum average daily relative humidity for the Tlhakgameng area in 2007 was 16.9% and in 2008 was 12% (Fig. 3.8A), the maximum average daily relative humidity was 76.7% in 2007 and 68.9% in 2008 (Fig. 3.8B) (ARC-ISCW, 2009).



A)



B)

Figure 3.8: The mean A) minimum and B) maximum percentage of relative humidity for the Tlhakgameng region for the period 2004-2008 (ARC-ISCW, 2009).

3.7.3 Temperature

According to De Villiers and Mangold (2002), NWP is characterized by great seasonal and daily variations in temperature, being very hot in the summer with a daily mean maximum temperature of 32°C in January and mild cold winters, with a daily mean 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 can exceed 15°C, while the eastern and central regions experience a range between 12°C and 15°C (De Villiers & Mangold, 2002). Parts of the north-eastern and north-western regions of the province receive between 1 and 31 days of frost, while the rest of the province receives 31 and 60 days of frost (De Villiers & Mangold, 2002). The average days of frost for the entire province are 31 (De Villiers & 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 a mean annual temperature of 18°C. Temperatures 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 Tlhakgameng in 2007 was 17.7°C and in 2008, 17.4°C (Fig. 3.9) (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. 3.10) (ARC-ISCW, 2009).

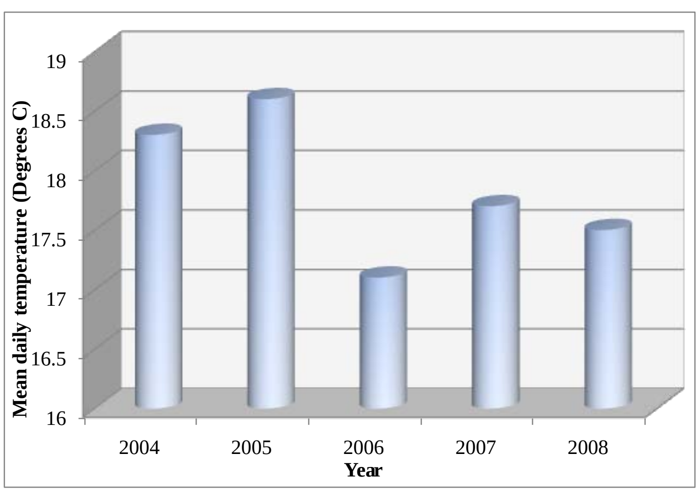
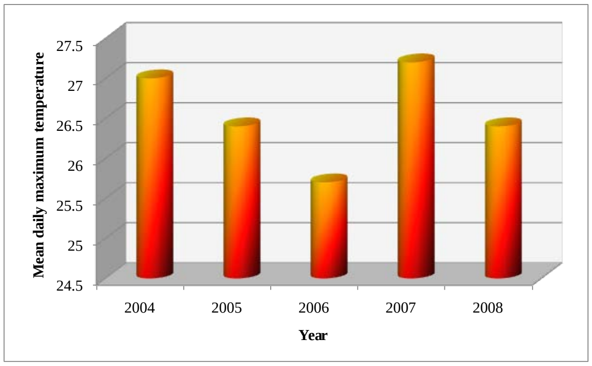
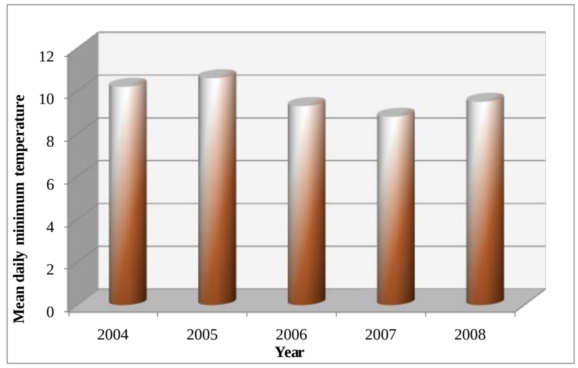


Figure 3.9: The mean daily temperature for Tlhakgameng for the period 2004-2008 (ARC-ISCW, 2009).





A) B)

Figure 3.10: The mean A) maximum and B) minimum daily temperatures for Tlhakgameng for the period 2004-2008 (ARC-ISCW, 2010).

3.8 Flora

The northern provinces of South Africa is represented by 204 families with 1 397 genera and 5 768 known infrageneric taxa (Retief & Herman, 1997). The Fabaceae, Poaceae and Asteraceae are the three largest families in these provinces (Retief & Herman, 1997). It is estimated that 10% of the infrageneric taxa are endemic to the northern provinces, especially species in the following genera, *Aloe*, *Euphorbia*, *Thesium*, *Indigofera* and *Brachystelma*, with the highest occurrence of these endemics in the eastern subregion (Retief & Herman, 1997). Since the North-West Province was declared post 1994, and made up of parts of the former Transvaal and Cape Provinces, no accurate figures exist for the flora as it has not specifically been quantified. The province also contains some of the most poorly sampled regions in South Africa (Bester *et al.*, 2008).

3.9 Vegetation

According to Low and Rebelo (1996), Tlhakgameng falls within the Savanna Biome. The vegetation has been classified as the Kalahari Thornveld type (Fig. 3.11 (a)) according to Acocks (1988), the Kalahari Plains Thorn Bushveld vegetation type (Fig.3. 11 (b)) according to Low and Rebelo (1996), and the Mafikeng Bushveld vegetation unit (Fig. 3.12) according to Mucina and

Rutherford (2006). According to Acocks (1988) the Kalahari Thornveld type is subdivided into two, namely the Kalahari Thornveld Proper (16a) and the Vryburg Shrub Bushveld (16b).

Scholes and Archer (1997) define savanna as vegetation 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 (Low & Rebelo, 1996). According to Mucina and Rutherford (2006) the Savanna Biome constitutes 32.8% of South Africa and 74.2% of Swaziland (Mucina & Rutherford, 2006) and is also the dominant vegetation in Zimbabwe, Namibia and Botswana (Low & Rebelo, 1996). According to Mucina and Rutherford (2006) the Savanna Biome is characterized by an herbaceous layer which is usually dominated by grass species and a discontinuous to sometimes open tree layer.

Tlhakgameng 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 five subdivisions, namely the north-eastern, eastern, western, north-western, and central forms of the veld type. Tlhakgameng is situated in the eastern form of the Kalahari Thornveld Proper veld type, which is characterized by open savanna (Acocks, 1988). According to Acocks (1988), ancient cultivation in the Vryburg region has over large areas practically removed the trees, leaving what is virtually a grassveld, often dotted with only a few shrub and trees species.

The Kalahari Plains Thorn Bushveld vegetation type is illustrated by a well-developed tree stratum and a moderately developed shrub layer (Low & Rebelo, 1996). This woody shrub-tree layer varies from 1 to 20 m in height and even become the dominant vegetation type in areas which are being overgrazed (Low & Rebelo, 1996). According to Low and Rebelo (1996) the grass cover depends on the amount of rainfall during the growing season. C4-type grasses dominate the grass layer in areas with a warmer growing season, but C3-type grass tend to be more dominant where the rainfall also has a winter component (Low & Rebelo, 1996). The Mafikeng Bushveld vegetation unit is characterized by a well developed tree, shrub and grass layer (Mucina & Rutherford, 2006). During the survey the natural areas around Tlhakgameng were characterized 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 Tlhakgameng were characterized by fairly dense tree and shrub layers.

Acacia erioloba was identified by Acocks (1988) as the most significant and dominant 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*. *Eragrostis lehmanniana* and *Schmidtia kalihariensis* form the dominant grass species of the Kalahari Plains Thorn Bushveld vegetation type (Low & Rebelo, 1996).

Dense stands of *Terminalia sericea* and *Acacia erioloba* are major features of certain areas. These areas are also characterised by a shrub layer consisting of species such as *Acacia karroo*, *A. hebeclada*, *A. 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* (Davoren, 2009).

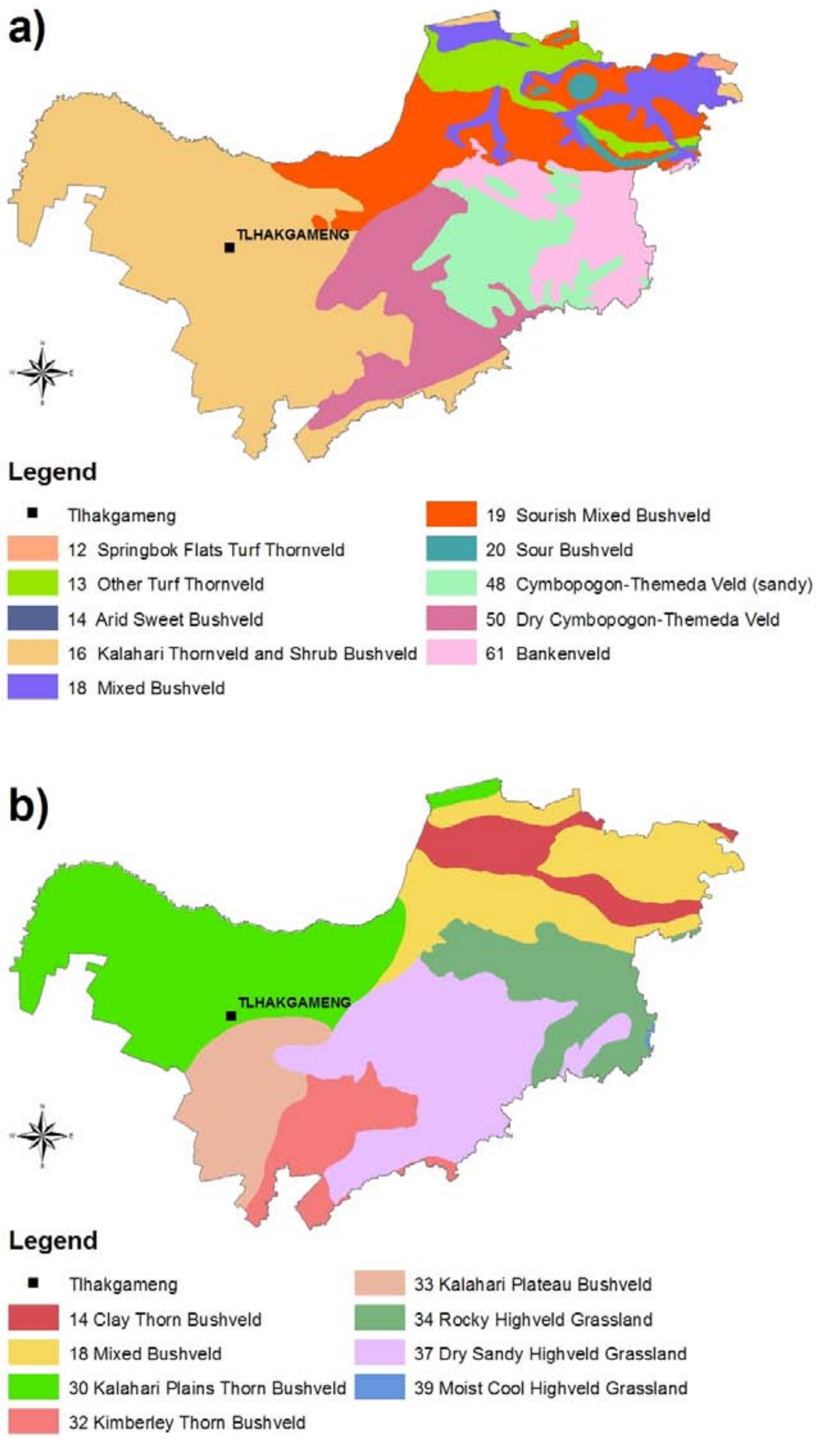


Figure 3.11: North-West Province (a) veld types as described by Acocks (1988) and (b) vegetation types as described by Low and Rebelo (1996).

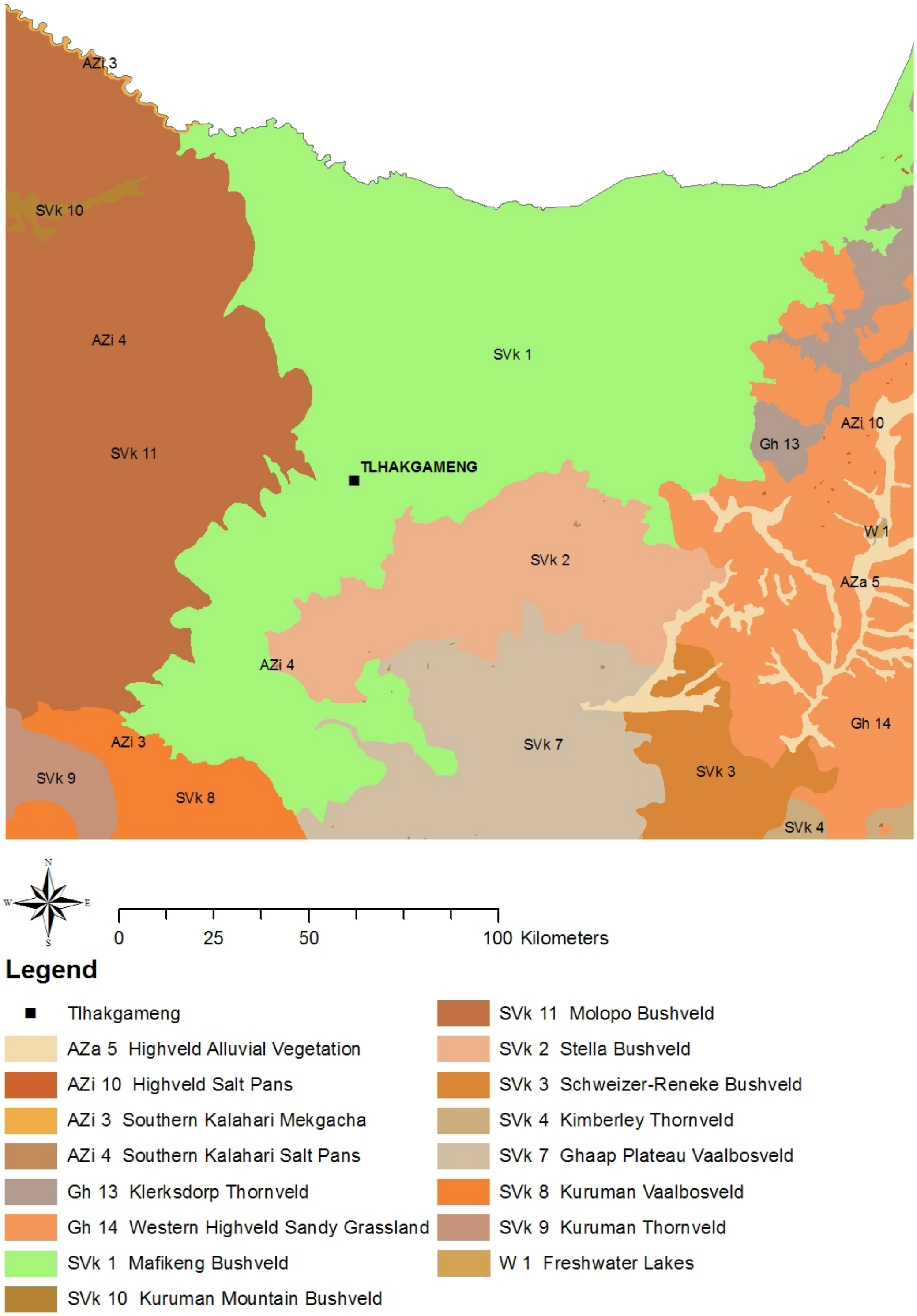


Figure 3.12: Map of the different vegetation units of the Tlhakgameng region as described by Mucina and Rutherford (2006).

3.10 Economic activities

The economy of the province is weak with a mere 4.9% contribution to the national Gross Domestic Product (GDP) and a 2% economic growth rate (Tladi & Tlhomelang, 2002). Mining and agriculture play a central role in the economy of the province, with the production of primary commodities such as platinum, gold, and maize contributing substantially to the economic status of the province (Tladi & 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 & 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 Tlhakgameng. However, there are also some important mines that occur within this region.

3.10.1 Mining

Mining has been the backbone of the South African economy since the discovery of diamonds and gold towards the end of the 19th century (Visser *et al*., 2002). However, 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). The mining sector has been seen as the major contributor to the NWP’s economy since 1996 and employs approximately 118 000 workers (Tladi & Tlhomelang, 2002).

In recent years the NWP has become known as the Platinum Province, since platinum has overtaken gold as the most valuable mining product (Visser *et al*., 2002). In 1994, NWP produced the third largest amount of gold, approximately 139.2 tons, 24% of the total production for South Africa and produces 70% of the world’s 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 NWP 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

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

According to Visser *et al*. (2002), the primary agricultural practices in NWP 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 province due to the low rainfall levels experienced across the province, but commercial maize farming has contributed significantly to the region's economic growth (Visser *et al*., 2002). In 1996 the gross income from the total commercial agricultural products in the 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 province amounted to 14.7%, 8% and 7.4% respectively of the total for South Africa. The residents of Tlhakgameng are mostly crop and livestock farmers.

3.10.3 Tourism

In the past few years the NWP has become an attractive tourism destination with its sunny climate, magnificent bird life and diverse natural and cultural heritage which enhances the province's 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 (Visser *et al*., 2002).

The southern and eastern regions host approximately two-thirds of the tourism activity in the 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 Tlhakgameng area has the potential of becoming a major wilderness destination equaling the world renowned experiences of the Kalahari Gemsbok Park and Etosha.

3.11 Conservation

Recently, the conservation and utilization of biodiversity has become ever more significant and one of the greatest driving forces behind conservation efforts has been the demand for "unspoiled" 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 NWP offer a diverse range of activities and experiences. In 1998 South Africa had 12 820.73 km^2 formally protected areas, while country-wide 16 064.37 km^2 was informally protected and managed by private residents or municipalities (Kumleben *et al*., 1998). Approximately 2 156.36 km^2 was held by the North-West Parks and Tourism Board, represented by proclaimed provincial Nature Reserves, Municipal Nature Reserves, Natural Heritage Sites, National Parks, Protected Natural Environment, 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 & Rebelo, 1996). According to Low and Rebelo (1996) this high level of conserved savanna belies the fact that half of the vegetation types are inadequately conserved (less than 5% of these fall within protected areas). 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 & Rebelo, 1996). Tourism and big game hunting further contribute to the conservation of the savanna (Low & Rebelo, 1996).

The conservation status of the Kalahari Plains Thorn Bushveld vegetation type is considered to be very poor (Low & 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 elsewhere (Mucina & Rutherford, 2006).

Chapter 4

Patterns of plant diversity and species richness in a rural settlement: an assessment of useful plants

4.1 Introduction

The correlates and causes of species diversity have long since intrigued naturalists and ecologists to conduct research (e.g. Hutchison, 1959; Huston, 1979; May, 1988). Numerous studies have considered patterns of diversity at spatial scales ranging from one meter-square plots to latitudinal gradients, and at temporal scales ranging from seasonal changes to geological or evolutionary time scales (Currie, 1991; Whittaker *et al*., 2001; Clemants and Moore, 2003; Field *et al*., 2005; Storch *et al*., 2005). The strong correlation between species richness and longitude, precipitation, temperature, potential evapotranspiration (PET), and insulation (sunlight) are widely recognized (Fischer, 1960; Currie, 1991; Palmer, 1995; Barthlott & Mutke, 2001).

According to Halpern and Spies (1995), the widespread loss of species and natural habitats have motivated ecological research to focus on the consequences of exploitive and long-term management activities for species diversity. Consideration of biological diversity has also guided the design, implementation, and critique of existing policy on natural resource management (Westman, 1990; Lubchenco *et al*., 1991; Kessler *et al*., 1992). Conceptual models have been developed by numerous authors that offer mechanistic explanations for the pattern and maintenance of diversity (Menge & Sutherland, 1987; Connell, 1978; Huston, 1979).

Several authors regard South Africa as an ideal country for analyses of species richness patterns due to its high environmental heterogeneity and extraordinarily rich flora (e.g. Goldblatt, 1978; Cowling *et al*., 1989; Lubbe *et al.*, 2010). Furthermore, it contains not only some of the most species-rich regions in the world (e.g. southwestern part of Fynbos biome), but also areas of floristic impoverishment, such as parts of the Upper Karoo and Kalahari Basin (Cowling *et al*., 1989; Cowling & Hilton-Taylor, 1992).

In the last few decades urbanization has not only been regarded as a major threat to biodiversity, but has also been seen as an important cause of habitat destruction of natural areas (McKinney, 2002; Miller, 2005; Kühn & Klotz, 2006). However, the pioneering work of Godefroid and

Koedam (2007) found that cities are capable of supporting remarkably high biotic diversity, which is supported by a study of Thompson *et al*. (2003) which found that garden floras show outstanding high levels of floristic diversity. Several studies have indicated that cities are richer in plant species than the surrounding areas (McKinney, 2002; Hope *et al*., 2003; Kühn & Klotz, 2006). This 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 the cities were established in areas of natural heterogeneity that naturally supports higher levels of biodiversity (Kühn & Klotz, 2006).

According to Sukopp *et al*. (1979), calculating the proportion of non-native species is useful because it indicates the intensity of disturbance caused by human activities. The impact that humans have on urban ecosystems can create the perfect environment for the establishment of alien species (Godefroid, 2001). Previous studies indicated that in urban areas the proportion of native species has been increasingly reduced due to urbanization, while the number of alien species has noticeably increased (e.g. Kent *et al*., 1999; Godefroid, 2001). 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 alien species than any other land-use type. Marco *et al*. (2008) confirmed that private gardens in France contain a large floral diversity strongly dominated by alien species.

Despite this concern with biodiversity, there are relatively few studies in southern African savannas that have attempted to quantify patterns of alpha and beta diversity (Cowling *et al*., 1989), and the relative decline between protected and adjacent non-protected areas, which would provide a measure of the success or failure of protected areas as one strategy to help prevent the decline of biodiversity worldwide (Shackleton, 2000). This is compounded by a lack of standard methodologies and little insight into local-scale patterns of diversity and its determinants, especially in the savanna-urban interface which is characterized by much human activity. Isolated attempts to study plant diversity of South African savannas in populated areas include studies in Bushbuckridge (Shackleton, 2000) and Ganyesa (Davoren, 2009). There is a dire need for more plant diversity studies in populated savanna regions of the North-West Province, and according to a collections map of Bester *et al*. (2008), Tlhakgameng is one of the most under sampled areas of the province.

Over the last few decades ecologists have applied spatial modeling to explore the response of ecological systems to disturbances occurring at different spatial scales (Perry & 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 anthropods (Acosta-Mercado & 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 & 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 main objectives of this chapter were to compare land-use types (fallow fields, homegardens, natural areas and wetlands) in a rural settlement in terms of:

(i) gamma-, alpha-, and beta diversity,

(ii) plant species composition, and

(iii) patterns of plant species richness.

This study is required to provide baseline data for future use in the testing of hypotheses to formulate a beta diversity theory for urban environments.

4.2 Materials and Methods

4.2.1 Vegetation survey

To meet the requirements for the application of geostatistics, a grid was placed over an aerial photograph of the settlement with sample points approximately 500 m apart from each other by means of ArcView 9.2 (Esri, 2006) (Fig. 4.1). During the survey, the land-use type was identified for each of these points that could be one of the following: fallow field, homegarden, natural area or wetland. Parks which are a common land-use area in most urban areas, were absent from our study area since it is a deep rural settlement. Points in the fallow fields, natural areas and wetlands were sampled in 20 x 20 m plots. Each plot consisted of five transects with 20 points each. Along each transect the nearest tree, shrub, forb and grass species at intervals of 1 m was noted and identified. Bare ground was noted if no plant occurred within 0.5 m before or after the point and 2 m perpendicular to the transect.

However, the five transects of a sample plot located in a homegarden were were randomly placed within microgardens. Molebatsi *et al*. (2010a) has shown that three to five microgardens occur per homegarden, namely any of the following: hedge, orchard, flower bed, vegetable garden, lawn, open space and natural area. A study by Davoren (2009) has shown that gardens are undersampled if all the transects are place in the same sample plot, as gardens are not heterogenous and species are not evenly spaced throughout the garden.

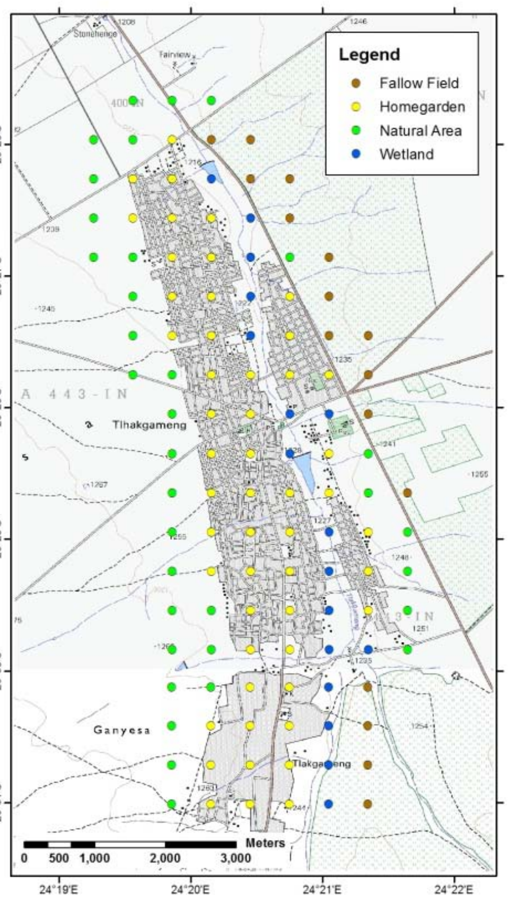


Figure 4.1: The four major land-use types of Tlhakgameng.

4.2.2 Data analysis

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

4.2.3 Inverse distance weighting (IDW)

The inverse distance weighting (IDW) method is one of the most frequently used deterministic models in spatial interpolation, whereas kriging is the preferred method in many spatial statistical analyses (Lu & Wong, 2008). The general idea of IDW is based on the assumption that the attribute value of an unsampled point is the weighted average of known values within the neighbourhood, and the weights are inversely related to the distances between the prediction location and the sampled locations (Lu & Wong, 2008).

The inverse-distance weight is modified by a constant power or a distance-decay parameter to adjust the diminishing strength in relationship with increasing distance (Lu & Wong, 2008).

The IDW method is often considered when predicting the unknown attribute values at certain locations. According to Burrough and McDonnell (1998), IDW cannot estimate the variances of predicted values in unsampled locations as compared to what geostatistical methods such as kriging can provide. A constant distance-decay value could be part of the reason that IDW provides less accurate predictions as compared to other interpolation methods (Goovaerts, 2000; Lloyd, 2005).

According to Lu and Wong (2008) the main advantage of IDW is that it is relatively quick to use, easy to compute and straightforward to interpret. The general idea of this method is that the attribute values of any given pair of points are related to each other, but their similarity is inversely related to the distance between two locations.

According to Whittaker (1972) alpha diversity refers to the diversity within a particular area or ecosystem, and is usually expressed by the number of species (i.e. species) or abundance (i.e. diversity) in that ecosystem, beta diversity is a comparison of diversity between ecosystems usually measured as the amount of species turnover between the ecosystems, and gamma diversity is a measure of the overall diversity for the different ecosystems within a large region.

4.2.4 Multivariate analysis

4.2.4.1 NMDS ordination

According to Kenkel and Orloci (1986), non-metric multi-dimensional scaling (NMDS) is often the method of choice for graphical representation of community relationships, because of its dependence on a biologically meaningful view of the data i.e. choice of standardization, transformation and similarity coefficient appropriate to the hypotheses under investigation; its distance-preserving properties i.e. preservation of the rank order of among-sample dissimilarities in the rank order of distances.

An ordination method known as non-metric multidimensional scaling was used to compare the floristic composition for each sample plot in all land-use types.

The ordinations were achieved with Primer 5 software (Clarke & Gorley, 2001). Frequency data gathered during the vegetation survey was used to construct ordinations for the different species groups, namely total, indigenous, indigenous cultivated, alien and naturalized species composition. These categories are defined as follows:

(i) Indigenous – naturally occurring within the study area (native to the area), usually not cultivated;

(ii) Indigenous cultivated – indigenous to South Africa and not occurring naturally within the study area (not native to the area), but cultivated in gardens;

(iii) Naturalized alien – not indigenous to South Africa, but occurs in the study area where it sustains self-replacing populations outside of cultivation without direct intervention by people;

(iv) Cultivated alien – not indigenous to South Africa and not naturalized in the study area, but cultivated in gardens and including garden hybrid species.

The species abundance data for each of the sample points were converted to a matrix of similarities between every pair of samples. Similarities permit a low-dimensional display of biotic relationships among the samples (Clarke & Ainsworth, 1993). The ordinations which were derived illustrated the distance between each plot as arank order, based on a dissimilarity coefficient that reflected their difference in species composition (Williams, 2005; Kent & Coker, 1992).

According to Williams (2005), NMDS minimizes stress by adjusting site positions to improve the fit between ordination distances and dissimilarities. Kent and Coker (1992) defined stress function of an NMDS ordination as a measure of how well two points fit to each other. Clarke (1993) stated that 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 should be implemented: a stress value smaller than 0.05 provides an excellent representation with no prospect of misinterpretation, a stress value smaller than 0.1 corresponds to a good ordination, a stress value smaller than 0.2 provide an acceptableordination, while stress values larger than 0.2 have the potential to be misleading and 0.35-0.4 values 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 produced was used to analyse the beta diversity (β-diversity) of all land-use types in 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 due to high similarity. The beta diversity can be calculated by dividing the gamma diversity of a certain region with the mean of the alpha diversity (Primack, 2002).

4.2.4.2 Diversity indices

Research on the alpha diversity of communities can provide valuable information into the development and compositional change of a community (Ganlin *et al*., 2006). There are several methods for measuring alpha diversity and most of them consist of two components, namely species richness and abundance (Magurran, 2004). According to Magurran (1988) species diversity measures include species richness indices and indices based on the proportional abundance of species. The species richness indices measure the number of species in a sampling unit, for example Margalef's or Menhinick's species richness indices (Magurran, 1988). Species abundance indices describe the proportional abundance of species, for example the Shannon-Wiener and Simpson species diversity indices (Magurran, 1988).

Frequency data was used to calculate diversity indices for all land-use types found in the study area with Primer 5 software (Clarke & Gorley, 2001). Species richness was determined with Margalef's species richness index, species evenness with Pielou's evenness index and species diversity with both the Shannon-Wiener and Simpson diversity indices (Clarke & Gorley, 2001). According to Magurran (1988), species abundance models range from those which characterize cases where there is high evenness to those which characterize cases where the abundances of species are very unequal. Indices based on the proportional abundances of species involve

Shannon and Simpson's indices, which seek to crystallize richness and evenness into a single figure.

Margalef's species richness index (d) was calculated as:

$d = (S-1)/\ln N$

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

Pielou's evenness (J') was calculated as:

$J' = H'/H'max = H'/\ln S$

Measures the proportion of individuals, where H' is the Shannon index and S is the number of species recorded. The maximum diversity (H'max) that could possibly occur would be found in a situation where all species had equal abundances. J provides the relative abundance or proportion of individuals among the species (Magurran, 2004).

The Shannon-Wiener index (H') was calculated as:

$H' = \sum p_i \ln p_i$

Measures statistical diversity, where p_i is the relative abundance of the i*th* species. This index provides a rough measure of diversity, which is much less biased by sample size than species richness.

The Simpson diversity (D) index was calculated as:

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

Measures heterogeneity, where N is the total number of individuals (all species) and n_i is the number of individuals for an i*th* species. A perfectly homogeneous population would have a diversity index score of 0. A perfectly heterogeneous population would have a diversity index score of 1 (assuming infinite categories with equal representation in each category). It is heavily weighted towards the most abundant species in the sample while being less sensitive to species richness.

4.3 Results

4.3.1 Gamma diversity of land-use types

A comparison of the different land-use types revealed that homegardens had the highest total plant diversity or gamma diversity (γ-diversity) (Fig. 4.2). Homegardens also had the highest number of indigenous and alien species respectively in comparison with other land-use types. Natural areas were found to be the second richest with regard to the total (γ-diversity) and indigenous species. Wetlands had the second highest richness of alien species. Fallow fields had the lowest γ-diversity in terms of total, alien and indigenous species of all the land-use types.

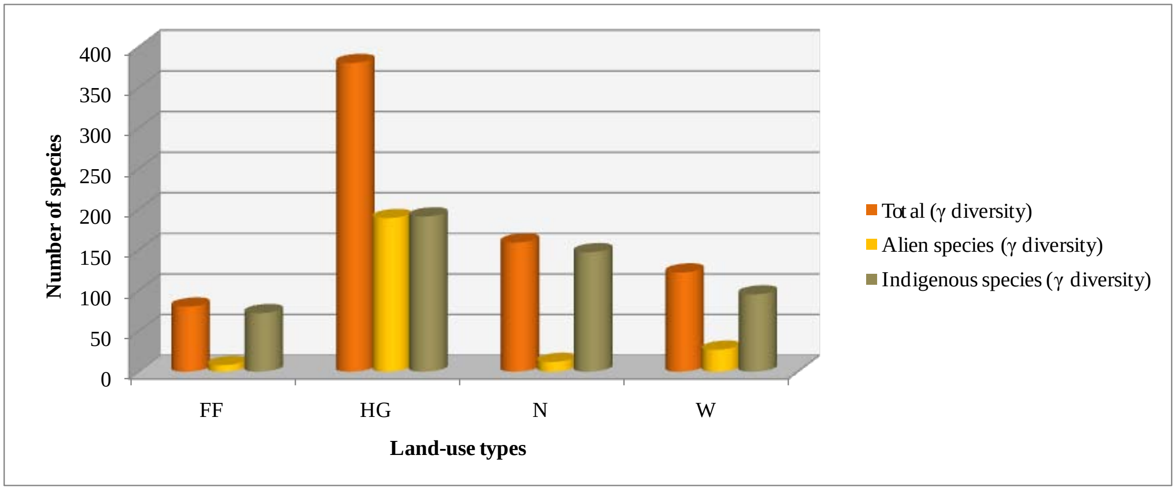


Figure 4.2: Gamma (γ) diversity and indigenous (indigenous and indigenous cultivated) and alien (alien cultivated and naturalized) species for each of the different land-use types. FF, Fallow field; HG, Homegarden; N, Natural area; W, Wetland.

4.3.2 Alpha diversity of all land-use types and patterns of species richness

4.3.2.1 Alpha diversity

Homegardens contained the highest alpha (α) diversity with a mean of 50 species per 100 m^2 in comparison with other land-use types, followed by the natural areas (mean of 30 species per 100 m^2) (Fig. 4.3). Wetlands had a mean of approximately 27 species per 100 m^2, followed by fallow fields with a mean of approximately 20 species per 100 m^2.

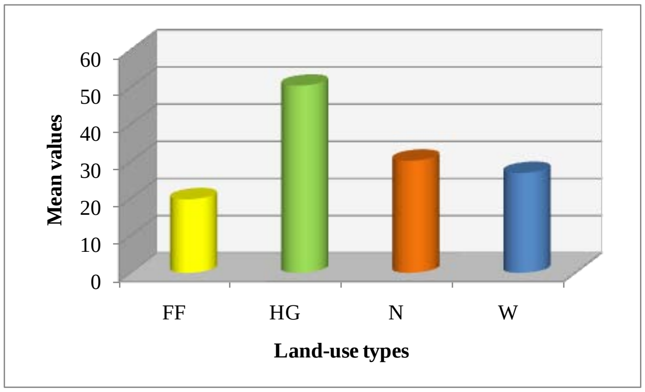


Figure 4.3: Mean species richness per 100 m^2 for each of the land-use types in Tlhakgameng. FF, Fallow fields; HG, Homegardens; N, Natural areas; W, Wetlands.

4.3.2.2 Patterns of species richness

As would be expected, there was a general increase in cultivated species richness (alien and indigenous) from the natural areas outside the settlement to the homegardens inside the settlement (Figs. 4.4 (A) and (B)). A number of homegardens towards the edges of the settlement near natural areas were, however, found to contain higher alien cultivated species richness than the other homegardens (Fig. 4.4(A)). Only one of the homegardens inside the settlement was characterized by exceptionally high alien cultivated species richness. Fallow fields, natural areas and wetlands were obviously found to have low alien cultivated species richness as compared to homegardens (Fig. 4.4 (A)). Three homegardens were found to have higher indigenous cultivated species richness in comparison to other homegardens inside the settlement. One of these three homegardens also had higher alien cultivated species richness. Fallow fields, natural areas and wetlands were found to have expected low indigenous cultivated species richness in comparison with homegardens (Fig. 4.4(B)).

The pattern of indigenous species richness was quite different from that of cultivated species. Natural areas were found to have the highest indigenous species richness in comparison to the other land-use types (Fig. 4.4(C)). Four of the natural areas were even characterized by comparitvely high indigenous species richness (37-45 species per 100 m^2). There were, however, even a number of homegardens (32-36 species per 100 m^2) and wetlands (29-31 species per 100 m^2) with high indigenous species richness. Most of the homegardens and fallow fields had relatively low indigenous species richness (less than 22 species per 100 m^2) (Fig. 4.4 (C)).

Naturalized species showed a distinct pattern totally opposite to that of the indigenous species. Although there is a general trend of an increase of naturalized species from outside to inside the settlement, as with the alien cultivated species, there were many more homegardens with relatively high naturalized species richness (Fig. 4.4(D)). Fallow fields and natural areas had very few naturalized species.

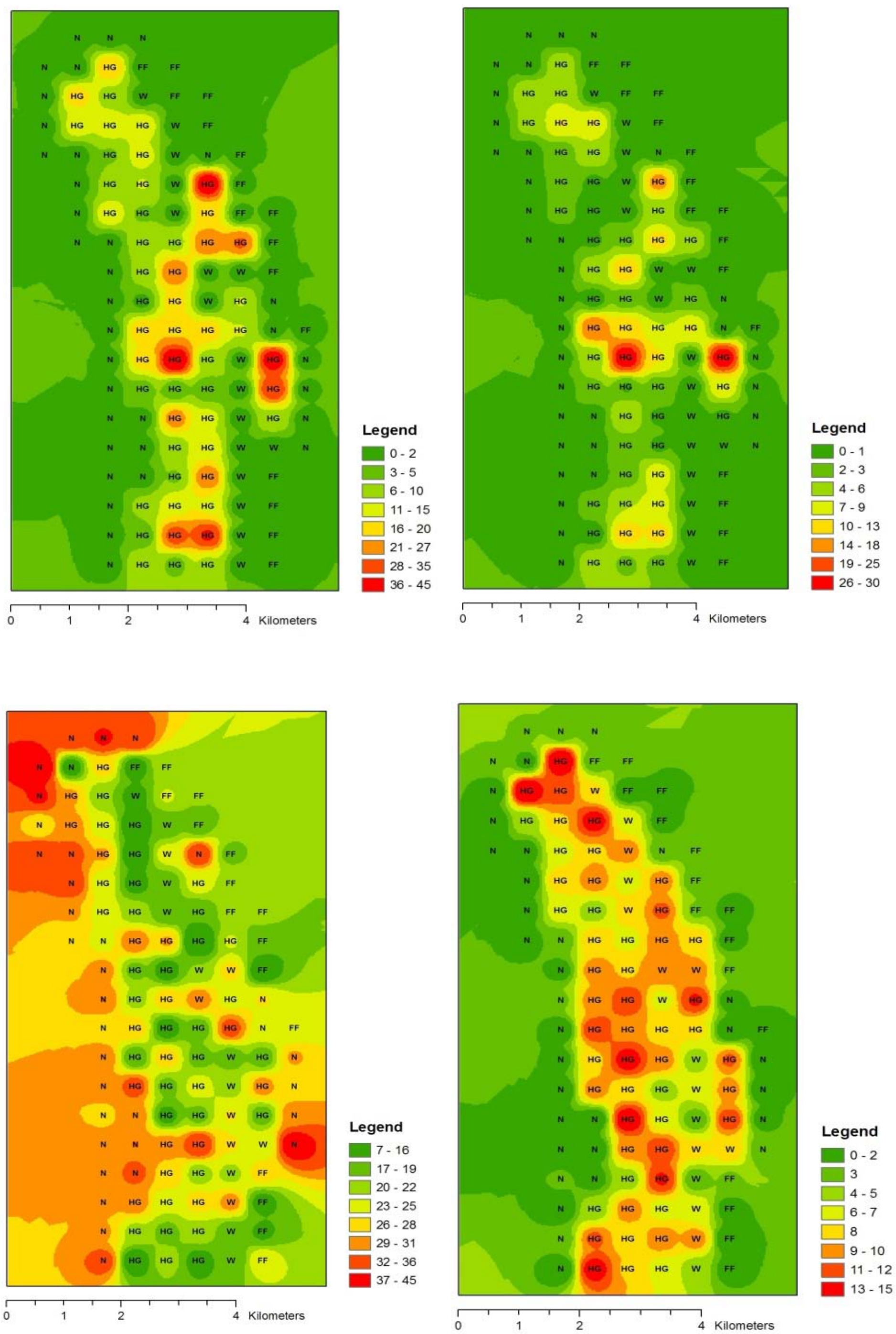
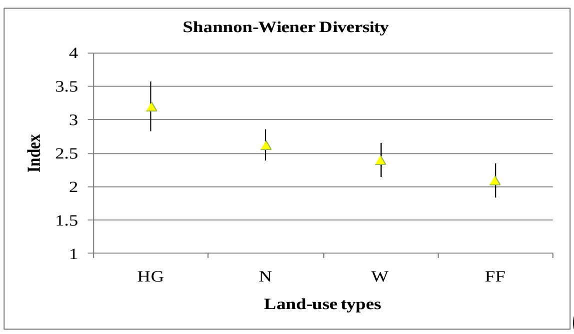


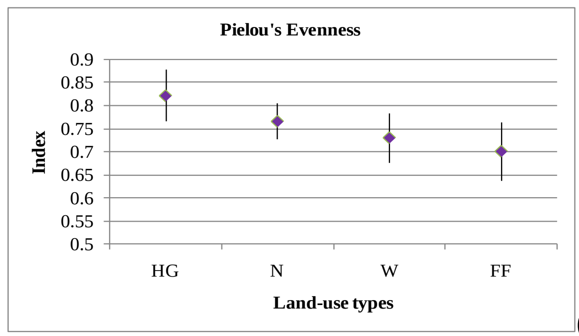
Figure 4.4: IDW for land-use types in Tlhakgameng with species richness of (A) alien cultivated species, (B) indigenous cultivated species, (C) indigenous species, and (D) naturalized species. FF, Fallow fields; HG, Homegardens; N, Natural areas; W, Wetlands. Colour coding represents the number of species per area – see legend.

4.3.2.3 Diversity indices

Diversity indices provide more information about community composition than simply species richness (i.e. number of species present per sample plot), in that they also take the relative abundances of different species per plot into account. Homegardens had the highest Shannon-Wiener Diversity index value of all the land-use types, followed by natural areas, wetlands and fallow fields (Fig. 4.5(A)). Pielou's evenness index showed the exact same trend, but with less variation between the different land-use types (Fig. 4.5(B)). Margalef's species richness index showed great variation between the land-use types indicating that the homegardens had by some margin the highest species richness values in comparison to other land-use types, followed by natural areas, wetlands and fallow fields (Fig. 4.5(C)). Homegardens also had the highest Simpson Index of Diversity of all the land-use types, followed by natural areas, wetlands and fallow fields (Fig. 4.5(D)).



(A)



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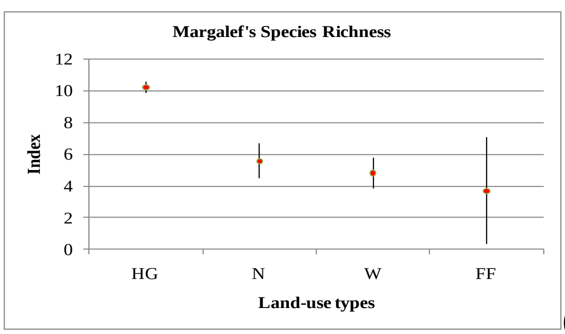
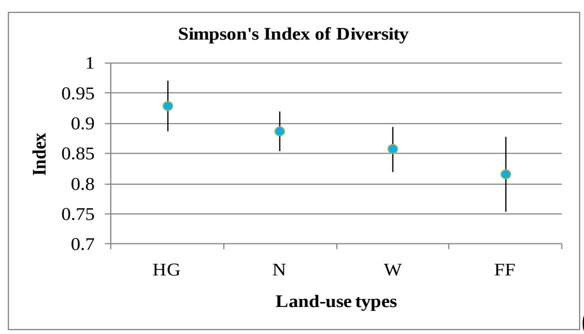


(C)



(D)

Figure 4.5: M ean values of (A) Shannon-Wiener Diversity, (B) Pielou's Evenness, (C) Margalef's Species Richness, and (D) Simpson's Index of Diversity for land-use types of Tlhakgameng. HG, Homegarden; N, Natural area; W, Wetland; FF – Fallow field.

4.3.3 Beta diversity of land-use types

β-diversity represents the turnover of species composition along a geographical or environmental gradient. If there is no change in species composition along the gradient then β-diversity will be low (Primack, 2002). Homegardens were found to have the highest β-diversity in comparison to other land-use types, followed by natural areas, wetlands and fallow fields being the least (Fig. 4.6).

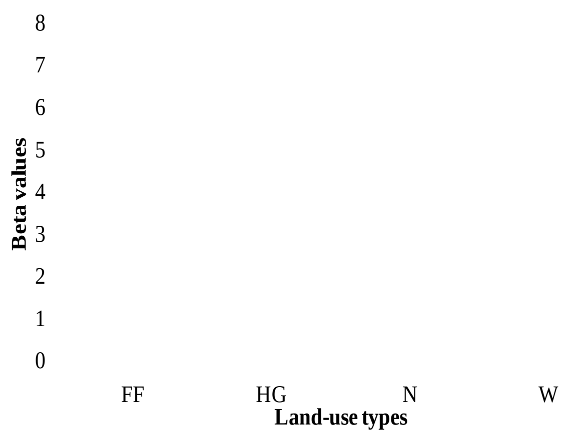


Figure 4.6: β-diversity (γ-diversity/α-diversity) for land-use types of Tlhakgameng. FF, Fallow fields; HG, Homegardens; N, Natural areas; W, Wetlands.

4.3.3.1 Total species

The sample plots of all four land-use types form four clusters in the NMDS ordination (Fig. 4.7) indicating a general dissimilarity (difference) in their total species composition. Some of the sample plots between, natural areas and fallow fields and between wetlands and fallow fields show similar species composition. The stress value of the ordination was lower than 0.2, suggesting a satisfactory ordination and the groupings were clear enough for explanation. Beta diversity results were also confirmed by this ordination. Homegardens, natural areas and wetlands had a higher species turnover (dissimilarity in species composition) between plots than fallow fields, indicated by the plots being scattered more widely on the graph and not forming a tight cluster like the fallow fields (Fig. 4.7).

Fallow fields had therefore a lower species turnover because sample plots are grouped closer together. The different fallow fields are more similar in terms of species composition, thus have a low turnover of species (Fig. 4.7).

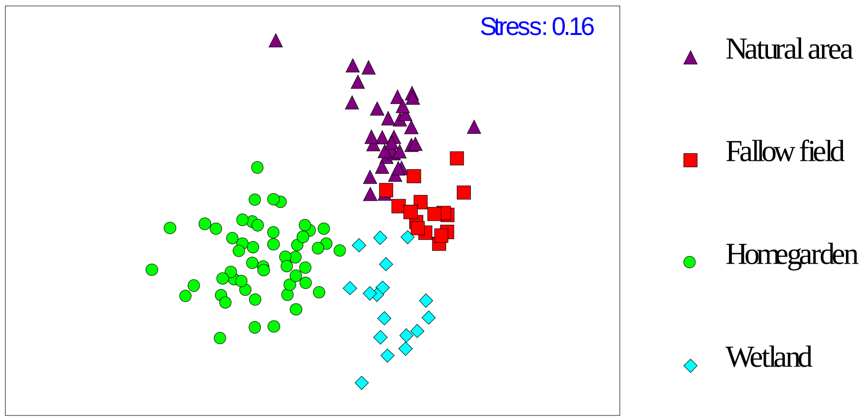


Figure 4.7: NMDS ordination of the total species composition for sample plots of the land-use types of Tlhakgameng (based on the total species diversity, alien and indigenous).

4.3.3.2 NMDS for indigenous species

In terms of species composition of indigenous species, a similar trend was observed than for total species richness. The four different land-use types formed four clusters in the NMDS ordination (Fig. 4.8). Several of the sample plots in different land-use type are more similar in species composition than with sample plots of the same land-use type (Fig. 4.8). The stress value of the ordination for indigenous species was also less than 0.2, meaning that the ordination was satisfactory. As was noted for total species composition the fallow fields have a low turnover of indigenous species which implies low β-diversity. The sample plots of homegardens and natural areas are more scattered, suggesting a higher dissimilarity in species composition. This higher turnover of species implies a higher β-diversity (Fig. 4.8)

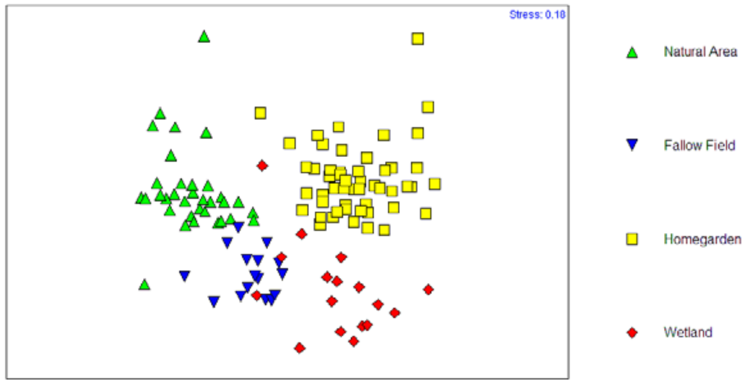


Figure 4.8: NMDS ordination of the indigenous species assemblages of the sampled plots for land-use types in Tlhakgameng.

4.3.3.3 NMDS for naturalized species

In comparison with total species and indigenous species, it was only the homegardens which formed a clear cluster in the NMDS ordination based on naturalized species (Fig. 4.9). The fact that the sample plots of homegardens were grouped close together, indicating that they are similar in terms of species composition, thus have a low turnover of species which implies low β-diversity. Dissimilarity in species composition of sample plots of natural areas, wetlands and fallow fields are suggested by their wide scattering. They have a high turnover of species which implies a high β-diversity. The stress value of the ordination was less than 0.2 indicating a satisfactory numerical outcome (Fig. 4.9).

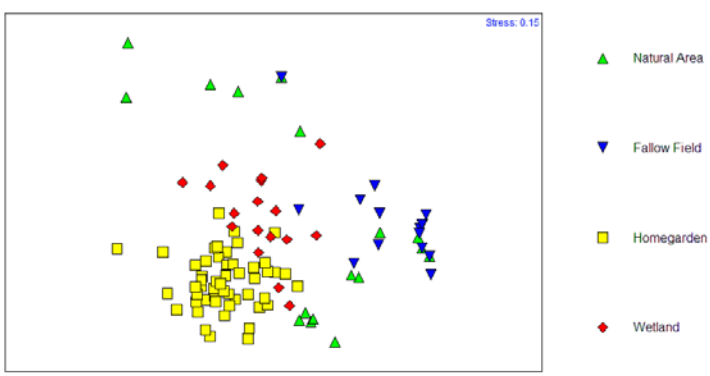


Figure 4.9: NMDS ordination of the naturalized species assemblages of the sample plots for land-use types in Tlhakgameng.

4.4 Discussion

Different land-use types were compared in terms of gamma (γ), alpha (α) and beta (β) diversity. Homegardens were found to have the highest α-, β- and γ-diversity in comparison to other land-use types. In Germany, species richness was found to be significantly higher in urbanized than agricultural or semi-natural areas (Knapp *et al.*, 2008). Similarly, our study recorded the highest γ-diversity inside the settlement, i.e. in homegardens rather than in natural areas, wetlands and fallow fields. Homegardens had the highest α- diversity as this land-use was represented by anthropogenically enhanced variety within sample plots. The result was expected based on the findings of Marco *et al*. (2008) that natural areas were mostly dominated by indigenous species, while the flora inside gardens was enhanced by a high number of cultivated indigenous, alien and naturalized species.

A study by Shackleton (2000) assessed β-diversity between protected and communal land in the Bushbuckridge lowveld savanna and determined that there was no difference between treatments along the primary environmental gradient present in the study area. However, the land-use types in this study were not surveyed along a direct environmental gradient. Indirectly, there was a difference in β-diversity between heavily and moderately disturbed areas, with natural areas having higher β-diversity than fallow fields and wetlands. A decrease in species diversity may be due to disturbance, i.e. over-harvesting of selected useful species by people from the communal land or overgrazing by animals. Furthermore, Shackleton *et al*. (1994) mentioned that disturbance had a significant impact on community structure and species composition, which was evident in our study as the turnover in species composition of homegardens was high in comparison to fallow fields, natural areas, and wetlands. The study of Lubbe *et al*. (2010) found that socio-economic factors also have an effect on vegetation patterns and species richness was shown to be driven by socio-economic status and cultural factors.

Furthermore, floristic diversity of urban areas is partly dominated by ruderal species which are mainly aliens introduced by gardeners, landscape managers and farmers over a period of time (Vincent & Bergeron, 1985). 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). Studies of Deutschewitz *et al*. (2003) and Kühn and Klotz

(2006) found that urban areas are capable of supporting both high indigenous and alien species richness. Similarly in Tlhakgameng, a rural settlement, homegardens inside the settlement were found to support a wide variety of both alien and indigenous species. The study of Deutschewitz *et al*. (2003) showed that natural areas, gardens, parks and wetlands can increase indigenous species richness at the landscape level. The Tlhakgameng study found that not only natural areas on the periphery of the settlement, but also homegardens inside the settlement have higher indigenous (native) species diversity in comparison to other land-use types such as wetlands and fallow fields. Homegardens had the highest total indigenous species richness, due to human interventions (cultivation of indigenous species) or the persistence of indigenous species within yard remnants of natural areas.

Clemants and Moore (2003) mentioned that the longer period that the city has existed, then the more successful establishment of aliens, which was also seen in our study majority of participants were found to cultivate ornamentals which were mainly aliens. Homegardens had the highest total number of species (γ-diversity), natural areas had the second highest number of species in Tlhakgameng. The higher total species diversity of homegardens can be explained by the increased numbers of alien and naturalized species that are cultivated or introduced by residents, while natural areas have low alien species richness and are mainly dominated by indigenous species.

NMDS was analysed which also measures β-diversity. NMDS was analyzed based on naturalized species, indigenous species and total species for all land-use types. NMDS for alien cultivated and indigenous species could not be analyzed because of many zeros between the sample plots. IDW was used to analyse four land-use types based on alien cultivated species, indigenous cultivated species, indigenous species and naturalized species. Diversity indices provide more information about community composition. The following indices were analysed Shannon-Wiener Diversity Index, Pielou's Evenness Index, Margalef's Species Richness Index and Simpson Index of Diversity was measured for al land-use types. Diversity indices provide more information about community composition Shannon-Wiener Diversity Index, Pielou's Evenness Index, Margalef's Species Richness and Simpson Index of Diversity was measured for all land-use types.

For all indices, homegardens were found to have higher values in comparison to other land-use types, followed by natural areas, wetlands and fallow fields. Shannon-Wiener Diversity Index decreases if a single species dominates, even if the overall species richness might be high (Drescher, 1998). Domination by a single species in homegardens hardly occurs due to the availability of a wide variety and the preference of choice exhibited by the gardener. Pielou's Evenness explains how evenly the individuals are distributed among different species, with disturbed, unmaintained areas such as fallow fields having the lowest evenness – dominated by one or a few species only. Margalef's Species Richness is weighed towards species richness and Simpson's Index towards species abundance, hence the trend mimics what was found for the Shannon and Pielou values.

There was low turnover in species composition between plots for natural areas, wetlands and fallow fields resulting in low β-diversity. β-diversity for homegardens was found to be higher in comparison to other land-use types. This can be ascribed to the gardens being intensively managed and choice of plants plays an important role to amplify the establishment of species. This is in accordance with the findings of Lubbe *et al*. (2010) that urban domestic gardens have a higher α-, β- and γ- diversity than other land-use types on a local scale. However, the naturalized species of sample plots in homegardens have shown low β-diversity. This is because there is only a limited species pool of alien ruderals able to colonize gardens. Natural areas, wetlands and fallow fields had higher β-diversity in terms of the naturalized species assemblages which are determined by the type and intensity of the disturbance.

Homegardens are managed by their owners, suggesting that their choices and perceptions determine which species are planted, cultivated or removed. The choice of species for cultivation depends upon the preferences, alimentary, aesthetic, medicinal and it is also related to socioeconomic and cultural factors (Blanckaert *et al*., 2004). Homegardens contributed greatly towards urban floristic diversity, even though they are characterized by alien and naturalized species of which the majority is ornamental flora or naturalized weeds. Kent *et al*. (1999) has shown that different land-use types in urban areas influence plant species composition and patterns.

4.5 Summary

The main objective of this chapter was to compare homegardens with other land-use types (fallow fields, natural areas and wetlands) in terms of γ-, α- and β-diversity. Other objectives were to compare land-use types in terms of species composition and patterns of plant species richness. The results of this study confirmed that homegardens had higher species richness in comparison to other land-use types. Gamma, α- and β-diversity for homegardens were found to be higher in comparison with other land-use types. Similarly, the study of Lubbe *et al*. (2010) found that the urban domestic gardens had a higher α-, β- and γ-diversity in comparison to other land-use types on a local scale. In contrast, the study of Smith *et al*. (2006c) indicated that the α-diversity of homegardens and natural areas are similar, but our results concur with Kent *et al*. (1999) that residential areas tends to have a higher α- diversity than natural areas. The difference is due to the high level of human intervention in homegardens, whereother land-use types are characterized by a low level of human intervention. It was further aimed to determine the plant species composition, patterns of plant species richness and also to determine to what extend does homegardens contribute towards floristic diversity of a rural settlement. Patterns of species richness are clearly indicated on IDW maps, while a difference in species composition is illustrated by means of NMDS ordinations. The results of this study are preliminary and cannot be used to establish any general pattern for the North-West Province.

This study shows that rural homegardens exhibit a wider cultivated species diversity in comparison to other land-use types, which was also found by Marco *et al*. (2008) even though no comparison was made with other land-use types. Homegardens are characterized by a high level of species richness and a strong heterogeneity probably linked to the individualism of different cultures. The increasing urbanization of rural areas has led to a strong development of the garden flora, which is the main source of alien and invasive plants. This supports the hypothesis that plant diversity patterns of rural settlements are dependent on the type of land-use and homegardens have the highest diversity. Chapter 5 attempts to make sense of the richness behind the patterns, with special emphasise on homegardens. More research is also needed to clarify the patterns of different land-use types in a rural settlement and to determine factors such as socio-economic conditions that influence these patterns. According to McKinney (2006), urban conservation should therefore focus on promoting preservation and restoration of local indigenous, instead of alien species. Awareness of gardeners and consumers about the nutritional and cultural value of indigenous species should be increased.

Chapter 5

Floristic composition of a rural settlement: expanding our knowledge of a poorly sampled region

5.1 Introduction

According to Tilman (2000), biodiversity has long since been a source of scientific interest and has been identified as one of the key indices of sustainable land-use practices, and considerable resources are expended to identify and implement strategies that will reverse the current declines in biodiversity at local, regional and international scales. Most nations are signatories to the 1993 International Convention on Biological Diversity (McNeely, 1995). Despite this action, worldwide, species diversity has noticeably been reduced within many different habitats due to human domination of the Earth's ecosystems (Tilman, 2000). Wilcove *et al.* (1998) stated that biologists agree that humanity is in the process of completely destroying an important portion of the Earth's species. Several human activities that threaten biodiversity were identified by Wilcove *et al*. (1998) and McKinney (2006), the major threat being habitat loss, closely followed by the spread of alien species and the most recent threat being human induced climate change (Hannah *et al*., 2004).

Of the three major threats, spread of alien species is generally associated with horticulture (Henderson, 2001). The introduction of alien species in urban areas is influenced mainly by people's desire to cultivate the horticultural flora, which is mostly alien and invasive species, or as an unintentional by-product of cultivation (Wilcove *et al.*, 1998, Miller, 2005, McKinney, 2006, Marco *et al*., 2008). The major contributor to the diversity of urban environments is horticultural floras which are mostly characterized by ornamental plants and vegetables (Gaston *et al*., 2005, Marco *et al*., 2008). According to Gaston *et al.* (2005), a large proportion of "green space" in urban areas is represented by domestic gardens and residential areas which are of potential importance for the maintenance of biodiversity in such areas (Smith *et al*., 2005, Thompson *et al*., 2005, Smith *et al*., 2006).

The importance of homegardens studies especially the value of gardens for the protection of species has now been realised (e.g. Kumar & Nair, 2004). Homegardens are regarded as important sites of conservation for a large diversity of plants, both wild and domesticated, because of their uses to the household (Das & Das, 2005). In many countries, homegardens are considered traditional agroforestry systems used for the cultivation of a diverse and stable supply of socio-economic products (Das & Das, 2005). In South African cities, urban agriculture is seen as an increasingly major means of supplementing incomes (May & Rogerson, 1995). The study done by High and Shackleton (2000) revealed that rural inhabitants make substantial use of wild resources from communal areas around their settlement, as well as from arable and residential plots.

Regardless of the enormous knowledge that is available on the alien floras of urban environments, this feature has never been quantified for South African cities. The effect of socio-economic status of residents on useful plants and their management will be explained in chapter 7. The main aim of this chapter is to determine and analyse the floristic composition of Tlhakgameng to provide a baseline for comparitive urban floristic studies of larger or culturally different urban areas. The objectives of this study were to provide a first total floristic survey of the vegetation of a typical, historically disadvantaged settlement, namely to (i) asses the dominant families and abundant species, (ii) determine the degree to which threatened, endemic and invasive species occur, (iii) compare the growth forms of species for all land-use types, (iv) determine the origin of alien cultivated and naturalized species and, (v) document the useful plant diversity in the study area. Additionally, the comparison of the garden flora with the flora of other land-use types in the settlement will shed light on the contribution that domestic gardens make towards the plant diversity of the study area.

5.2 Materials and Methods

5.2.1 Vegetation survey

As explained in Chapter 4, Geographic Information System (GIS) techniques (Esri, 2006) were applied by overlaying a grid over the Tlhakgameng region with points 500 m apart. This approach was followed to allow for more detailed analysis of biodiversity data in other chapters. A grid with a total of 118 sample points were placed over the different land-use types (Table 5.1). For the purpose of the plant survey, a plot of 20 x 20 m was placed at each sample point. Presence-absence data collected for each of the plots was used to determine and analyse the floristic composition of Tlhakgameng. Even though frequency data was collected, it was not used in this chapter. For analysis of frequency data along a socio-economic gradient, refer to Chapter 7.

Table 5.1: Number of sample points within each land-use type of Tlhakgameng.

Land-use types	**Number of plots**
Fallow fields	16
Homegardens	51
Natural areas	34
Wetlands	17

5.2.2 Data analysis

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

5.2.3 Herbarium specimens

Tlhakgameng is a floristically under-sampled area according to a 2007 historical collection map of the North-West Province (Fig. 5.1) created with the Pretoria Computerised Information System (PRECIS) (Bester *et al*., 2008). During the survey, voucher specimens were collected and identified by comparing them with herbarium specimens in the AP Goossens (PUC) herbarium. Each specimen was collected in duplicate and the duplicates species were deposited in the Pretoria National Herbarium (PRE) for name verification.

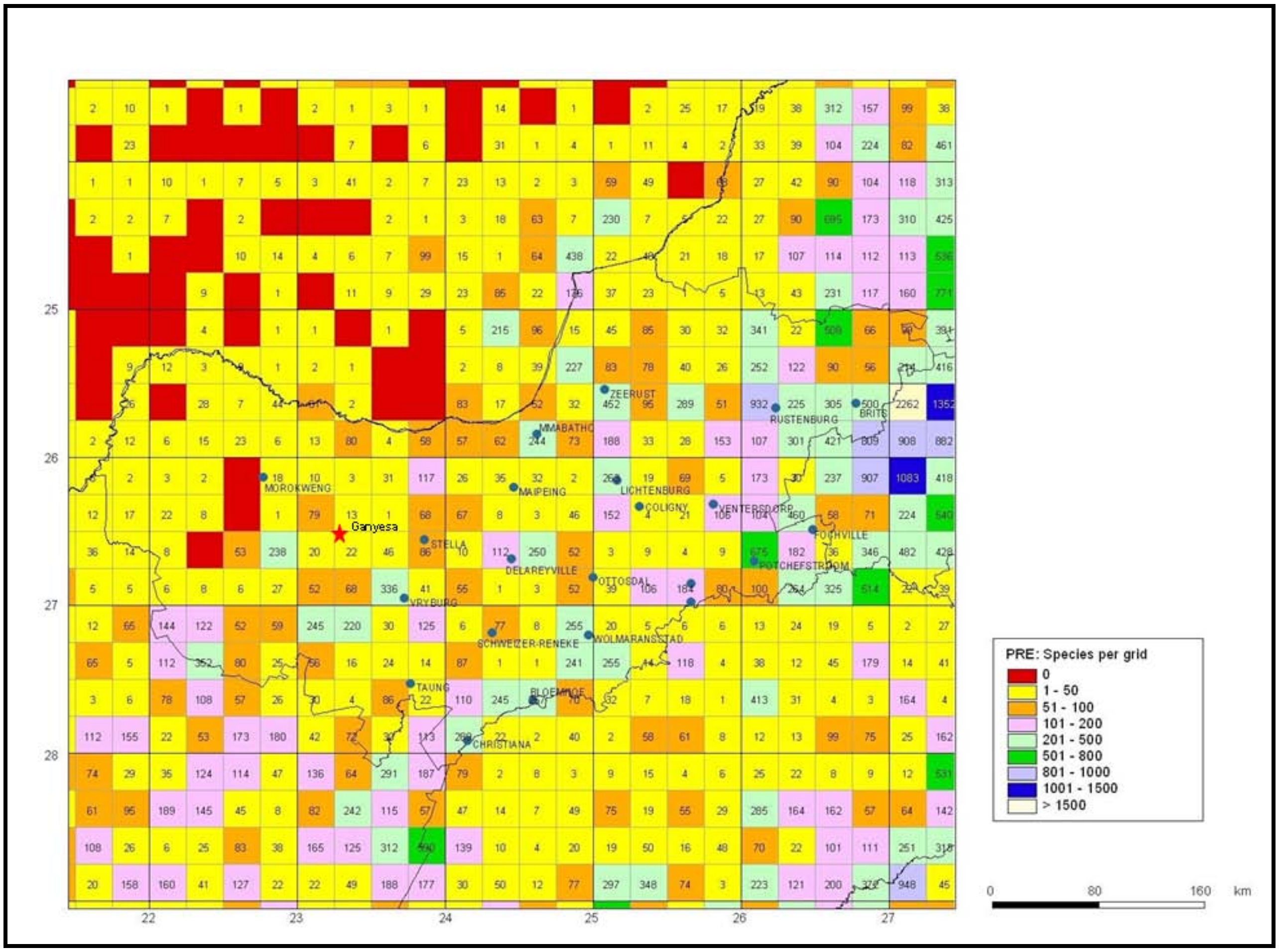


Figure 5.1: PRECIS map of voucher specimen collections per grid for the North-West Province (Bester *et al*., 2008).

5.3 Results

5.3.1 Twenty dominant families

A total of 96 plant families were recorded for all land-use types in Tlhakgameng, representing 460 species. These families comprise the following, 201 indigenous (44%), 146 alien cultivated (32%), 60 indigenous cultivated (13%) and 53 naturalized (11%) species. The twenty most dominant families represent 291 species (63%) of the total number of species recorded (Table 5.2). Families found to have the highest number of taxa were the Asteraceae, Fabaceae and Poaceae which are amongst the top ten largest South African plant families (Table 5.3). The Poaceae which is the third largest in the study area is only the seventh largest family in South

Africa (Table 5.3). Dominance of families was determined by number of species from each family and not the frequency of occurrence of species. The dominant families of the study area contained many garden genera that are extensively cultivated (e.g. Asteraceae – *Tagetes patula*; Fabaceae – *Vigna unguiculata*; Poaceae – *Cynodon dactylon* and *Zea mays*; Lamiaceae – *Vitex trifolia*; Rosaceae – *Prunus persica*).

Table 5.2: Twenty most dominant families for Tlhakgameng based on the number of species per family. The contribution of each family towards the total species pool in Tlhakgameng is expressed as a percentage. The five families that are also ranked under the top ten for South Africa are indicated with their position in superscript.

Families	**Number of species**	**Species %**
Asteraceae[1]	59	13
Fabaceae[2]	43	9
Poaceae[7]	41	9
Solanaceae	14	3
Crassulaceae	12	3
Lamiaceae	11	2
Cactaceae	10	2
Malvaceae	10	2
Mesembryanthemaceae[3]	10	2
Amaranthaceae	9	2
Hyacinthaceae	8	2
Sterculiaceae	8	2
Rosaceae	8	2
Verbenaceae	8	2
Asphodelaceae[9]	7	2
Apocynaceae	7	2
Chenopodiaceae	7	2
Cucurbitaceae	7	2
Convolvulaceae	6	1
Cyperaceae	6	1

Table 5.3: Ten most dominant families 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 5.4: The ten most dominant genera for Tlhakgameng based on number of species per genus.

Genus	Number of species	Family
Eragrostis	9	Poaceae
Acacia	8	Fabaceae
Aloe	5	Asphodelaceae
Solanum	5	Solanaceae
Ipomoea	5	Convolvulaceae
Indigofera	5	Fabaceae
Amaranthus	4	Amaranthaceae
Euphorbia	4	Euphorbiaceae
Aristida	4	Poaceae
Asparagus	4	Asparagaceae

5.3.2 Dominant genera

In total, 302 genera were recorded for all land-use types in Tlhakgameng. The ten most dominant genera represent 11% of the total number of recorded species for all land-use types. The ten dominant genera mostly belong to the twenty largest families found in Tlhakgameng, except for the genera *Euphorbia* and *Asparagus* in the family Euphorbiaceae and Asparagaceae respectively. The Poaceae and Fabaceae are represented the most by the ten dominant genera in the study area. Six (11%), of the 53 species representing the ten most dominant genera of Tlhakgameng, were found to be alien to South Africa (Fig. 5.4).

5.3.3 Twenty dominant species

The twenty plant species that occurred most frequently were all present in more than half of all plots (Table 5.5). *Cynodon dactylon* was ranked as the most frequently recorded species as it occurred in 86% of sampled plots for all land-use types. Another grass species, *Eragrostis lehmanniana*, had the second highest frequency (75%). Three remaining species of the top five were a shrub species *Acacia hebeclada* (75%), the geophyte *Bulbine abyssinica* (72%) and the herbaceous species *Felicia muricata* (69%). Quarter of the twenty most abundant species are naturalized in South Africa (3) or cultivated (2), while fifteen are indigenous and occurring naturally. The twenty most abundant species mainly belong to the Poaceae (six species) and Asteraceae (four species).

Table 5.5: The twenty most dominant species recorded for all land-use types in Tlhakgameng based on frequency of occurrence (the percentage of sample sites in which the species was recorded). *, naturalized; **, cultivated.

Species name	**Families**	**No. of sample plots**	**Plots %**
*Cynodon dactylon***	Poaceae	101	86
Acacia hebeclada	Fabaceae	89	75
Eragrostis lehmanniana	Poaceae	88	75
Bulbine abyssinica	Asphodelaceae	85	72

Species name	Families	No. of sample plots	Plots %
Felicia muricata	Asteraceae	82	69
Senna italica	Fabaceae	77	65
*Guilleminea densa**	Amaranthaceae	70	59
Eragrostis trichophora	Poaceae	63	53
Schmidtia pappaphoroides	Poaceae	62	53
*Schkuhria pinnata**	Asteraceae	55	47
Hermannia tomentosa	Sterculiaceae	55	47
Portulaca quadrifida	Portulacaceae	47	40
Aristida diffusa	Poaceae	44	37
Heliotropium lineare	Boraginaceae	42	36
Tarchonanthus camphoratus	Asteraceae	42	36
Harpagophytum procumbens	Pedaliaceae	34	29
*Dodonaea viscosa***	Sapindaceae	33	28
*Portulaca oleracea**	Portulacaceae	33	28
Tragus koeleroides	Poaceae	30	25
Pentzia globosa	Asteraceae	25	21

5.3.4 Endemic species

A total of 27 species endemic to South Africa were recorded at Tlhakgameng (Table 5.6). The majority of these species were commonly cultivated except for five naturally occurring species, namely *Crabbea angustifolia*, *Eragrostis pseudo-obtusa*, *Hypertelis arenicola*, *Selago mixta* and *Sida spinosa*. *Carpobrotus edulis* occurred most frequently in 12% of sampled plots from all land-use types, *Sida spinosa* in 10%, and *Selago mixta* had the highest number of individuals amongst all but occurred only in 9% of the sampled plots (Table 5.6). *Aptenia cordifolia* and *Tulbaghia violacea*, two cultivated indigenous species, had the highest number of individuals, but both only occurred in 4% of the sampled plots for all land-use types. The remaining species occurred in less than 4% of the sampled plots for all land-use types.

Table 5.6: A list of South African endemic species found in Tlhakgameng, as well as their families, number of individuals, and the number of sample sites in which they were found. **, cultivated.

Species name	**Families**	**Total number of individuals**	**Plot %**
*Carpobrotus edulis***	Mesembryanthemaceae	15	12
Sida spinosa	Malvaceae	13	10
Selago mixta	Scrophulariaceae	146	9
*Portulaca grandiflora***	Portulacaceae	13	8
*Ruschia perfoliata***	Mesembryanthemaceae	7	6
*Malephora crocea***	Mesembryanthemaceae	6	5
*Crassula capitella***	Crassulaceae	7	5
*Cyperus textilis***	Cyperaceae	6	5
*Aloe striata***	Asphodelaceae	5	4
*Aptenia cordifolia***	Mesembryanthemaceae	10	4
*Tulbaghia violacea***	Alliaceae	8	4
*Kalanchoe longiflora***	Crassulaceae	3	3
*Lampranthus roseus***	Mesembryanthemaceae	3	3
*Senecio scaposus***	Asteraceae	4	3
*Tulbaghia natalensis***	Alliaceae	4	3
*Plectranthus penteri***	Lamiaceae	4	3
*Euryops chrysanthemoides***	Asteraceae	3	2
*Tulbaghia simmleri***	Alliaceae	2	2
*Crassula ovata***	Crassulaceae	2	2
Hypertelis arenicola	Molluginaceae	4	1
*Plectranthus saccatus***	Lamiaceae	1	1
*Aloe striatula***	Asphodelaceae	1	1
*Dimorphoteca eckloni***	Asteraceae	1	1
Eragrostis pseudo-obtusa	Poaceae	1	1
Crabbea angustifolia	Acanthaceae	1	1
*Agapanthus praecox***	Agapanthaceae	1	1
*Lampranthus glaucus***	Mesembryanthemaceae	1	1

5.3.5 Endangered and protected species

According to the South African Red Data List (Raimondo *et al*., 2009), eight species recorded from Tlhakgameng have a threat status, which includes species listed as declining (5), near threatened (2) and vulnerable (1). The most common of these were *Drimia sanguinea* (near threatened) occurring in 71% of all land-use types, while *Acacia erioloba* (declining and protected) occurred in only 36% and *Cotyledon orbiculata* (23%) (near threatened). The occurrence of all the remaining species was less than 10% for all sample plots (Table 5.7).

Table 5.7: Species recorded from Tlhakgameng that are threatened in the current South African Red Data List (Raimondo *et al*., 2009).

Taxon name	**Natural/Indigenous cultivated**	**National status**
Acacia erioloba	Natural	Declining (Protected)
Boophane disticha	Natural	Declining
Crinum bulbispermum	Natural	Declining
Eucomis autumnalis	Indigenous cultivated	Declining
Hypoxis hemerocallidea	Indigenous cultivated	Declining
Cotyledon orbiculata	Indigenous cultivated	Near Threatened
Drimia sanguinea	Natural	Near Threatened
Lampranthus glaucus	Indigenous cultivated	Vulnerable

5.3.6 Useful cultivated flora

The majority of species cultivated in homegardens were ornamentals (57%), 21% food and 8% shade, while hedge and medicinals both contributed 7%. Dominant useful species in homegarden plots include *Eleusine coracana* – food, *Casuarina cunninghamiana* – hedge, *Achillea millefolium* – ornamental, *Nicotiana tabacum* – medicinal and *Celtis sinensis* – shade (Fig. 5.2).

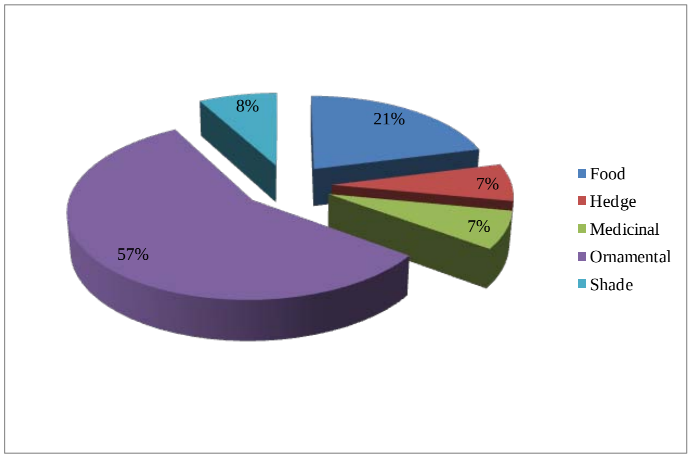


Figure 5.2: Proportion of total useful plant flora contributing to each plant use category for both alien and indigenous species cultivated in homegardens of Tlhakgameng.

5.3.7 Origin status of Tlhakgameng flora

The largest portion of the species found in all land-use types of the study area does not occur naturally in South Africa (56% of the species). This large proportion includes 32% alien cultivated, 13% indigenous cultivated and 11% naturalized species (Germishuizen *et al*., 2006), mostly associated with homegardens. Of the remaining 44% naturally occurring indigenous species, most are widespread species that occur in more than eight of the 13 regions specified in Germishuizen *et al.* (2006). Widespread species contribute greatly towards the flora in all land-use types, namely 180 species (39%), probably as they have less specific environmental preferences. Most of the cultivated indigenous species (75) was contributed by the flora of the Eastern Cape and KwaZulu-Natal (Coastal provinces). These two provinces are amongst those with the highest annual rainfall for South Africa (Department of Environmental Affairs and Tourism, 1999). The other regions which also contributed to the homegarden flora of

Tlhakgameng were as follows: Mpumalanga (32), Limpopo (31), Gauteng (27) and North-West (24). Two regions (Northern and Western Cape) made small contributions.

5.3.8 Origin status of alien cultivated and naturalized species

From the 51 sampled plots of homegardens, the majority of alien cultivated species (21%) were found to originate from Asia with only 4% of naturalized species. Asia was found to constitute a higher proportion of alien cultivated species as compared to others. The second highest was South America with 15% of alien cultivated species and 41% of naturalized species (the highest). Central and North America followed by 13% of alien cultivated species, with 21% and 11% of naturalized species respectively. All the remaining origins were found to be less than 10 % for alien cultivated species. Europe contributed 12% naturalized species and North America 11%. The remaining origins contributed less than 10% naturalized species (Fig.5.3).

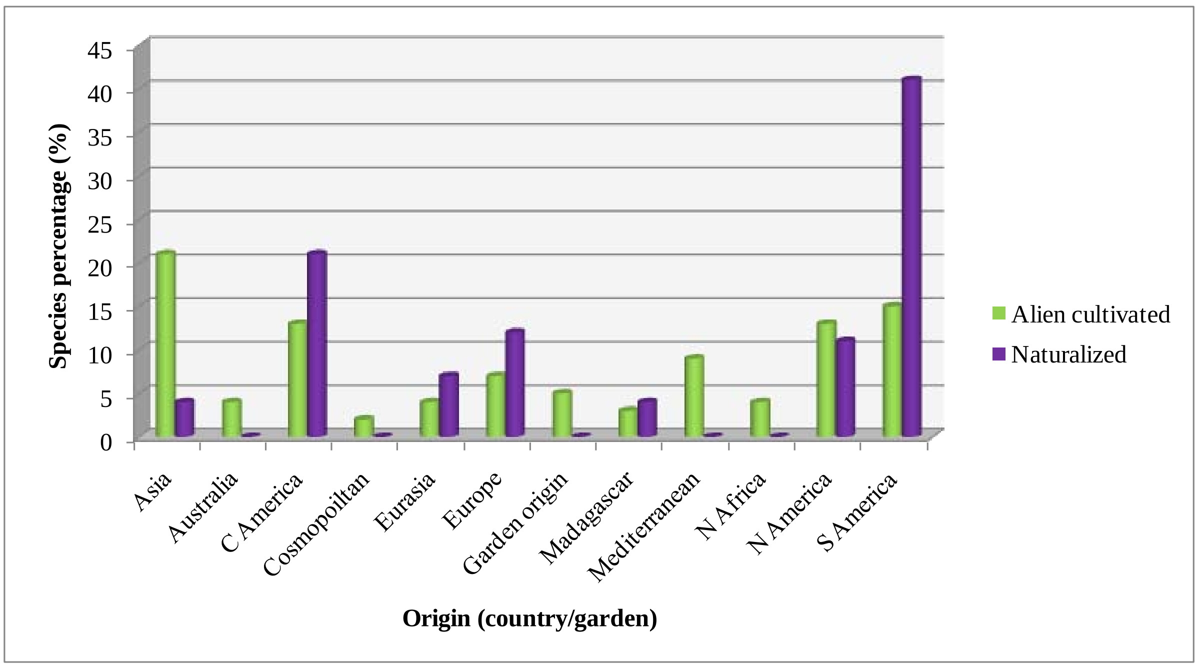


Figure 5.3: Origin of the alien cultivated and naturalized flora in Tlhakgameng homegardens.

5.3.9 Invasive species

Apart from the substantial utilisation, maintenance and conservation of plant diversity taking place in gardens there are also some negative aspects, in terms of the occurrence of invasive alien species. In all land-use types sampled, 40 declared invader and weed species were found (Table 5.8) (Henderson, 2001). Category 1 declared weeds had the highest number of species (21) and included, amongst others, *Nerium oleander* which occurred in 19% of the sampled plots. This was followed by Category 3 declared invaders (10 species) such as *Morus alba* (24% of the sampled plots). *Cynodon dactylon,* which has shown the highest occurrences (86%) of all species, was one of the 9 species which was classified as Category 2 declared invaders.

Table 5.8: Declared/proposed invaders and weeds (Henderson, 2001). Category 1- declared weed, 2 – declared invader, 3 – declared invader; **, cultivated.

Species name	**Type**	**Category**
Achyranthus aspera	Weed	1
*Anredera cordifolia***	Weed	1
*Arundo donax***	Weed	1
*Bryophyllum delagoense***	Weed	1
*Cereus jamacara***	Weed	1
*Canna indica***	Weed	1
Datura ferox	Weed	1
Datura stramonium	Weed	1
*Echinopsis spachiana***	Weed	1
*Lantana camara***	Weed	1
*Nerium oleander***	Weed	1
Nicotiana glauca	Weed	1
*Opuntia ficus-indica***	Weed	1
Opuntia imbricata	Weed	1
Opuntia spinulifera	Weed	1
*Pennisetum setaceum***	Weed	1
*Rosa rubiginosa***	Weed	1

Table 5.8: continued

Species name	**Type**	**Category**
Solanum elaeagnifolium	Weed	1
*Tecoma stans***	Weed	1
Xanthium spinosum	Weed	1
Xanthium strumarium	Weed	1
*Acacia decurrens***	Invader	2
*Atriplex nummularia***	Invader	2
*Casuarina cunninghamiana***	Invader	2
*Cynodon dactylon***	Invader	2
*Gleditsia triacanthos***	Invader	2
*Leucaena leucocephala***	Invader	2
*Prosopis glandulosa***	Invader	2
*Robinia pseudoacacia***	Invader	2
*Salix babylonica***	Invader	2
*Ailanthus altissima***	Invader	3
*Berberis thunbergii***	Invader	3
*Grevillea robusta***	Invader	3
*Ipomoea purpurea***	Invader	3
*Jacaranda mimosifolia***	Invader	3
*Ligustrum lucidum***	Invader	3
*Melia azedarach***	Invader	3
*Mirabilis jalapa***	Invader	3
*Morus alba***	Invader	3
*Schinus molle***	Invader	3

5.3.10 Growth forms

The most abundant growth form found in all land-use types was forbs, with homegardens ranking the highest as compared to other land-use type with 168 species, followed by natural areas with 78, wetlands with 64 and fallow fields with 36 species (Fig. 5.4). Dominant forb species recorded in all land-use types were *Felicia muricata* which occurred in 69% of the sample plots, while *Senna italica* occurred in 65% of the sample plots.

The second most abundant growth form was shrubs, where homegardens also ranked high in comparison with other land-use types with 82 species, natural areas with 35, wetlands with 25 and fallow field with 15 species (Fig. 5.4). Dominant shrub species for all land-use types were *Acacia hebeclada* occurring in 75% of the sample plots and *Tarchonanthus camphoranthus* in 36% of the sample plots.

The third most abundant growth form was trees, with homegardens having 60 species, natural areas with 18, wetlands with 14 and fallow fields with 5 species (Fig. 5.4). Dominant tree species recorded for all land-use types were *Prunus persica* occurring in 31% of the sample plots and *Acacia karoo* in 14% of the sample plots. The remaining growth forms (succulents, graminoids, geophytes and climbers) were also best represented in homegardens (Fig. 5.4). Dominant species for these growth forms in sample plots were as follows: succulents – *Portulaca quadrifida* (40%) and *Portulaca oleracea* (28%); graminoids – *Cynodon dactylon* (86%) and *Schmidtia pappaphoroides* (53%); geophytes – *Bulbine abyssinica* (72%) and *Harpagophytum procumbens* (29%); climbers – *Citrillus lanatus* (19%) and *Vitis vinifera* (16%).

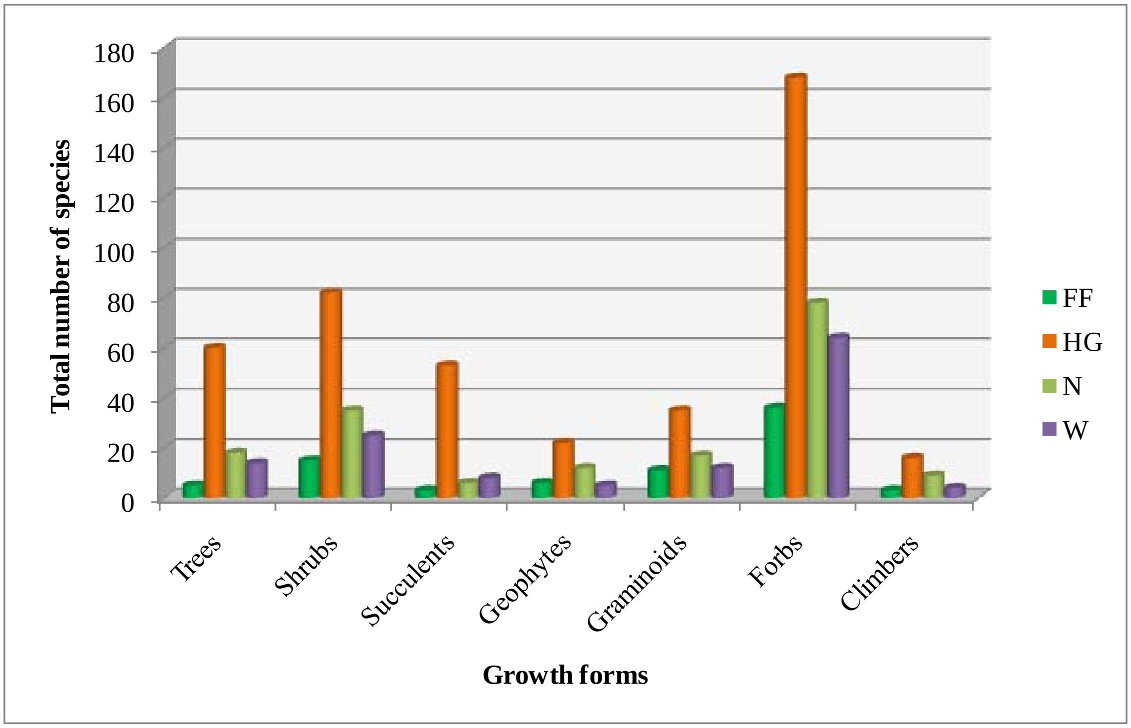


Figure 5.4: Total number of species per growth form for each of the four land-use types in Tlhakgameng. FF, Fallow field; HG, Homegarden; N, Natural area; W, Wetland.

5.3.11 Total species diversity

The total number of species and the numbers of alien cultivated, indigenous cultivated, indigenous and naturalized species were compared between land-use types (Figure 5.5). In comparison to other land-use types, homegardens were found to have rich species diversity for alien and indigenous cultivated, and naturalized species. However, natural areas were found to have the highest number of indigenous species as compared to other land-use types. In homegardens, alien cultivated species were found to be the most dominant as compared to others followed by indigenous species. Naturalized species found in homegardens were the low as compared to indigenous cultivated ones, but still the highest for the study area (Fig 5.5). Wetlands and fallow fields were found to have the least number of indigenous species as compared to other land-use types, however wetlands had more naturalized species than natural areas and fallow fields.

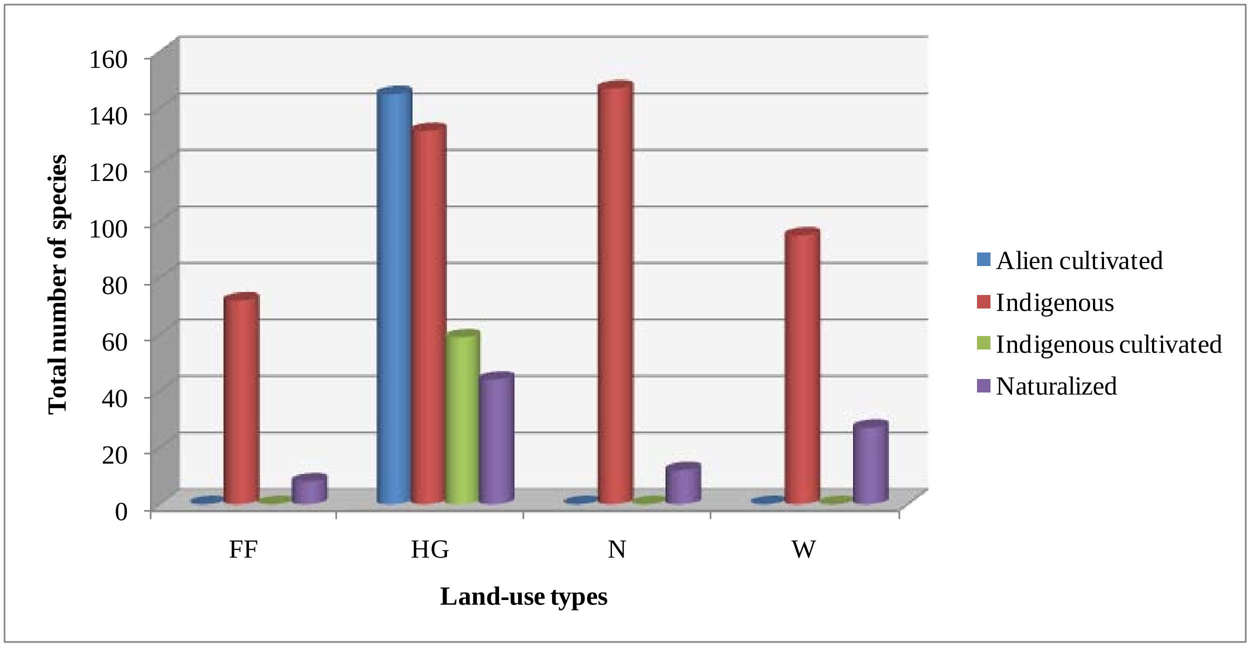


Figure 5.5: Comparison of the composition of the total species richness of four different land-use types in Tlhakgameng.

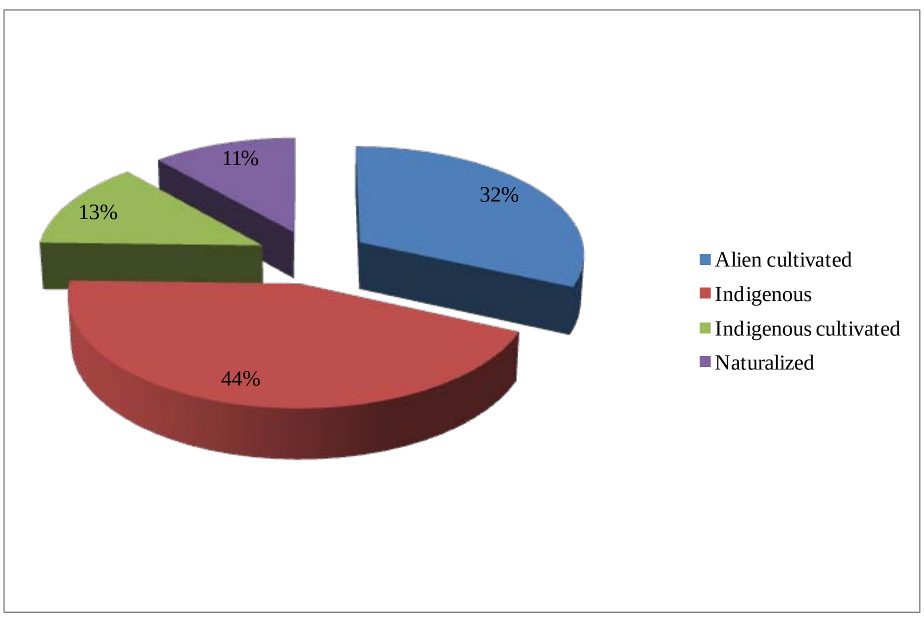


Figure 5.6: The total species richness of 460 species divided up as alien cultivated, indigenous, indigenous cultivated and naturalized.

5.3.12 Species richness of homegardens

In comparison to the other land-use type, homegardens had the largest number of alien and indigenous cultivated species as well as naturalized ones (Figs. 5.5 & 5.6). *Zea mays* and *Prunus persica* were the dominant alien cultivated species, *Guilleminea densa* and *Schkuhria pinnata* were the dominant naturalized species, and *Cynodon dactylon* and *Eragrostis lehmanniana* were the dominant indigenous species while, *Dodonaea viscosa* and *Vigna unguiculata* were the dominant indigenous cultivated species recorded for the homegardens.

5.4 Discussion

5.4.1 Dominant taxa

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). The Asteraceae, Fabaceae and Mesembryanthemaceae are the three largest families in South Africa (Table 5.2) based on their species count (the number of species that make up the family).

This study indicated that only five of the ten most dominant families in South Africa were also dominant in Tlhakgameng (Table 5.3). Families such as Asteraceae, Fabaceae and Poaceae are the three largest families in Tlhakgameng and their high abundance can be attributed to their extensive cultivation in homegardens as part of the ornamental flora and the large number of naturally occurring weedy species.

Majority of the Tlhakgameng genera are well-represented in the South African natural flora (comprising 356 species – 77%), however the genera of 104 species (23%) are not found naturally in the North-West province, e.g. *Prunus* and *Allium* (Germishuizen *et al*., 2006). From the dominant genera, many species such as *Solanum* and *Aloe* are popular ornamental species and some are declared weeds, which explain to a certain extent the frequent occurrence of these genera in gardens. As 11% of species from these indigenous genera are alien to South Africa, it means that some alien species share a close affinity with South African indigenous species at generic level (Germishuizen *et al*., 2006). Of the 20 dominant species, more were naturalised weeds than cultivated species. These naturalised species may originally have been horticultural subjects that escaped from gardens into the natural surroundings (Hodkinson & Thompson, 1997). Alien weedy species generally belong to plant families that are cultivated mostly for their high ornamental value (e.g. *Rosa chinensis*, *Canna* x *generalis*, *C. indica* and *Amaranthus caudatus*).

5.4.2 Endemic and endangered species

Several rare and endangered species have been preserved in homegardens over time (Watson & Eyzaguirre, 2002). Endemic and endangered species represent only a small portion of the garden flora. However small the contribution of a few gardens may seem to make towards the protection of such species, its collective effort across an entire urban ecosystem and also globally holds tremendous potential (Savard *et al*., 2000; Gaston *et al*., 2005). However, the cultivation of these species takes place because of its use value and not necessarily with conservation in mind. As perceptions of what is considered useful changes over time, these plant species of conservation concern may be replaced with something new. The presence of these rare and endangered species in domestic gardens corroborates the role that such land-use types can fulfil in the conservation of indigenous biodiversity, but its contribution is of temporary nature. Through interaction of gardens with other types of greenspace in close vicinity within the urban environment, better support of biodiversity is possible – a concept described by Colding (2007) as 'ecological land-use complementation'. This means that more indigenous species can be supported in terms of nutrition, space and water resources by the combined patches of the entire urban green infrastructure, which stresses the importance of proper planning of urban development. Furthermore, such conservation resources that already exist can be utilized better in protecting not only endangered, but also abundant indigenous species (Hamilton, 1999).

5.4.3 Useful plants

The crop combinations found in homegardens of a region are strongly influenced by the specific needs and preferences of the household and nutritional complementarities with other major food sources, besides ecological and socioeconomic factors (Christanty *et al*., 1986; Vogl *et al*., 2002). Gardening in Tlhakgameng was seen to be strongly influenced by the European culture of ornamentals, thus resulting in the high degree of ornamental plant species (57%) for the study area. Inhabitants of Ganyesa, a small rural village in the North-West Province situated 30 km away from Tlhakgameng, also used many ornamental species for cultivation – an indication that even poorer, more traditional communities regard aesthetics as important (Cilliers, 2010). Weeds, the second largest group, are not favoured by gardeners because of its occurrence in unwanted locations. However, these plants are almost always present in gardens and contribute towards the ecological environment within the garden (Anon., 2007). South Africans cultivate plants as part of their cultural heritage and because of the associated value e.g. food, natural healing remedies, construction material and other uses (Van Wyk *et al*. 1997; Van Wyk & Gericke 2000).

Food plants made a large contribution (27%) to the total flora of Tlhakgameng. Similarly in Ganyesa, 28% of plant species were classified as food plants (Cilliers, 2010). This is an indication of the dependence of poorer communities on their vegetable gardens for livelihoods. The introduction of a new species to the garden may be chosen by a gardener because of its properties i.e. food, medicinal, ornamental etc., based on the information heard from the neighbours or relatives (Kumar & Nair, 2004). The other use categories were (medicinal, shade and hedge species) all made very small contributions in Tlhakgameng.

5.4.4 Species distribution

Species that occur naturally in South Africa are referred to as indigenous species. Widespread indigenous species were most common in homegardens, including tree species such as *Acacia karroo* and *Tarchonanthus camphoratus*, and grasses (*Cynodon dactylon* and *Eragrostis lehmanniana*). Species originating from the coastal provinces, the wetter parts of South Africa, were commonly cultivated in gardens. Fewer species were contributed by the drier regions of South Africa, despite these species probably being the best adapted to the climate of the study area and would be much more water wise (Joffe, 2007). The fact that indigenous species are present as part of cultivation practices, is ascribed to the prevailing indigenous knowledge systems of the Tswana regarding important plants (Molebatsi *et al*., 2010a). In many cases, however, gardeners rather purchase the more colourful or hardy alien horticultural species, of which there is normally a greater variety available at nurseries.

Plant species occur from different climatic situations prefer either humid or semiarid environments because of their preferred growing conditions, and it would thus be able to survive such conditions elsewhere (Wezel & Bender, 2003). Commonalities between the climate of the region of origin and the South African climate could be the reason why cultivated alien plants are able to flourish under cultivation in Tlhakgameng. These species are often hardier, but also lack natural enemies which makes them healthier plants. The Americas and Asia were the biggest contributors to the alien horticultural flora of Tlhakgameng, indicating that plant species from these regions are best-suited for the local climatic conditions, even hardier than most indigenous cultivated species. Apart from hardiness and suitability to grow under cultivation, these cultivated alien species also possess another important, mutual characteristic – ornamental value – that makes it popular for cultivation. The garden hybrid species-group also made a substantial contribution, suggesting that these taxa are already adapted to the reigning environmental conditions of domestic gardens.

5.4.5 Invasive species

According to Richardson *et al*. (2005), South Africa is regarded as a country threatened by invasive alien plants with 1226 alien taxa occurring within its borders.

Many of these alien species have the potential to escape from cultivation in gardens to form self-sustaining natural populations (naturalize) (Sullivan *et al.*, 2005). This may have disadvantageous effects on the survival and existence of indigenous vegetation and biodiversity (Pimentel *et al.*, 2000; Richardson & Van Wilgen, 2004). The number of alien invasive species found in all land-use types of Tlhakgameng (19) confirmed that this is not only a problem of natural areas, but especially that of human-created ecosystems where sources of alien invasives are maintained. Most of the invasive species found in homegardens either were cultivated extensively in the past (not commercially available anymore, e.g. *Ligustrum lucidum*) or is still cultivated today (*Canna* x *generalis*, *Celtis sinensis* and *Pennisetum clandestinum*). The fact that these species are still dispersed could be an indication that they may become even more problematic in the future and that more cultivated species have the potential to spread into the natural environment. However, the low occurrences of most of the cultivated invasive species in gardens present little opportunity for these species to spread outside of cultivation. This information on the presence and abundance of invasive species in all land-use types can be incorporated into management and eradication plans of invasive species in the future.

5.4.6 Species diversity

The higher total number of species (gamma diversity) of homegardens when compared to other land-use types as was also indicated in chapter 4, is further proof of the heterogeneous nature of urban areas and gardens. In the Phoenix Arizona metropolis, Hope *et al*. (2003) found that the city had much higher gamma diversity than the surrounding desert as a result of the introduced alien vegetation that has replaced the indigenous species. The high gamma diversity of rural homegardens is the result of the diverse species pool that gardeners can choose from for cultivation purposes. Plant diversity is generally viewed as an indication and determinant of overall biodiversity, influencing all related biota (Matson *et al*., 1997) and the green space in urban areas are thus of critical importance for all that is living in these environments. According to Tilman (2000), greater plant diversity leads to greater productivity in plant communities, nutrient retention in ecosystems and ecosystem stability. On the other hand, lower plant diversity leads to greater loss of soil nutrients through leaching which ultimately decreases soil fertility and further lowering plant productivity (Tilman, 2000).

The reason for more alien than indigenous cultivated species in homegardens is that cultivation practices promote the planting of hardy and aesthetic alien species that could be imported from all over the world (Thompson *et al*., 2003; Kühn *et al*., 2004), simultaneously contributing to high species diversity. Gardens are furthermore continually supplied with nutrients and water, thus removing the constraints of survival associated with natural areas and therefore increasing the number of species that could exist in a limited environment (Niinemets & Peñuelas, 2008; Hope *et al*., 2003). Species that would not survive the conditions of natural habitats are thus enabled to survive.

5.5 Summary

This chapter confirms that settlements are floristically diverse (Thompson *et al*., 2003) and can be regarded as heterogeneous agroforestry systems (Das & Das, 2005). This is even so in an isolated, poor village in rural South Africa. The results of this study confirmed that homegardens have higher species richness than other types of land-use. However, natural areas were found to be the second highest in species richness, but they are more homogeneous than homegardens in terms of species diversity (refer to Chapter 4). The majority of the species found in homegardens were cultivated horticultural floras, comprising indigenous and alien ornamental and weeds, which furthermore confirms that homegardens contain an enormous plant biodiversity. The cultivation of alien species in homegardens further increases the biodiversity of urban areas.

Homegardens may also provide a refuge for endemic or threatened species (Das & Das, 2005). Similarly, our study confirmed that several homegardens have a contribution towards the preservation of endemic, rare and endangered or threatened species. The majority of such species found in Tlhakgameng were cultivated in homegardens. As a result, the conservation of these species is in turn greatly dependant on the home owners, whose cultivation decisions are in turn adversely affected by modern life style and their socio-economic status. However, homegardens are floristically diverse and dynamic agroforestry systems that can serve as *ex situ* conservation sites. As a result, 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 Tlhakgameng. Products produced from homegardens are primarily consumed by household or sold as a means of generating an income. This supports the hypothesis that homegardens and communal land harbor a wide array of useful and potentially useful plants. As a result, homegardens play a significant role in subsistence of the inhabitants in Tlhakgameng. Chapter 6 attempts to characterise the homegarden system and describes a layout that supports a high abundance and richness of species.

Chapter 6

The Tswana *tshimo*: A homegarden system of useful plants with a particular layout and function

6.1 Introduction

Since the ground-breaking research by Fernandes and Nair (1986) to bring homegarden systems to the fore, and followed by a paper of Jose and Shanmugaratnam (1993) which proposed these systems to be of an ecological nature, a plethora of papers have dealt with homegardens during the last two decades. Homegardens are regarded as a type of domestic garden; 'domestic' derives from the Greek *domos*, meaning 'house'. There are many types of domestic gardens which vary in how intensively they are cultivated and their location with regard to the home. Generally, and from an urban perspective, a domestic garden is considered as luxury space around the house used for relaxation, play areas, keeping pets, outdoor eating and the cultivation of ornamental plants. The difference between urban and rural gardens, however, lies in the purpose and use. Homegardens are often used for similar functions as urban domestic gardens, but based on their association with developing countries, their main purpose is to support livelihoods, primarily food production, medicine and spirituality (Alvarez-Buylla *et al*., 1989; Das & Das, 2005; Nemudzudzanyi *et al*., 2010).

A homegarden is an intensively worked land-use system involving deliberate management of multipurpose plants in association with agricultural crops, and invariably livestock, within the compounds of individual households (Fernandes & Nair, 1986). The uses of homegardens vary, as some are used for subsistence agriculture and others for the commercial production of food crops (Vogl *et al*., 2004). In the rural homegarden, gardeners usually grow fruit, vegetables, medicinal, spiritual and ornamental plants (Lamont *et al*., 1999; Kumar & Nair, 2004). In developing countries, homegardens are mainly kept as a way of supplementing the cereal-based diet of rural households and few gardeners have the objective to increase household income (Ruel, 2001), but merely to save on food expenditure (Martin *et al*., 2000). These gardening systems play an essential role in food and health security (Allen, 1999).

Homegardens preserve cultural history, as many useful plant species have been subjected to intense human management regimes on such sites over extended periods. Throughout time, farmers have cultivated and selected desired plants, and in this way, homegardens have become genebanks of current and potential resources (Alvarez-Buylla *et al*., 1989), as well as sites for domestication of useful plant species (Hawkes, 1983). In Africa, indigenous useful plants require minimum production input and people know how to cultivate and prepare these based on dynamic Indigenous Knowledge Systems (IKS). Such an example is African leafy vegetables, which grow quickly, are relatively drought tolerant, often cultivated without pesticides, and can be harvested within a short period of time from soils of limited fertility (Shiundu, 2002).

The purpose of this study was to document, characterise and compare the diversity of useful plants in deep rural, rural and peri-urban homegardens of a single ethnic group, the Batswana of the North-West Province, South Africa. The focus was on creating a database of intentionally planted and/or retained and managed useful plant species from homegardens, which creates a basis from which to indirectly assess whether urbanisation has an effect on garden floras within a single culture. By studying floristic changes within a single culture, the bias of preference for specific plants is ousted; a situation quite common in South Africa's racially segregated communities (Lubbe *et al.*, 2010). The specific objectives of this study were to (i) evaluate the composition of the flora in terms of indigenous or alien origin, (ii) examine the different use categories of homegarden plants, and (iii) determine whether placement of micro-gardens is linked to a specific garden layout in homegardens of the Batswana.

6.2 Materials and Methods

6.2.1 Study Area

The study was conducted in the deep rural setting of Tlhakgameng, rural setting of Ganyesa and peri-urban setting of Ikageng in North-West Province, South Africa (Figure 6.1). Deep rural was defined as an inhabited area where tribal authority manages the community and 90% of the inhabitants are subsistence farmers. Rural is defined as an inhabited area under municipal management, where less than 50% of the inhabitants are subsistence farmers. Peri-urban is an inhabited area on the fringes of a city that falls under the management of a city council, and less than 10% of the inhabitants are subsistence farmers.

North-West Province was chosen as a model study site. Firstly, it has a well-documented cultural history of plant usage and Indigenous Knowledge Systems (Grivetti, 1979; Ntamu, 1996). Secondly, it is close (200-300 km) to the main metropolitan area of Gauteng, which provides access to a variety of plant resources. Thirdly, it falls in the semi-arid climatic zone of South Africa (400-600 mm per annum) with winter temperatures that can drop to -7ºC (Mucina & Rutherford, 2006), all which makes for careful selection of horticultural species.

For the purpose of this study a homegarden (*tshimo*) was defined as a land-use form on private or communal land surrounding an individual house (*ntlo*) with a definite fence as border around the yard (*patlelo*), in which several useful tree species are cultivated together (intercropped) with crops and other useful plants; often with the inclusion of small livestock.

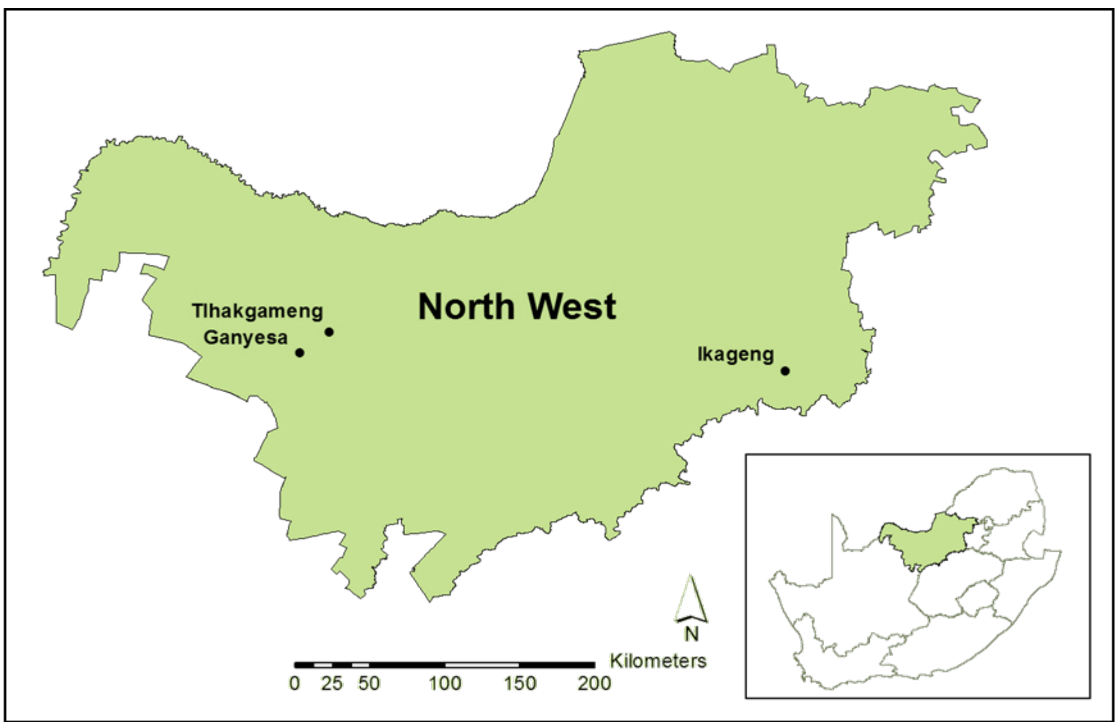


Figure 6.1: Locality of the study areas in North-West Province, South Africa: Ikageng, peri-urban; Ganyesa, rural; Tlhakgameng, deep rural.

6.2.2 Sampling, data collection and analysis

The survey of homegardens was undertaken in 2008 and 2009. Within the pool of available residences, 163 homegardens were selected for comparative purposes, 51 gardens were randomly selected from several localities in the deep rural town of Tlhakgameng, 61 from localities in the rural town of Ganyesa and 51 from the peri-urban area of Ikageng (suburb of the City of Tlokwe). Homegardens were randomly sampled, ensuring a minimum distance of 500 m apart. Sampling took place in plots of 20 x 20 m (400 m^2) which has been shown to be a representative sample (Davoren, 2009). The mean yard size was recorded as 1600 m^2 and the mean size of the cultivated areas were 1000 m^2.

In each garden, the coordinates, household age, yard size and various microgardens (such as food and medicinal gardens) were documented. A checklist of all vascular plant taxa in each homegarden was compiled. Species were included in the checklist if the gardener could indicate a use for the plant. Species were differentiated into indigenous (native), cultivated indigenous, naturalized alien or cultivated alien species (throughout this chapter alien species are denoted by

Identification was done up to the species level, with infraspecific taxa being merged into species. Duplicate specimens of taxa were identified by the Pretoria National Herbarium (PRE) and the AP Goossens Herbarium (PUC). Identification was aided by prominent literature (Bromilow, 1995; Van Wyk *et al*., 1997; Pienaar, 2000; Van Wyk & Gericke, 2000; Henderson, 2001; Glen 2002; Van Wyk, 2005), which also provided information on indigenous, alien, cultivation and use categories.

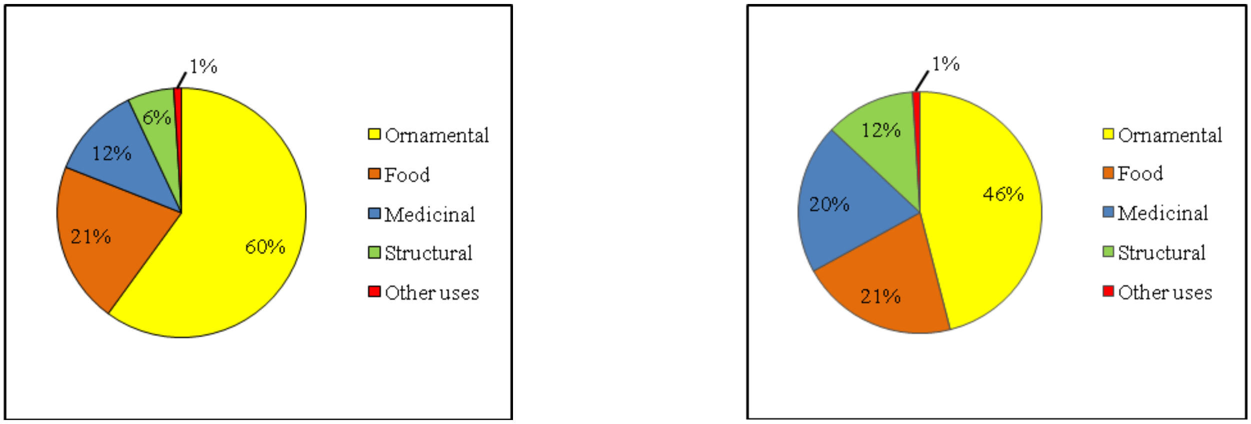
Plant species present in surveyed gardens were categorized according to their uses while their positions within the garden were noted, namely as situated in one of six main Tswana micro-gardens: food, medicinal, ornamental, functional, open area and natural area (Davoren, 2009). The occurrence of species was calculated as the percentage of homegardens in which a species was recorded. Micro-garden positions in gardens were determined where groups of species within a specific position were repeated for > 50% of the gardens; and therefore mappable.

6.3 Results

6.3.1 Species richness and diversity

A total of 525 useful plant species were recorded from 163 homegardens in Ganyesa, Ikageng and Tlhakgameng (Table 6.1). Gardens of deep rural areas had 39±18 species recorded on average per garden (294 useful species), versus the 35±16 per garden for rural (314 useful species) and 25±10 per garden for peri-urban areas (296 useful species). The number of species for the entire garden flora of deep rural areas (391 species) did not differ much from rural (399 species) and peri-urban areas (382 species). However, only 34% of the species found in homegardens of deep rural areas were not recorded for rural homegardens, but 56% of deep rural species were not recorded for peri-urban gardens. This discrepancy is further supported by the frequency of occurrence of useful plants, with 1 980 individuals (of 294 species) indicated as useful by 51 gardeners from deep rural areas and 2 323 indiviuals (of 314 species) from 61 rural gardens, but in contrast only 1 276 individuals (of 296 species) in 51 peri-urban gardens.

In deep rural gardens 73% of useful plant species are cultivated and 27% occur naturally. Deep rural gardens have 20% of species occurring in what is termed a ‘veld garden’, hence the high percentage of naturally occurring, useful plant species. In contrast, 78% of useful plants in rural gardens and 81% in peri-urban gardens are cultivated. Useful species can be grouped into plant-use categories, and for deep rural, rural and peri-urban gardens ±20% of the plant diversity represent food plants (Figure 6.2). Interestingly, peri-urban areas had the highest percentage of leafy vegetables (9%) in homegardens (Table 6.1). The flora of deep rural and rural homegardens contained ±20% medicinal plants (Figure 6.2). In contrast, medicinal plants only contributed 12% of the peri-urban garden flora. This lower percentage could be ascribed to the 60% ornamental plant species present in peri-urban gardens (Figure 6.2). Deep rural and rural homegardens are also dominated by ornamental species, but considerably less than peri-urban areas, namely 46 and 47% respectively. Peri-urban homegardens also have less structural species, namely hedges, windbreaks and shade trees, than the 12% of deep rural and rural areas (Figure 6.2). The Tswana homegardens of North-West have a core of 30 diagnostic species that occur in more than 25% of the 163 surveyed gardens (Table 6.2), with a mean number of 12±4 of these species occurring per sample plot.



A) B)

Figure 6.2: Contribution (%) of each of the five plant-use categories towards the flora of Tswana homegardens in: A, Ikageng (peri-urban); B, Tlhakgameng (deep rural) & Ganyesa (rural).

The five largest families recorded from the homegardens were the Asteraceae (85 species), Poaceae (54 species), Fabaceae (52 species), Solanaceae (26 species) and Lamiaceae (22 species). Other dominant families represented by 15-20 species of the garden flora are the Amaryllidaceae, Asphodelaceae, Crassulaceae, Malvaceae and Rosaceae.

Table 6.1: Proportion (%) of the flora of homegardens contributing to each of the plant-use categories and sub-categories.

Micro-garden	**Deep rural (Tlhakgameng)**	**Rural (Ganyesa)**	**Peri-urban (Ikageng)**	**Total**
Useful plant species	294	314	296	525
Ornamental	46	47	60	**54**
Fruit trees	7	7	6	5
Grain	4	3	2	3
Fruit vegetables	4	4	4	5

Leafy vegetables	6	5	9	6
Food	21	19	21	**19**
Medicinal	20	22	12	**17**
Hedge	3	3	1	2
Windbreak	2	2	1	2
Shade	7	6	4	5
Structural	12	11	6	**9**
Other uses	1	1	1	**1**

Table 6.2: List of the 30 most frequently recorded useful plant species from Batswana homegardens in North-West, South Africa, in descending order (n=163; >25% F (frequency)). Plant use: Fr, fruit; Gr, grain; He, hedge; Me, medicinal; Or, ornamental; Sh, shade; Ve, vegetable.

Species	**Vernacular name**	**Plant use**	**F**
Cynodon dactylon (L.) Pers.	Couch Grass	Or	94
Schkuhria pinnata (Lam.) Cabrera*	Dwarf Mexican Marigold	Me	66
Prunus persica (L.) Batsch.*	Peach	Fr	65
Portulaca oleracea L.*	Purslane	Ve	60
Mollugo cerviana (L.) Ser. ex DC.	Sandy Carpetweed	Me	48
Sida cordifolia L.	Flannel Weed	Me	48
Felicia muricata (Thunb.) Nees	White Felicia	Me	40

Zea mays L.*	Maize	Gr	38
Ficus carica L.*	Common Fig Tree	Fr	37
Vitis vinifera L.*	Grape	Fr	37
Schinus molle L.*	Pepper Tree	Sh	37
Bidens bipinnata L.*	Spanish Blackjack	Ve	37
Dodonaea viscosa Jacq.	Sand Olive	He	36
Bulbine abyssinica A.Rich.	Bushy Bulbine	Me	36
Eleusine coracana (L.) Gaertn.	African Goosegrass	Gr	35
Ziziphus mucronata Willd.	Buffalo Thorn	Me	35
Morus alba L.*	White Mulberry	Fr	34
Acacia hebeclada DC.	Candle Thorn	Me	34
Nerium oleander L.*	Oleander	Or	33
Amaranthus viridis L.*	Slender Amaranth	Ve	32
Cynodon hirsutus Stent	Red Quick Grass	Or	32
Verbesina encelioides (Cav.) Benth. & Hook.*	Wild Sunflower	Or	32
Cucurbita pepo L.*	Marrow	Ve	31
Senna italica Mill.	Black Storm	Me	31
Citrillus lanatus (Thunb.) Matsum. & Nakai	Wild Watermelon	Ve	29
Vigna unguiculata (L.) Walp.	Cowpea	Ve	27
Pollichia campestris Aiton	Waxberry	Fr	26

Catharanthus roseus (L.) G.Don.*	Madagascar Periwinkle	Me	26
Rosa chinensis Jacq.*	Fairy Rose	Or	26
Euphorbia inaequilatera Sond.	Smooth Milkweed	Me	26

6.3.2 Food crops

Cultivated food crops constitute 19% of the species in Tswana homegardens (Table 6.1). Although different types of food crops occur, 70 species were recorded. Only 20-30% of these species are indigenous (Figure 6.3). Food plants include 24 vegetables, 28 leafy vegetables, four tubers, three fodders, and 11 grains. *Zea mays** (Maize) was the most dominant cereal crop, and as a staple diet was found in 38% of the gardens. Food crops were generally grown as a monoculture or intercropped with others (e.g. *Z. mays* together with *Vigna unguiculata* (Cowpea) or *Citrullus lanatus* (Watermelon)). Leafy vegetables and grains were grown in clearly demarcated vegetable micro-gardens.

Ten food plant species each occurred in more than 20% of the Tswana homegardens, namely the vegetables *C. lanatus*, *Cucurbita pepo** (Marrow), *Lycopersicon esculentum** (Tomato), *Pollichia campestris* (Waxberry) and *V. unguiculata*, the leafy vegetables *Amaranthus viridis** (Slender Amaranth), *Bidens bipinnata** (Spanish Blackjack) and *Portulaca oleracea** (Purslane), and the grains *Eleusine coracana* (African Goosegrass) and *Z. mays**. On average, approximately 11±6 different food plants were encountered per deep rural homegardens, compared to the lower 8±4 species for both rural and peri-urban homegardens.

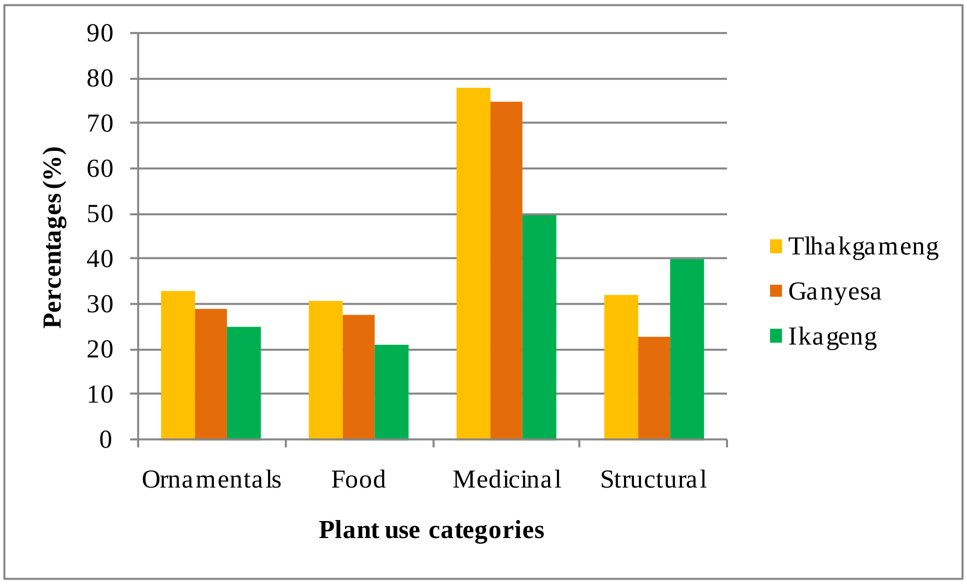


Figure 6.3: Percentage of indigenous species within each of the main plant use categories identified for the Tswana homegardens of North-West Province.

6.3.3 Fruit trees

The richness of fruit trees, which also includes species with medicinal uses, warrants that the results are described here separately. Fruit trees are grown in mixed stands (orchards) and in most cases behind the house. Generally, more than half of fruit trees recorded from orchards are exotic, with 15% of fruit trees in Tswana homegardens being naturally occurring indigenous species. This is best illustrated by *Grewia flava* (Velvet Raisin Bush) that is found naturally as mature, fruit-bearing individuals in 20% of deep rural and rural homegardens, but is nearly completely absent from peri-urban gardens (2%). As the orchards are dominated by exotic aliens, some species that are declared as invasive aliens by South African law occur frequently, namely *Eriobotrya japonica** (Loquat), *Morus alba** (White Mulberry) and *Opuntia ficus-indica** (Prickly Pear).

Six fruit trees occur in more than 20% of the Tswana homegardens, namely (in descending order of frequency) *Prunus persica** (Peach), *Vitis vinifera** (Grape), *Ficus carica** (Common Fig Tree), *Morus alba**, *Prunus armeniaca** (Common Apricot) and *Punica granatum** (Pomegranate). In terms of frequency of occurrence, 211 individual fruit trees have been recorded from 51 deep rural homegardens, 216 from 61 rural gardens and 90 from 51 peri-urban homegardens. This suggests that on average, orchards were the largest in deep rural areas (four trees per orchard).

6.3.4 Medicinal plants

Medicinal plants constitute 17% of all the useful plant species recorded for the 163 Tswana homegardens (Table 6.1), and consists mainly of forbs (22 annual, 33 perennial and 13 geophytic species), 18 shrub species and five tree species, namely *Acacia erioloba* (Camel Thorn), *A. karroo* (Sweet Thorn), *Erythrina lysistemon* (Common Coral Tree), *Olea europaea* subsp. *africana* (Wild Olive) and *Ziziphus mucronata* (Buffalo Thorn). Medicinal plants are found throughout the garden, but are most often grouped in small gardens (*tshingwana*). Deep rural gardens account for 59, rural gardens for 69 and peri-urban gardens for 36 medicinal species. Most of the species (>70% of the cases in deep rural and rural areas) were indigenous (Figure 6.3). However, when considered separately, 50% of medicinal plants in peri-urban gardens are exotic aliens (Figure 6.3), compared to the 22% and 25% of deep rural and rural homegarden floras respectively.

Ten medicinal species occurred in more than 20% of the homegardens, namely (in descending order of frequency) *Felicia muricata* (White Felicia), *Bulbine abyssinica* (Bushy Bulbine), *Ziziphus mucronata*, *Acacia hebeclada* (Candle Thorn), *Senna italica* (Black Storm), *Catharanthus roseus** (Madagascar Periwinkle), *A. karroo*, *Gisekia pharnacioides* (Ostrich Grape), *Acrotome inflata* (Tea Bush) and *Artemisia afra* (African Wormwood). These species are most commonly used to treat diarrhea, fever and pain. In terms of frequency, 610 individual medicinal plants have been recorded from deep rural, 563 from rural and 248 from peri-urban homegardens. On average, approximately 12±3 and 11±4 different medicinal plant species were encountered per deep rural and rural homegardens respectively, compared to the lower 5±2 species per peri-urban homegarden.

6.3.5 Ornamental plants

Ornamental plants constitute 54% of all plant species recorded for the 163 Tswana homegardens (Table 6.1), and consist mainly of forbs (27 annual, 82 perennial, 26 geophytic and 47 succulent species), 17 climbers, 55 shrubs and 27 trees. Ornamental plants are found throughout the garden, but are most often grouped together in flowerbeds. Deep rural gardens are decorated from a species pool of 136, rural gardens from 144 and peri-urban gardens from 178 ornamentals. Most of the species (70% of the cases) were cultivated aliens. However, when considered separately, 33% of ornamental plants in deep rural gardens are indigenous, compared to the 29% and 25% of rural and peri-urban homegarden flora respectively (Figure 6.3).

Nine ornamental species occurred in more than 20% of the homegardens, namely (according to growth form in descending order of frequency) the grasses *Cynodon dactylon* (Couch Grass) and *Cynodon hirsutus* (Red Quick Grass), the annuals *Verbesina encelioides** (Wild Sunflower) and *Tagetes erecta** (African Marigold), the perennials *Portulaca grandiflora* (Moss Rose), *Pelargonium hortorum* (Pelargonium) and *Canna indica** (Indian Shot), and the shrubs *Nerium oleander** (Oleander) and *Rosa chinensis** (Fairy Rose). On average, approximately 11 ornamental plant species were encountered per homegarden for all three study sites.

6.3.6 Functional plants: hedges, windbreaks and shade trees

Since a number of plants, especially trees, have multiple uses, this section represents species where gardeners have specifically stated that their use is of a structural nature and not for any other purpose. Hence, three uses fall exclusively in this category, and are present in more than 80% of deep rural and rural homegardens. Peri-urban gardens have less than 50% of the total number of species used as shade trees or hedges in Tswana homegardens. Furthermore there is a dramatic decrease of windbreaks in peri-urban areas and only one species, *Arundo donax** (Giant Reed), is used for this purpose. Hedges are popular in deep rural and rural homegardens, and *Dodonaea viscosa* (Sand Olive) is planted extensively in these areas (65 and 41% of respectively). In contrast, *Ligustrum lucidum** (Chinese Privet), is planted as a hedge in 57% of peri-urban homegardens, despite it being a declared invasive alien species in South Africa. Overall, the majority of species in this category are alien species (>50%) (Figure 6.3) and all species cultivated as windbreaks are aliens.

Ten species of structural use occurred in more than 20% of the homegardens, namely (in descending order of frequency) *Acacia tortilis* (Umbrella thorn), *Melia azedarach** (Syringa

Berry), *Prosopis glandulosa** (Honey Mesquite), *Searsia lancea*, *S. pendulina* (White Karree) and *Schinus molle** (Pepper Tree) as shade trees, *Dodonaea viscosa* and *Ligustrum lucidum** as hedges, and *Arundo donax** and *Casuarina cunninghamiana** (Beefwood) as windbreaks. On average, approximately four plant species are used for structural purposes per garden in deep rural and rural homegardens, compared to only one species per peri-urban homegarden.

6.3.7 Micro-gardens

Food gardens are diverse and are divided into two sub-types, namely orchards (fruit trees; e.g. *P. granatum** (Pomegranate)) and vegetable gardens. Vegetable gardens are divided into intercropping sections to cultivate grains e.g. *Sorghum bicolor* (Grain Sorghum), leafy vegetables (e.g. *Cleome gynandra* (Spider Wisp)) and vegetables bearing fruit (e.g. *C. pepo** (Marrow)). Medicinal gardens are characterised by different medicinal species being planted and managed within a single clump, usually close to the house (e.g. *Artemisia afra*).

Ornamental gardens are comprised of four subtypes, the main type being flower beds (e.g. *V. encelioides**) that hold a large diversity of aesthetic species. Lawns, constituting areas planted with grass species (e.g. *Pennisetum clandestinum** (Kikuyu Grass)) that are regularly cut, are common where irrigation is available. Species of special value, or which might require special treatment due to harsh conditions, are planted in containers. Pots are often used, in the more urbanised environment, to hold shade and water loving plants (e.g. *Drimiopsis maculata* (Spotted-leaved Drimiopsis)) and are kept on verandas. The rural and deep rural homegardens are characterised by cultural containers constructed from sand and water mixtures and are positioned near the main entrance gate of the homegarden. These structures are specifically used to grow succulents for spiritual purposes (e.g. *Cotyledon orbiculata* (Pig's Ear)).

Functional gardens have four subtypes and these are not species rich, but contain key species that are cultivated for a specific service. Windbreaks (e.g. *Casuarina cunninghamiana**) are often grown along vegetable gardens and houses to protect the crops and inhabitants from the sand-laden Kalahari winds in Tlhakgameng and Ganyesa. Fire screens, made from branches, are commonplace in areas without electricity and protect the outside cooking area from wind. These screens are constructed by planting quick growing species (e.g. *Atriplex nummularia** (Old Man

Saltbush)) close together for density. Shade trees (e.g. *Searsia lancea* (Karree)) are frequently found in the poorer, rural areas where there are no luxuries like outdoor patios and indoor cooling. It is also the meeting place for people from the more traditional environs (*ubuntu* concept).

Open areas around the house are of cultural significance (*lebala* concept) and are extensively swept and weeded (e.g. *Mollugo cerviana* (Sandy Carpetweed)), and the responsibility of the daughter-in-law. Small patches of natural areas are found in especially deep rural, but also rural areas (e.g. *Eragrostis lehmanniana* (Lehmann's Lovegrass)). These areas serve as short-term grazing for animals to be milked or slaughtered, or a place where useful indigenous plant species are collected for household purposes (*naga* concept).

6.3.8 Garden layout

Peri-urban homegardens (n=51) showed no specific pattern or existence of *tshingwana* (micro-gardens). Useful plants are generally scattered throughout the yard in three main micro-gardens, namely flower beds, vegetable gardens and lawns. The most frequently occurring micro-gardens were lawns (100% of gardens), flower beds (96%), pots (78%), open areas (71%) and hedges (64%) (Table 6.3). Vegetable gardens were found in 54% of gardens, but medicinal gardens only in 18% (Table 6.3).

Rural homegardens (n=61) revealed a specific pattern and occurrence of micro-gardens. Five micro-gardens occurred in more than 70% of the homegardens, namely shade trees, flower beds, open areas, vegetable gardens and ochards (Table 6.3). Vegetable gardens were recorded for 79% of homegardens, which is higher than deep rural areas. Containers (made from sand) planted with succulents were found as regularly as pots (Table 6.3). Medicinal gardens were recorded for a third of the homegardens only.

Deep rural homegardens (n=51) revealed a definite pattern, occurrence and placement of micro-gardens. Five micro-gardens occurred in more than 80% of homegardens, namely open areas, shade trees, natural areas, ochards and fire screens (Table 6.3). Nine micro-gardens were recorded for more than 70% of the homegardens. Containers planted with succulents were found in 73% of homegardens and are kept for spiritual purposes. Windbreaks (39%) were less common than expected, especially when compared to the high occurrence in rural gardens. Medicinal gardens were the most frequent for deep rural areas, occurring in 38% of homegardens (Table 6.3).

The garden layout of a typical Tswana *tshimo* was constructed based on the occurrence of micro-gardens and their sub-types in similar positions in more than 50% of the homegardens (Figure 6.4). Medicinal gardens were also indicated despite low frequencies of occurrence. The front door and main gate entrance were included for orientation, and the position of micro-gardens were mapped in relation to these markers. Medicinal gardens, windbreaks and natural areas had the lowest occurrence, but open areas, flower beds and shade trees were frequently encountered and easy to allocate to a specific position. In most cases the positions were based on homegarden layouts from deep rural areas, except for lawns, pots and windbreaks that were based on data from rural areas. Peri-urban areas were westernized and did not contribute enough data to be included here.

Natural areas are found in many (n=81) homegardens of deep rural and rural areas. Gardeners reported that they harvest various medicinal species from these natural areas. A linear regression of naturally occurring indigenous species numbers with medicinal plant numbers per garden revealed that the number of medicinal species was higher in gardens with a higher richness of naturally occurring species (Figure 6.5). Up to 25% of medicinal plants used from the homegarden can be found as naturally occurring plants in managed patches of natural vegetation.

Table 6.3: Occurrence of micro-gardens in Tswana homegardens as a percentage of the number of gardens recorded for Tlhakgameng, Ganyesa and Ikageng. **[**Numbering corresponds to numbered positions on the garden layout plan (Figure 6.4)]

Micro-gardens (*tshingwana*)	**Tlhakgameng (n=51)**	**Ganyesa (n=61)**	**Ikageng (n=51)**
1. Food:			
1.1 Orchard	82	72	52

1.2 Vegetable	73	79	54
2. Medicinal	38	36	18
3. Ornamental:			
3.1 Flower beds	75	84	96
3.2 Containers	43	56	78
3.3 Succulent containers	73	57	39
3.4 Lawn	51	65	100
4. Structural:			
4.1 Windbreak	39	62	2
4.2 Fire screen	82	68	13
4.3 Shade	98	84	59
4.4 Hedge	78	67	64
5. Open area (*lebala*)	100	84	71
6. Natural area (*naga*)	84	66	6

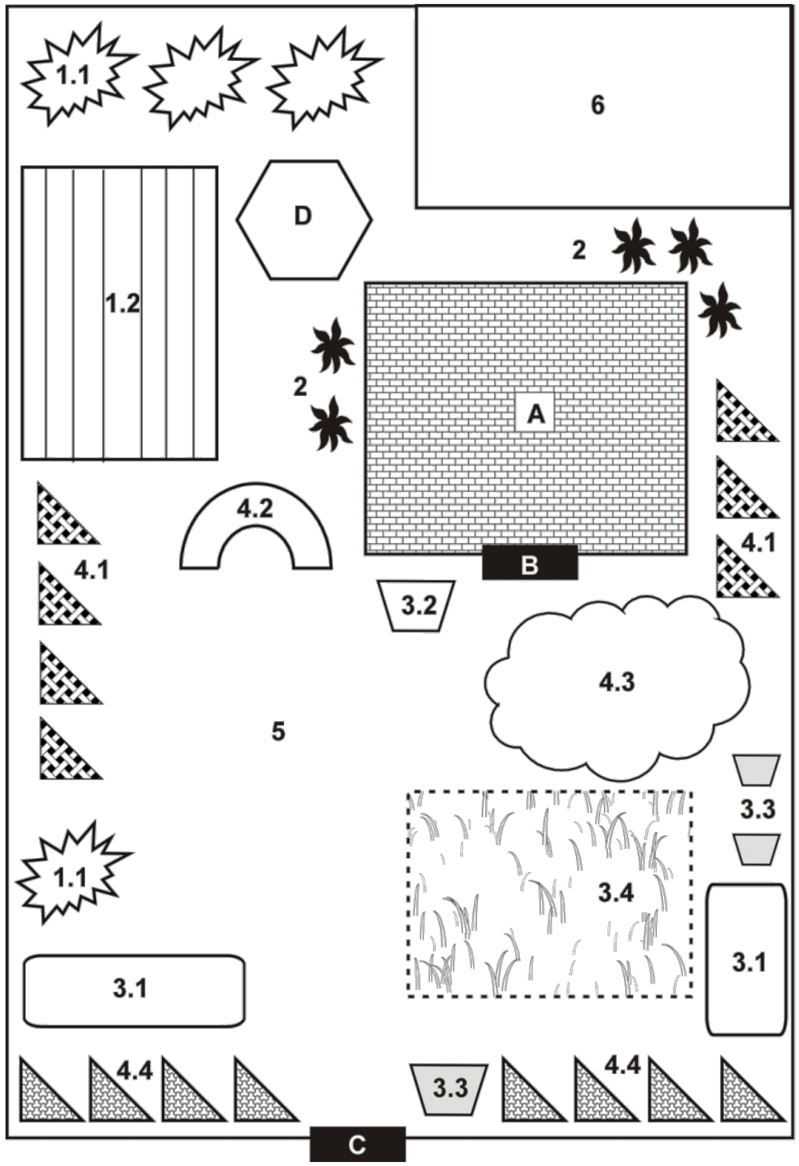


Figure 6.4: General garden layout of a Tswana *tshimo* (homegarden) based on the occurrence of micro-gardens in more than 50% of the cases (n=102). Key to the map: A, position of the house; B, front door of house; C, main entrance gate; D, livestock holding pen; 1.1, orchard; 1.2, vegetable garden; 2, medicinal garden; 3.1, flower bed; 3.2, container; 3.3, succulent container; 3.4, lawn; 4.1, windbreak; 4.2, fire screen; 4.3, shade tree; 4.4, hedge; 5, open space (*lebala*); 6, natural area (*naga*). Drawing not according to scale.

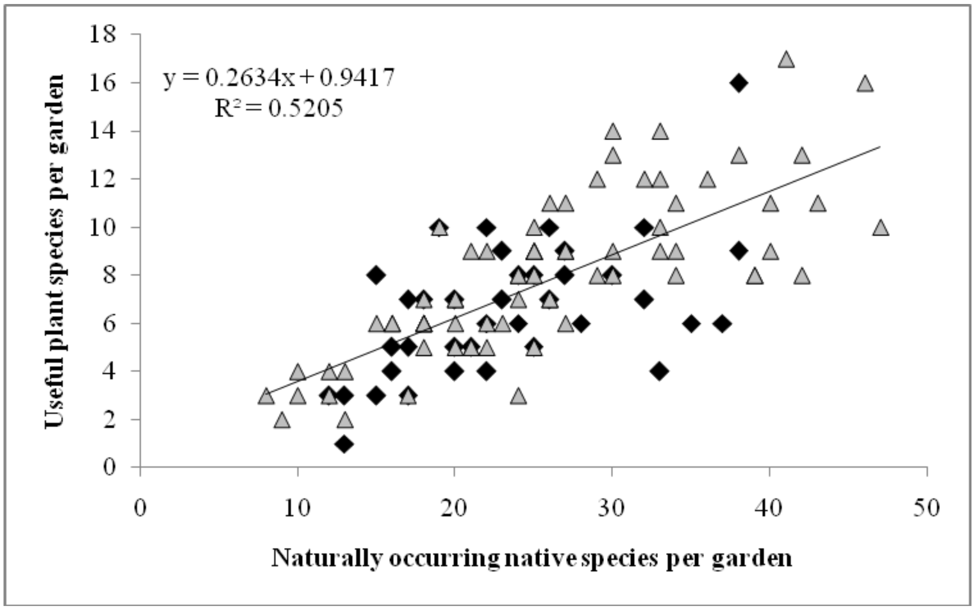


Figure 6.5: Linear regression of the number of naturally occurring indigenous (native) species and number of medicinal plant species found in rural (triangle) and peri-urban (diamond) Tswana homegardens. N=112

6.4 Discussion

6.4.1 Indigenous versus alien

Useful plant species that are alien to South Africa account for more than 60% of species found in Tswana homegardens. This is especially the case in the homegardens of peri-urban areas. These areas have access to a larger horticultural species pool and are less bound by cultural practices and preferences (Davoren, 2009). Probably the most concerning issue, when alien species are considered, is the possibility of species becoming naturalised (Siebert *et al*., 2010) or invasive (Cilliers *et al*., 2008). Several such species have been recorded for Tswana homegardens from rural areas (Davoren, 2009).

Deep rural and rural areas manage and make better use of useful indigenous plants, suggesting that such knowledge on this topic is ignored or lost in cities (Zobolo & Mkabela, 2006). Outsiders (e.g. other cultures) have the ability to threaten tribal custodianship of indigenous species by exposing people to attractive and easily cultivated alternatives (Izidine *et al*., 2008).

Historical aspects also influence the proportion of indigenous taxa. For instance, the high proportion of indigenous medicinal taxa probably stems from the Batswana's pastoral history (Grivetti, 1979), which allowed for useful indigenous plants to be taken directly from nature. However, due to fewer naturally occurring indigenous food plants being available in this semi-arid region, compared to the eastern and southern parts of South Africa, indigenous species were not domesticated for crop production, which could explain why the majority of the Batswana's cultivated crops are alien.

6.4.2 Plant use categories

Production of food crops is limited in peri-urban homegardens when compared to deep rural and rural areas. Head *et al*. (2004) has indicated that intensive backyard food production has lost its emphasis to a large extent in the first generation of migrants to cities. Kirkpatrick *et al*. (2007) has confirmed this, showing a notable decline in the percentage of productive vegetable and fruit micro-gardens, and, similarly to the peri-urban gardens of this study, vegetables and fruit trees are cultivated amidst a substantial component of ornamentals. Generally peri-urban areas have realised the value of leafy vegetables to alleviate food insecurity (Shiundu, 2002). Especially fruit and shade trees were relatively abundant in all gardens and correspond with the findings of Paumgarten *et al*. (2005) for South Africa.

The occurrence of medicinal gardens in Tswana homegardens is low, but in southern Africa many species are harvested from natural areas rather than the garden (Matavele & Habib, 2000). This is, however, in contrast with homegardens of the Zulu people in South Africa, where micro-gardens with medicinal plants are the norm (Nemudzudzanyi *et al*., 2010). The natural areas within Tswana homegardens are also extensively harvested for indigenous medicinal species and can be considered as a type of medicinal garden, albeit unmanaged and temporary.

Ornamental plants, as a use category, were the most species rich and diverse and the abundance of species is linked to higher levels of urbanisation. The availability of aesthetic plants that are drought and cold tolerant has stimulated this European practise within the Tswana culture (Davoren, 2009), especially in peri-urban areas. Additionally, these plants are also more freely available in peri-urban areas, mostly through exposure to gardens which were kept according to

European culture (Cilliers, 2010). However, ornamentals were not completely foreign to the Tswana culture, as is evident from the numerous traditional containers with succulent plants in gardens from deep rural areas (Molebatsi *et al*., 2010). Zulu homegardens, in contrast, are strictly cultural and functional, and ornamental species do not feature in rural areas (Nemudzudzanyi *et al*., 2010).

The structural use category is an indication of how residents of both rural and peri-urban areas value biodiversity, considering that plants are an important component of both the culture and livelihoods of African communities. Species cultivated for structural purposes are, as expected, more frequent in deep rural areas where the financial means do not exist to replace plant resources (High & Shackleton, 2000), i.e. hedges with concrete walls, shade trees with patios, or fire screens with gas or electrified kitchens. The value of biodiversity is therefore much higher in deep rural areas where the plant diversity is conserved through their uses (Das & Das, 2005).

6.4.3 Garden layout

Very little studies have been done on the layout of homegardens of South Africa which makes it difficult to put our findings on garden structure in context. Two other similar studies attempted at constructing a general layout plan for home gardens in South Africa, namely Nemudzudzanyi *et al*. (2010) in KwaZulu-Natal and Coetzee *et al*. (2007) in Gauteng. The micro-gardens identified for Tswana homegardens are equivalent to what was called ‘structural elements’ by Coetzee *et al*. (2007). The Tswana gardens have micro-gardens or ‘structural elements’ that correspond to what were defined in the previous studies. However, the spiritual gardens of Nemudzudzanyi *et al*. (2010) or ancestral worship and charm elements of Coetzee *et al*. (2007) were not as evident in our study. Why the Tswana homegardens from this study are less spiritual and more functional requires further investigation.

6.5 Summary

This study revealed that Tswana homegardens are dominated by alien species, with the proportion of alien species increasing from deep rural to peri-urban areas. The hypothesis that indigenous species diversity is reduced in the peri-urban homegardens through replacement with exotic plant species is therefore supported.

There are five main plant-use categories in Tswana homegardens. This study shows that in food microgardens, grains are predominant in deep rural areas and leafy vegetables in peri-urban areas. Medicinal species are rare in peri-urban areas, but ornamental species are diverse. Structural species are cultivated more often in deep rural and rural areas, especially shade trees. As the figures for deep rural and peri-urban homegardens are often dissimilar, it can therefore be said that plant use categories are influenced by urbanisation.

Six main micro-gardens were identified for Tswana homegardens. Peri-urban gardens do not support this layout fully. The number of food, medicinal, structural, open area and natural area microgardens decrease from deep rural to peri-urban homegardens. The sixth, the ornamental microgardens, increase in frequency and extent from deep rural to peri-urban areas.

This study shows that Tswana homegardens constitute an Indigenous Knowledge System with a particular layout and function. This supports the hypothesis that inhabitants of poor rural areas keep cultural homegardens to provide a wide array of services to sustain their livelihoods. Chapter 7 attempts to unravel the economic side of keeping homegardens and how these improve the livelihoods of poor rural communities.

Chapter 7

Indigenous Knowledge Systems: Garden management practices of the Batswana in the eastern Kalahari

7.1 Introduction

Indigenous Knowledge Systems (IKS), as stated by Domfeh (2007), refers to the complex knowledge system acquired over generations by communities as they interact with the environment. Furthermore, it refers to the knowledge and skills of indigenous people that evolved through trial and error for generations to cope with environmental changes and the associated practices (Melchias, 2001). This knowledge has been developed by experimentation and even though these experiments were not documented, the knowledge systems were legitimized and fortified under suitable institutional frameworks, culture and practices (Eyong, 2007). Indigenous knowledge is logical information that remains in diverse social structures. It includes spiritual relationships, relationships with natural resources, relationships between people, and is reflected in language, social organization, values, institutions and laws (Domfeh, 2007). It is characteristically holistic, integrative, and situated within broader cultural traditions (Ellen *et al*., 2000). Indigenous knowledge is usually unwritten and it is only conserved through oral tradition within indigenous communities, thus there is a lack of documentation (Khasbagan & Soyolt, 2008).

Eyong (2007) defines indigenous people as people that lived in an area within a nation-state, prior to the formation of that nation-state, but may identify with it and have maintained a great part of their distinct linguistic, cultural, social and organizational characteristics. Indigenous people have shown to have a wealth of knowledge on plant usage, function, efficient cultivation methods, and medicinal properties to name a few (Ulluwishewa *et al*., 2008). Indigenous people often depend entirely on the natural resources available within the ecosystems where they live and they maintain practices to manage resources sustainably (Ulluwishewa *et al*., 2008). Many societies see themselves as a part of the natural world as opposed to being detached from nature, as is the case in much of western ideology where man conquers nature. Indigenous communities are capable and have created their own methods of conservation and sustainable management practices (Colfer, 1997; Gegeo, 1998). Although often contested widely, it has been shown that indigenous communities tend to maintain their land and resources (Crevello, 2004).

According to Dovie *et al*. (2008), age and gender play a major role in the IKS of plant selection and use whilst mitigating food insecurity and poverty. Studies by Dovie *et al*. (2004, 2008) found that males and older people were generally more knowledgeable regarding the usefulness of woody plant species and that young people and middle-aged females were highly knowledgeable of types of resources and their uses. Similarly, Zobolo and Mkabela (2006) found that specifically older women were more knowledgeable about useful plant species found around the home and fields, and have played a significant role in sustaining, managing and using biodiversity. Women know how to manage most of the resources that are used (Howard, 2003) and even grow them around the house (Nemudzudzanyi *et al.*, 2010). Indigenous women have a broad knowledge of medicinal plants due to their role as mothers (Kothari, 2003). Similarly, the study of Kelkar (1995) also found women to be knowledgeable about nutrition and storage of food. Mikkelsen (2005) mentioned that the recognition and restoration of indigenous women's knowledge in future generations would improve sustainable use of natural resources.

Local and indigenous knowledge are useful and valuable sources of information for designing and implementing scientific plans, because they are local and provide specific information (Wong *et al.*, 2001). Local and indigenous knowledge are therefore vital for ecological studies in unfolding unique taxa, uses and processes when considering our progress towards providing appropriate management decisions for biological conservation. Indigenous and traditional management systems are dynamic and effective management systems based on the capacity of rural people to live in harmony with their environment (Fisher, 1991; Gurung, 1987; Gilmour & Fisher, 1991).

According to Warren (1991), indigenous knowledge is valuable for both culture and research aimed at improving conditions such as poverty alleviation in rural communities. Indigenous knowledge and practices are important aspects of a society's culture and its technology. These aspects need recognition, full understanding and utilization, because they are valuable to food security in African communities especially. According to Crevello (2004) there is now increasing recognition that IKS are the keys to sustainable development and that local environmental knowledge should be an important basis for sustainable natural resource management. Over centuries Africans have used indigenous knowledge to survive, but insufficient attention has been given to local knowledge within mainstream food security development and management interventions (Oniang'O *et al*., 2004).

Indigenous knowledge (IK) is threatened by modernization and urbanization. Thus, IK is disappearing at an alarming rate in developing countries. Furthermore, lack of IK documentation has posed problems on the retention of IK since it is shared through oral traditions. According to Morolo (2004), the rapid disappearance of IK has led to the oppression and underdevelopment of communities, creating an opportunity for loss of culture and identity. There is thus an urgent need to document and preserve IK so that it can be available for poverty reduction initiatives before much of it is completely lost.

The significance of IKS is so enormous, that it should be protected, preserved and documented in the interest of future generations before it is lost (Chhetry & Belbahri, 2009). Traditional knowledge systems and the modern scientific knowledge system are not mutually exclusive. Rather, they should be viewed as complementary through interactions and co-operation, as they can together be powerful forces in modern initiative in development and conservation (Pei *et al*., 2009).

It is suspected that westernization has in recent decades resulted in the fading of the IKS associated with homegardens, and hence productivity of these agricultural systems has decreased (Domfeh, 2007). The aim of this study was to document and describe the value and use of IKS as applied by rural Batswana in Tlhakgameng to manage their homegardens. Through the documentation of IKS, the possible erosion thereof is somewhat countered and made available to a wider audience for application, development or further research. Specific objectives of this study included the (i) determination of different socio-economic status (SES) classes, and (ii) the assessment of different garden management systems (IKS) of the SES classes.

7.2 Materials and Methods

7.2.1 Social survey

A structured questionnaire (Appendix 1) was developed, tested and improved during a survey of homegarden management systems of a neighbouring town, Ganyesa (Davoren, 2009). An adapted and modified questionnaire was used for interviews with 51 households in Tlhakgameng to gather information on garden management, indigenous knowledge and socio-economics. The questionnaire contained key questions addressing garden importance and perceptions, gardening activities and techniques, age and gender of the gardener, uses of plants, IKS, household economics and social information. The gardeners were interviewed in their home language, Tswana, and were informed that the interviews were anonymous and that there was no right or wrong answer.

7.2.2 Interviews

7.2.2.1 Thematic context analysis

In total three perception questions were asked to develop a better understanding of the respondents' feelings and ideas concerning the use and importance of their gardens, and to assess how rural communities interpret the term 'garden'. The respondents' answers were analyzed by means of a content analysis system originally created by Staton-Spicer and Basset (1979) to analyze orally communicated concerns.

7.2.2.2 Garden management

Seven questions pertained to the respondent's knowledge level of gardening activity. For each question the respondents were allowed to explain how often each activity took place on a weekly, monthly and yearly basis. Each answer was allocated a specific score that would be over-weighted for individuals who spend more time gardening on a weekly basis (Davoren, 2009). Watering, weeding, sweeping and removal of dead material were expressed as mean number of times per week, pest control per month, and fertilizing and pruning per annum. A scoring system was implemented to also include the monthly and yearly activities of low frequency. Garden activities conducted on a weekly basis were given the highest score (6), and activities completed per month or per annum were given the lowest scores (2 and 1 respectively).

7.2.2.3 Determination of SES classes

Four different parameters were selected to determine the SES classes and each of these were defined in terms of a scoring system (Table 7.1). These parameters were scored with the highest scores allocated to conditions which contribute towards food security, financial stability and future opportunities for self enrichment (Lubbe *et al*., 2010). Scores of all the households were plotted from highest to lowest and the resultant curve was subjected to a double intercept of an exponential trend line to demarcate three SES classes (Figure 7.1).

Table 7.1: Parameters and scoring system to determine socio-economic status classes in Tlhakgameng.

Parameter	**Allocation of scores**					
Economic wellbeing	Unemployment rate: (1) 80-100%; (2) 60-79%; (3) 40-59%; (4) 20-39%; (5) 0-19%	Livestock: (1) poultry; (2) pigs; (3) goats/sheep; (4) donkeys; (5) cattle	Transportation: (0) none; (2) bicycle; (3) donkey cart; (4) taxi/bus; (5) own car	Monthly income: (1) R 0-500; (2) R 500-1000; (3) R 1000-1 500; (4) R 1500-2000; (5) > R 5000	Job security: (1) family/friends; (2) temporary job; (3) government grant; (4) informal business; (5) permanent job	
Household	Number of inhabitants: (1) 9-12; (3) 5-8; (5) 1-4	Number of rooms: (1) 1-5; (3) 6-10; (5) 11-15	Structure: (1) zinc structure; (3) mud/wood structure; (5) brick structure			
Basic services	Lighting: (0) none; (1) fire; (2) candles; (3) paraffin; (5) electricity	Heating: (0) none; (1) wood; (3) paraffin; (5) electricity	Cooking: (1) wood fire; (2) charcoal; (3) paraffin; (4) gas; (5) electricity	Water source: (1) natural source; (2) rain water; (3) communal tap; (4) tap in yard; (5) borehole	Water availability: (1) > 1 km; (2) 500m-1 km; (3) 100-500m; (4) 50-100m; (5) <50m	Lavatory: (0) none; (3) outside house; (5) inside house
Educational level	(0) none; (2) primary school; (3) secondary school; (4) grade 12; (5) tertiary qualification					

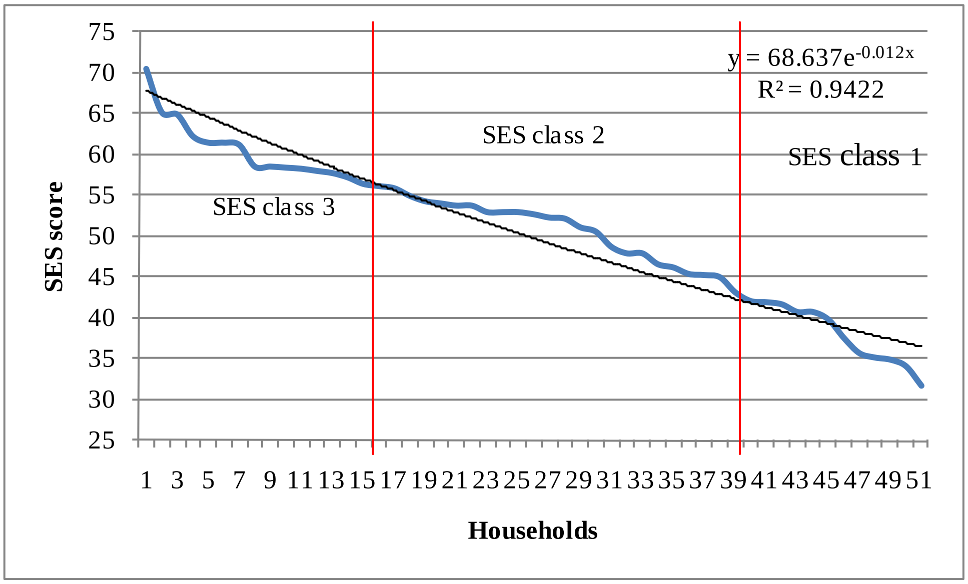


Figure 7.1: Three classes demarcated by the intercept of an exponential trend line based on socio-economic status scores for the population in Tlhakgameng.

7.2.3 Vegetation survey

ArcView 9.2 (Esri, 2006) was used to overlay a 500 m point grid over the settlement as mentioned in Chapter 4 and sampling of gardens was done for each of the points on the grid. The homegardens extended over the entire settlement within different socio-economic areas of Tlhakgameng, which insured that the data were representative of the entire settlement. Five microgardens within the homegarden was sampled, namely vegetable and ornamental gardens, open space, hedges and natural area (Molebatsi *et al*., 2010). A 20 m transect was placed in each of the microgardens and along each transect the nearest tree, shrub, forb and grass species was noted and identified at intervals of 1 m. Bare ground was also noted, if no plant occurred within 0.5 m before or after the point and 2 m perpendicular to the transect.

7.3 Results

7.3.1 Socio-economic classes

Three SES classes were identified for Tlhakgameng, with totals of below 40 (50% and less of 80) indicating class 1, 40 to 60 (50 to 75% of 80) for class 2, and more than 60 for class 3 (Table 7.2). These classes provide groupings to allow for the further analysis of the data.

Table 7.2: Mean SES class scores for selected parameters of the three socio-economic classes of Tlhakgameng. SES class 1, 13 households; SES class 2, 21 households; SES class 3, 17 households.

Parameter	Mean SES (class) scores (20 max.)		
	1	2	3
[1]Economic wellbeing	10.8	12.4	15.1
[2]Household	11.4	13.0	15.8
[3]Basic services	9.6	12.7	14.9
[4]Educational level	6.5	12.4	14.4
Total score (80 max.)	38.3	50.5	60.1

[1]Employment, livestock, mode of transport, monthly income; [2]Number of individuals per household, size of dwelling (number of rooms), structure; [3]Lighting, heating, water source, water availability, lavatory; [4]Highest qualification of working household members.

7.3.2 Human perceptions

The majority of households in the three SES classes regarded monthly food expenses as the highest, more than clothing, insurance and transport expenses (Table 7.3). All classes regarded medical, schooling, housing and remittance expenses as the least (Table 7.3).

Table 7.3: Expenditure of three socio-economic classes indicated from the highest to the lowest.

	Socio-economic classes (Scores)			
	1	2	3	Total (position)
Food	1	1	1	3 (1)
Clothing	2	2	3	7 (2)

Insurance	3	2	2	7 (2)
Transport	3	2	3	8 (4)
Medical expenses	5	5	5	15 (5)
School	5	5	6	16 (6)
Housing	7	7	6	20 (7)
Remittances	7	7	8	22 (8)

The three socio-economic classes perceived the importance of a garden in a similar way. All socio-economic classes' response to this open-ended question either suggested that it provides food or saves money for the family. No other reasons were given. In SES class 1, 85% stated that a garden is significant because it provides food for the family, followed by SES class 2 with 74% and class 3 being the least with 67%. SES class 3 (33%) recognized the importance of having a garden as a way of saving money (Fig. 7.2).

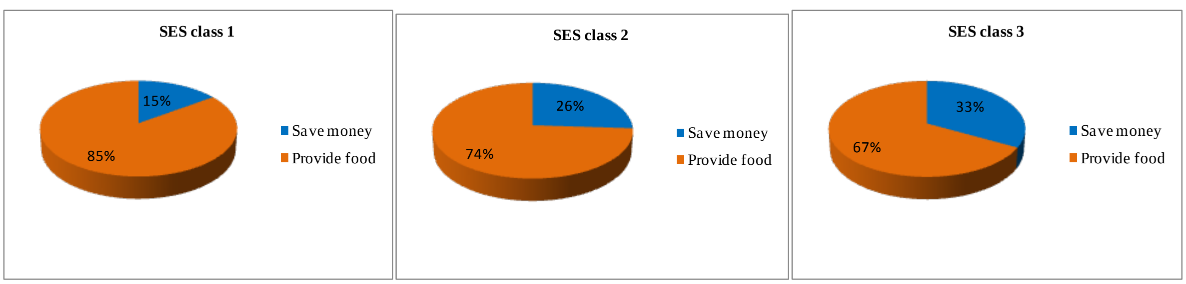


Figure 7.2: Perceptions of the three socio-economic classes regarding the importance of a garden in Tlhakgameng.

The three socio-economic classes had the same view regarding garden function, defining it in all three cases as a place where someone could grow grains, fruits and vegetables. SES class 3 regarded a garden more as a place where someone can grow vegetables (54%) and fruit (39%) than to cultivate grains (7%). SES class 2 regarded a garden as a place where someone can cultivate vegetables (42%), fruit (33%) and grains (25%). In SES class 1, the majority considered a homegarden as a place to grow vegetables (48%), but also fruit (38%) and to a lesser extent grain (14%). In all socio-economic classes the major function of a homegarden was to grow vegetables (Fig. 7.3).

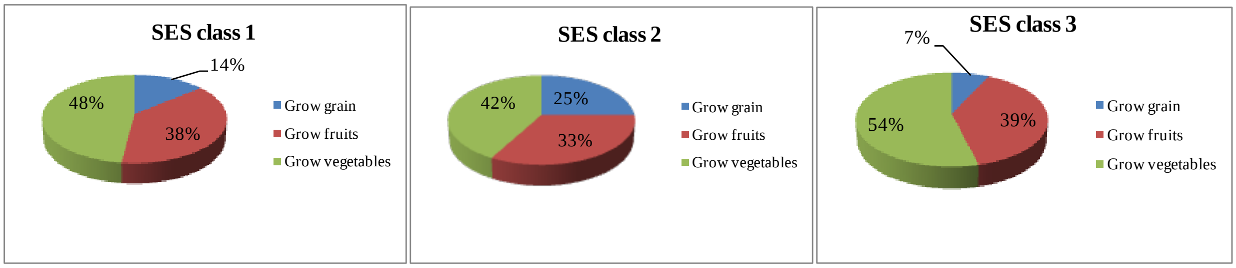


Figure 7.3: Perceptions of garden function by three socio-economic classes in Tlhakgameng.

In all cases, as also confirmed by people's perceptions of garden function above, the major use of homegardens across SES classes was food production (Fig. 7.4). However, when providing a list of garden uses, the people of Tlhakgameng selected consumption (food crops), shade, firewood and medicine as major uses. SES class 1 suggested that the most extensive use of the homegarden is to grow crops (for consumption) and SES class 3 the least, but still more than any other use. All classes regarded use of the garden for shade or firewood more or less the same, namely 22% for firewood and 27 or 28% for shade. However, medicinal use was the lowest in homegardens, with SES class 1 having the lowest value (9%) and SES class 3 the highest (18%) (Fig. 7.4).

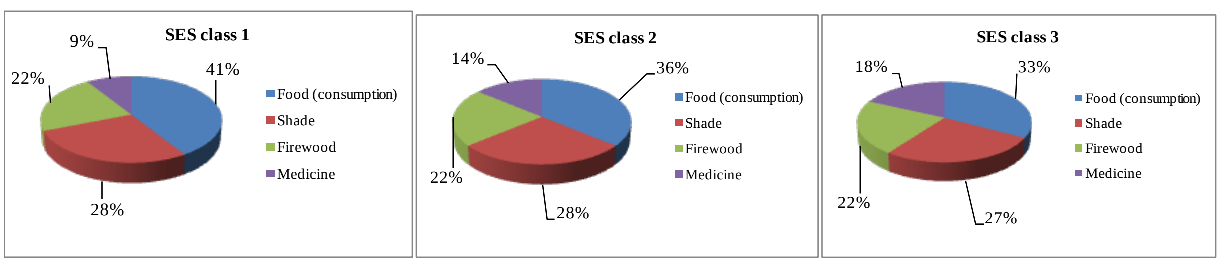
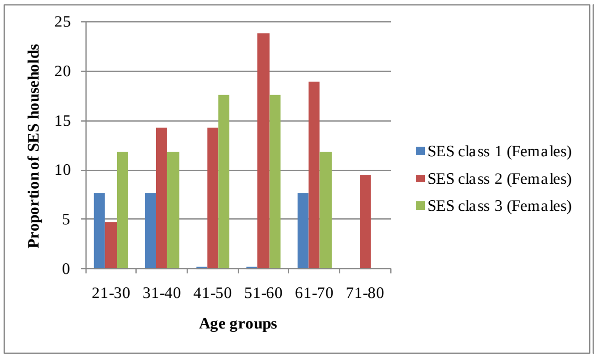


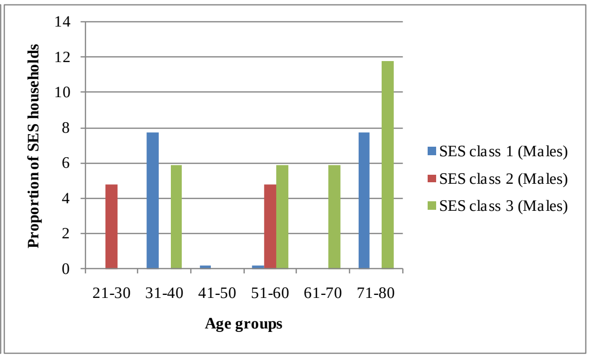
Figure 7.4: Perceptions on the main uses of gardens as recorded for each of the three socio-economic classes in Tlhakgameng.

7.3.3 Human resources

From all SES classes the age of female gardeners ranged between 21 and 80, with class 2 the only grouping to have female gardeners aged between 71 and 80 (Fig. 7.5 A). The majority of female gardeners were in the 41-70 age class. In comparison to other classes, female gardeners in class 1 were scarce. Male gardeners aged from 31-40 and 71-80 were from class 1. Male gardeners in class 2 were aged between 21-30 and 51-60, however in class 3 were aged between

31-71-80. Comparing both genders, females seemed to be more involved in gardening activities than males (Fig.7.5 A & B).





A) B)

Figure 7.5: Age and gender of the main gardener for all socio-economic classes in Tlhakgameng, for females (A) and males (B).

Garden activities that were conducted by household members to assist with garden duties were as follows: cultivating, watering, pruning and sweeping except for class 2 which was not practicing pruning. Pruning was also the least activity conducted by class 1 and 3. Majority of females in class 2 were more involved than others in class 1 and 3 (Fig. 7.6).

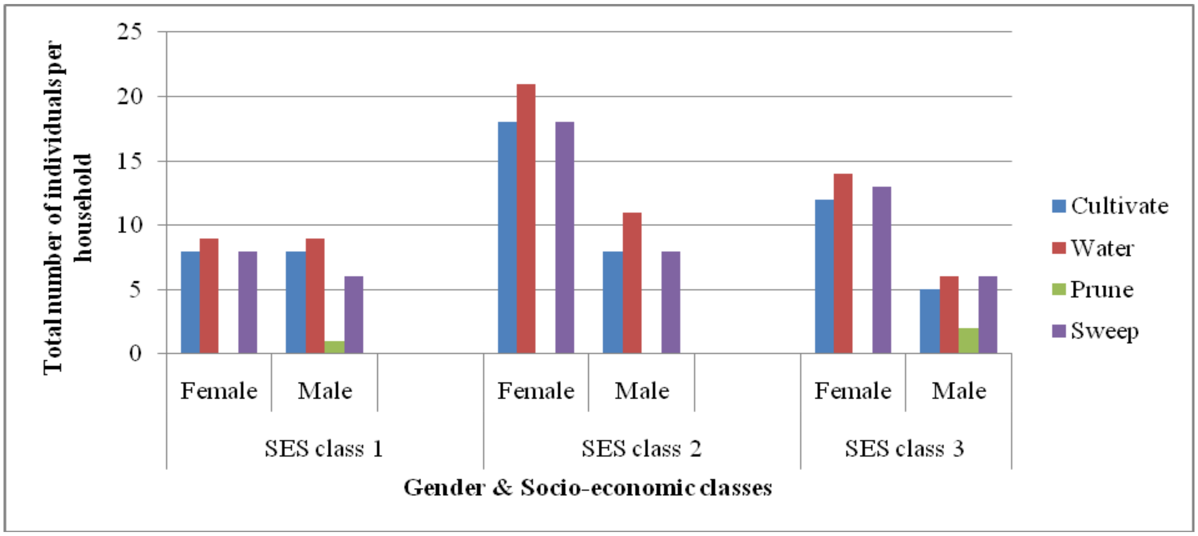


Figure 7.6: Participation of male and female household members in gardening activities (cultivating, watering, pruning and sweeping) for three socio-economic classes in Tlhakgameng.

7.3.4 Garden management

All three classes were conducting seven activities in their gardens (Fig. 7.7). In all classes watering and weeding were the most frequent activities. Activities requiring financial input, such as fertilizer and pest control, were more frequent in classes 2 and 3. Sweeping was more prominent in SES class 1.

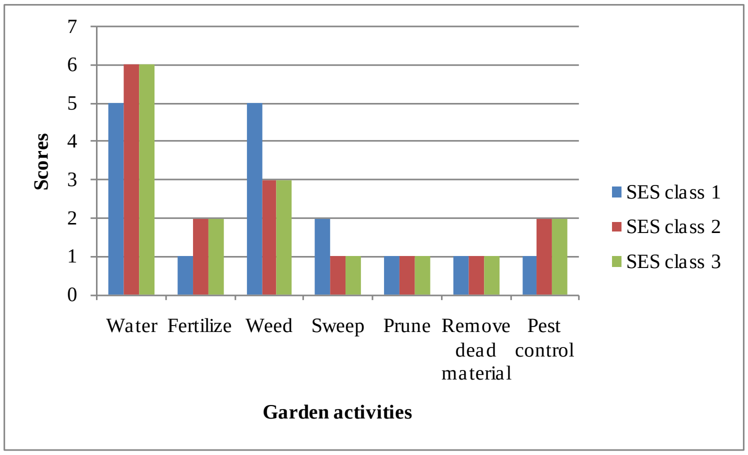


Figure 7.7: Garden activities conducted in the homegardens of three socio-economic classes in Tlhakgameng.

The type of water source used by all socio-economic classes was either from the communal tap, or a borehole or a municipal tap inside the owner's yard. Majority of the respondents in SES class 1 (92%) were fetching water from the communal tap, with 8% having use of a borehole. In SES class 2, 48% of the respondents were fetching water from the communal tap, whereas 42% used a borehole and 10% had a municipal tap inside the yard. In SES class 3, 35% of the respondents were using a communal tap, while 35% were utilizing borehole and 30% were having municipal water available inside their yards (Fig. 7.8).

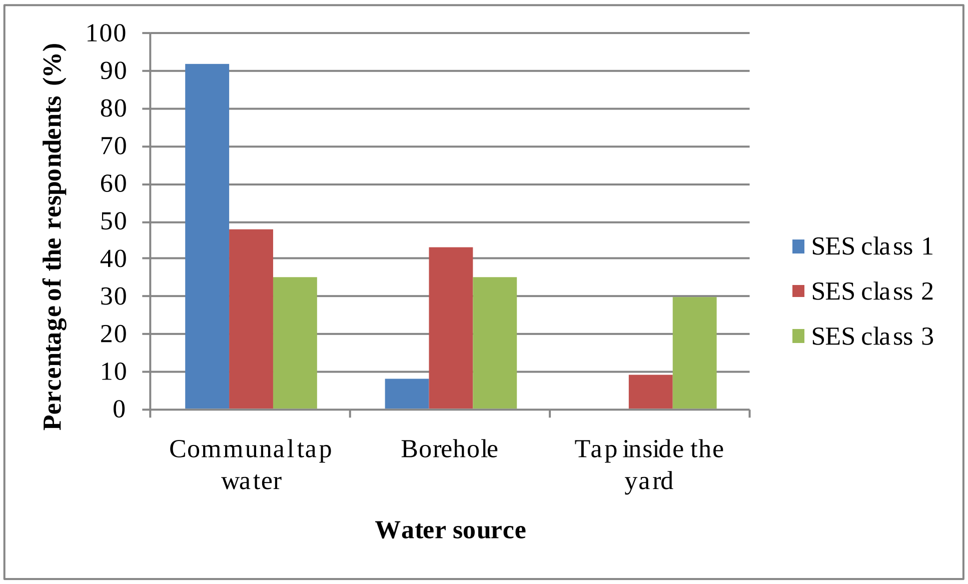


Figure 7.8: Water sources for the households of different SES classes in Tlhakgameng.

7.3.5 Indigenous Knowledge Systems

All the socio-economic classes indicated that they have gathered their knowledge of traditional garden management and practices from five sources. Although half of SES class 1 claimed that most of their knowledge was self-taught, many confirmed that it was transferred from elders, namely 28% said that they learnt it from their grandparents and 17% that they learnt it from their parents (Fig. 7.9). Similarly in SES class 2, majority of the population (48%) stated that they are self-taught. However, 30% indicated that they have learnt it from their grandparents and 11% from their parents. Unlike the other classes, the majority of the population in SES class 3 (38%) did not regard themselves as self-taught but claimed to have learnt the knowledge from their grandparents, and 17% said they learnt from their parents (Fig. 7.9).

To a lesser degree all classes indicated that they have also learnt from their employer (European). SES class 3 was the only group that felt that knowledge of gardening was also transferred in school (Fig. 7.9).

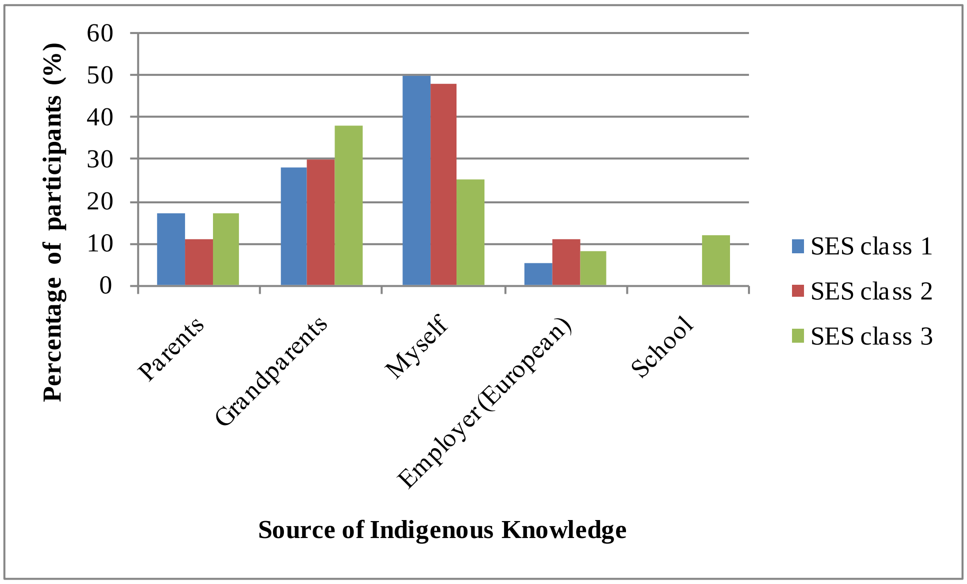


Figure 7.9: Transfer of indigenous knowledge about garden management and practices to the next generation by Tlhakgameng residents.

7.3.6 Useful plants

Participants from SES classes 1 and 2 were producing their own seeds. Majority of the participants (86%) in class 2 were buying their seeds, whereas only 14% were producing their own seeds. In SES class 1, 77% were buying the seeds, but 23% were producing them (Fig. 7.10). In SES class 3, all households were buying seeds.

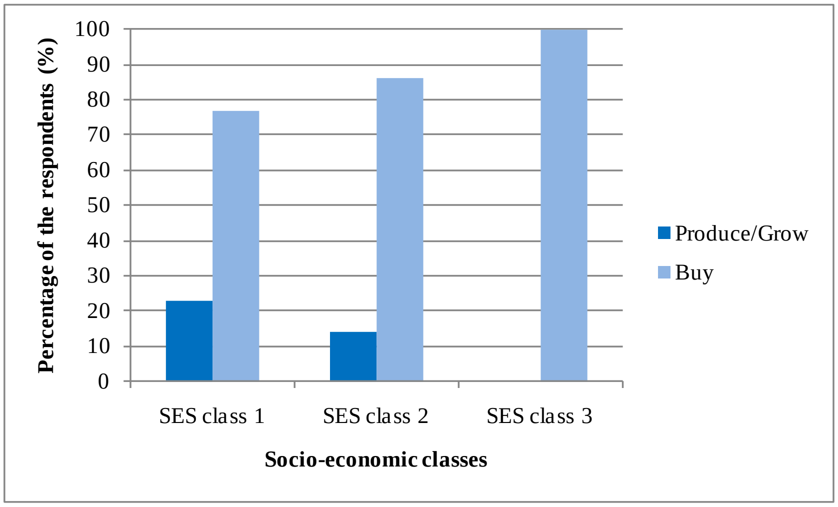


Figure 7.10: Origin of seeds used by Tlhakgameng residents for cultivation purposes.

Majority of the respondents from all classes were purchasing and producing their own food (e.g. grain, vegetables). In SES class 3, 71% of the respondents were buying and growing foods, however 62% from class 1 and 43% from class 2. In comparison with other two classes, class 2 was found to be high percentage (47%) of respondents which buy food, followed by class 1 with 23% and class 3 being the least with 17%. Minority of the population from all SES classes were only producing and not buying food, class 1 with 15%, 12% in class 3 and 10% in class 2 (Fig.7.11).

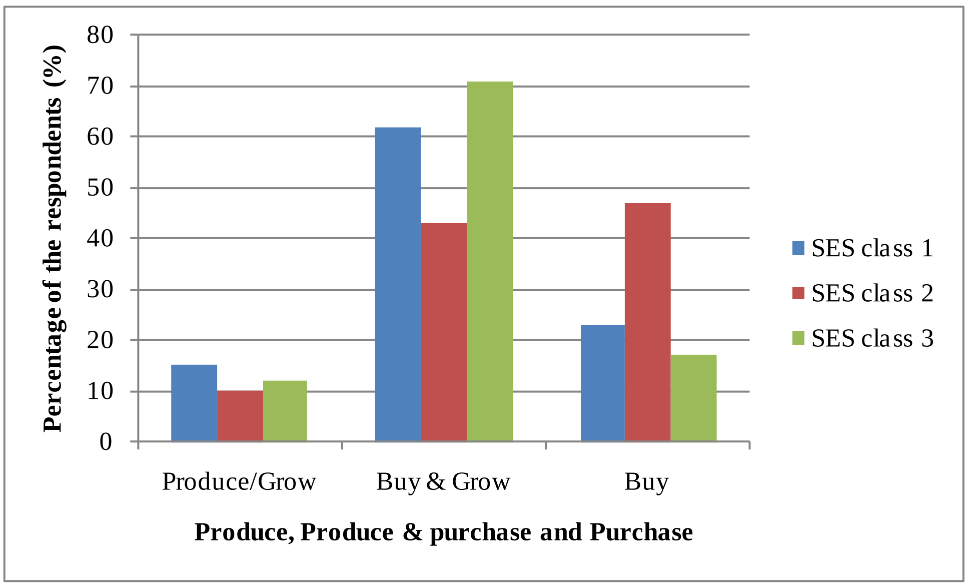


Figure 7.11: Degree to which different SES classes in Tlhakgameng produce or purchase their food (e.g. vegetables).

Respondents from all SES classes claimed to grow fruits/vegetables in their gardens for their own consumption and to sell. The majority of the respondents (77%) in SES class 1 grow fruits/vegetables for their own consumption only, followed by SES class 2 with 71% and class 3 being the least with 59%. However, 41% of the respondents in class 3 grow fruits/vegetables for their own consumption and to sell (Fig. 7.12). None of the classes were found to focus only on selling the grown products.

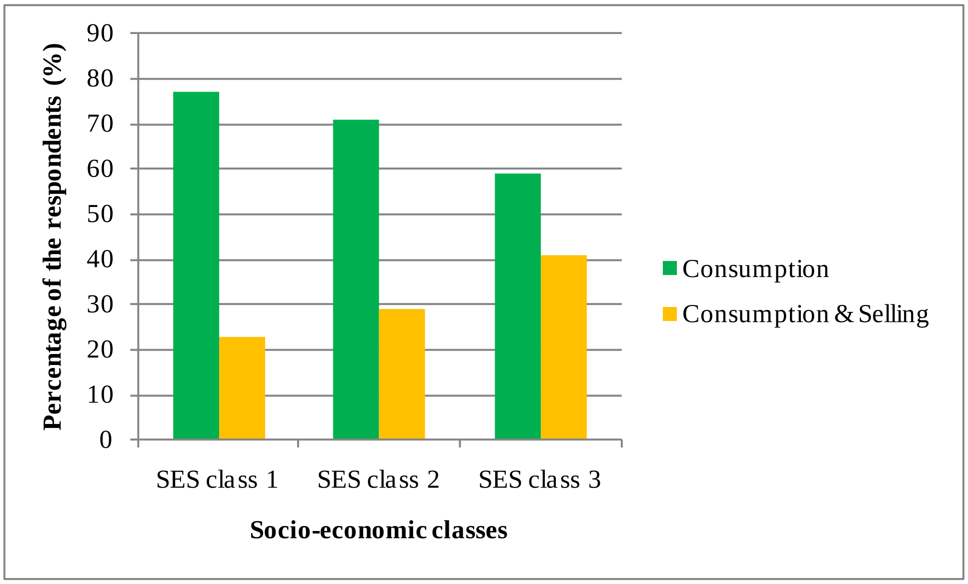


Figure 7.12: Main purpose for cultivating fruits/vegetables in Tlhakgameng homegardens in each of the SES classes.

The majority of households from all SES classes grow ornamentals in their gardens. SES class 2 was found to be the prominent cultivators of ornamentals (90%), followed by class 1 with 85% and class 3 with 82% (Fig. 7.13). However, minority of the population from all socio-economic classes do not prefer ornamentals.

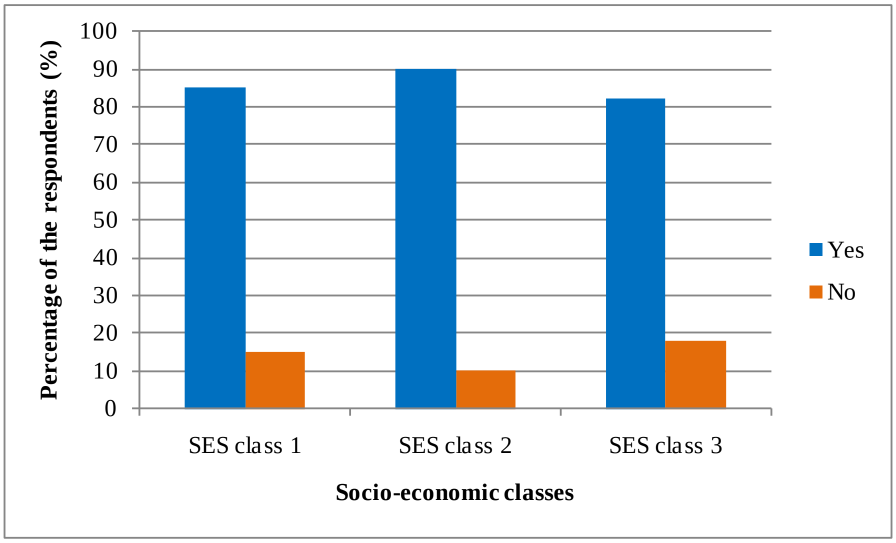


Figure 7.13: Preference of residents in Tlhakgameng either to grow or not to grow ornamentals in their gardens.

Socio-economic classes 1 and 2 all indicated that they use plants harvested from natural areas, however in SES class 3 only 82% indicated that they use the plants from natural areas (Fig.7.14).

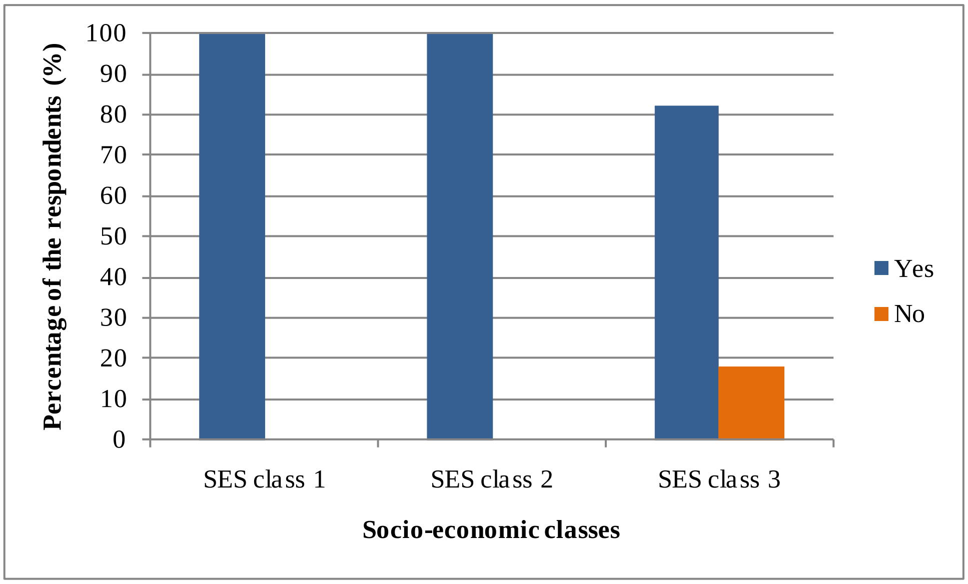


Figure 7.14: Response of households in Tlhakgameng on the harvesting of useful plants from natural areas.

Plants harvested from the wild by rural people in Tlhakgameng were used in different categories, namely firewood (cooking and heating), medicine, building material (e.g. fence, kraal etc.) and other uses. In SES class 1, 27% of the participants were harvesting firewood for cooking, 26% firewood for heating, 22% for other uses, 14% for medicine and 11% for building material. Majority of the participants (27%) in class 2 harvest for medicine, however the same percentages (21%) were harvesting for building material, firewood-heating and other uses with minority (10%) harvesting firewood for cooking. In SES class 3, most participants (24%) stated that they harvest for building material, whereas 22% for (heating, medicine and other uses) with 10% harvesting firewood for cooking (Fig.7.15).

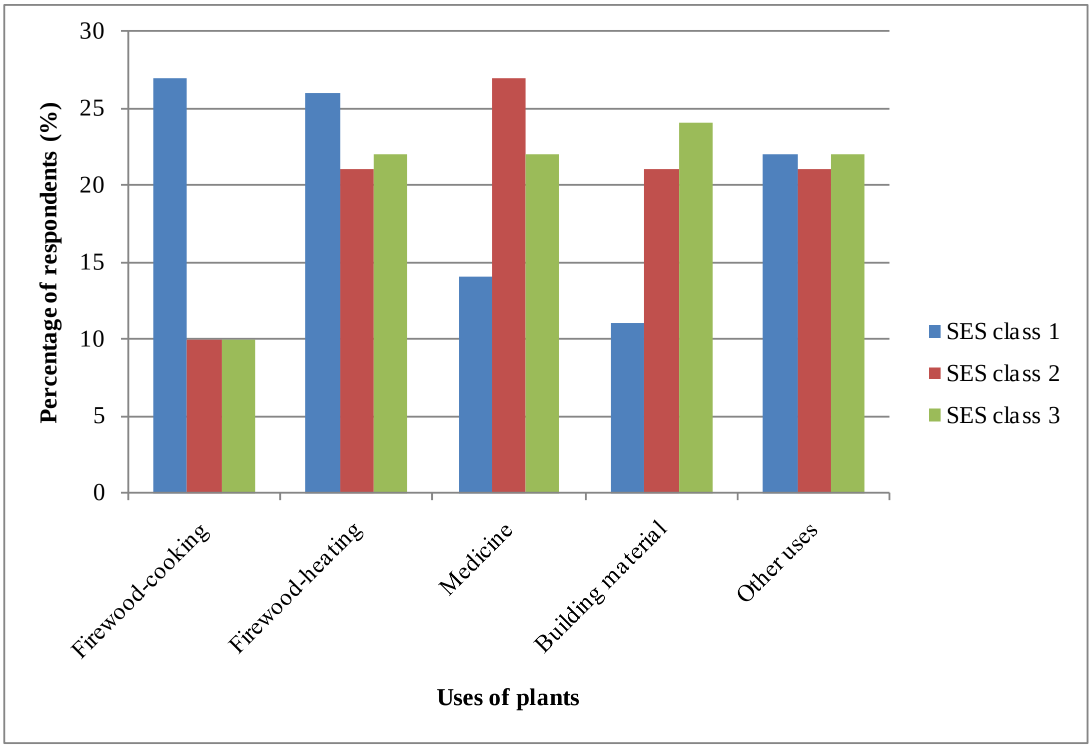


Figure 7.15: The main uses of plants harvested by the respondents from natural areas in Tlhakgameng.

7.4 Discussion

7.4.1 Human perception

All three socio-economic classes defined a garden as a place where someone can cultivate grain, fruits and vegetables. Cultivation of vegetables is regarded as the most important function of a homegarden by all SES classes. SES class 3 presumably does not regard homegardens as important to cultivate grain. This can be ascribed to their socio-economic status which either suggests ownership of large fields elsewhere or suitable income to avoid the hard labour of keeping fields. All socio-economic classes stated that gardens are important because it saves money and provide food for their families. The study of Coomes and Ban (2004) indicated that the perception of people in Northeastern Peru about a garden is that is a place to cultivated crops and non-crops species. Furthermore, in Cuba people regard a garden as a place where someone can cultivate fruits, vegetables and cereals (Wezel & Bender, 2003). The SES classes regarded homegardens as important for subsistence (provide food) and to save money.

People safe money when they are not buying grain, fruits and vegetables from the market but growing their own. Because food is regarded as the most expensive need in Tlhakgameng, the cultivation of food in homegardens releases money for other expenses such as clothing. Medical expenses are reduced as medicinal plants are cultivated in their gardens or harvested from natural areas. Schooling expenses are low, as the school fees for their children are paid by the Department of Education. The majority of the participants own their homes, so they don't pay rent and only a minority of the population was financially supporting other members of the family.

The populations from all socio-economic classes were mainly utilizing the homegarden for food production for consumption, which was also documented for Cuban people where fruits, vegetables, tubers, cereals, spices and medicinal plants were cultivated in their homegardens (Wezel & Bender, 2003). Even though people have different perceptions about the garden they understand its function and significance to their families i.e. the main reason being providing food to their families. Homegardens were also regarded as important as it provided firewood (old trees that were no longer producing fruit were used) and shade for all SES classes. Medicinal plants were also cultivated, but especially as a major part of the garden flora in SES class 3. This is probably so as the higher SES classes cultivate less food for subsistence, but the scarcity of medical services in the region forces them to keep medicinal material for home remedies.

7.4.2 Human resources

The study of Dovie *et al*. (2008) in Thorndale village (South Africa), showed that age and gender plays a major role in the knowledge about plant selection, use etc., which was also the case in our study. Gardeners were aged between 21 and 80 years, suggesting that knowledge of garden management is well distributed within the society. However, most gardeners were between the ages of 40 and 60. This suggests that middle age and elderly people are mainly responsible for gardening activities in Tlhakgameng and are the keepers of such knowledge. However, households indicated that family members of all ages and gender are regularly required to perform at least some garden activities and therefore the knowledge has some means of transfer. Female gardeners were more prominent compared to males. This was particularly evident in

SES classes 2 and 3 and is ascribable to the culture of Tswana which requires the women to work the fields. In addition, these wealthier classes have the men employed elsewhere. In SES group 1, most household members are unemployed and both males and females are active in the garden to generate enough food for subsistence.

Cultivating, watering, pruning and sweeping are four activities conducted by family members to assist the main gardener. Female individuals were more involved in garden activities compared to males, whereas male gardeners were solely responsible for pruning. Women were involved in garden activities such as cultivation, watering and sweeping. Women are often reported to play an important role for *ex situ* conservation of plant genetic resources in homegardens by cultivating indigenous species for subsistence, whereas men are often more interested in the introduction and cultivation of exotic cash crops (Del Angel-Pérez & Mendoza, 2004).

7.4.3 Garden management

Garden activities conducted by the respondents of all three SES classes were mainly watering (most frequent activity) and weeding (second most frequent activity). Fertilizing and pest control were also regarded as important. However, SES class 1 regarded sweeping of the yard more important than fertilizing and pest control. This is in accordance to subsistence communities elsewhere, such as the people of the Bukoba district in North-Western Tanzania who do not use fertilizers, herbicides and pesticides in their garden (Rugalema *et al*. 1994a). This could either be due to financial constraints experienced by this lowest SES class or the prevailing intercropping systems which protect crops against herbivory, disease and nutrient deficiencies.

As watering is regarded as the most important activity in gardens, availability of water becomes an important aspect in garden management. The majority of the participants from SES class 1 were fetching their water from communal taps as they do not have municipal services and the water is free. Some of the participants in class 2 and a third of class 3 had municipal tap water available inside their yards. However, in class 1 none of the participants had municipal tap water. SES class 2, without municipal services, sink boreholes to improve their livelihoods.

Generally water availability is a problem, especially for poorer households, as buckets of water are collected with wheelbarrows up to 500 m from the home.

7.4.4 Indigenous Knowledge Systems

Participants indicated that the knowledge used to manage their gardens was self generated (‘learning by doing’). However, all classes gave credit to knowledge transfer by parents and grandparents. IKS of garden management was also influenced to a lesser degree by knowledge gathered from working in gardens of a western culture. SES class 3 was the only class that claimed to have learnt about garden management techniques at school. As the majority of gardeners were the elderly and women, our results concur with Zobolo and Mkabela (2006) that the keepers of indigenous knowledge are elderly women.

7.4.5 Useful plants

More than 40% of all respondents in the three SES classes stated that they buy, but also grow their food. In the more affluent SES class 3, more than 70% buy and grow their food, whereas the majority of SES class 2 (>50%) only buy their food. SES class 2 has a lower unemployment rate than SES class 1, providing more resources to purchase food, but unlike SES class 3, due to a lower income, can probably not afford labour around the house that can tend a garden to grow food.

SES class 3 regard fruit and vegetables from the garden as products to be sold and not just for consumption. However, rural people, especially poorer households such as SES class 1, consider the function of a garden to cultivate fruits/vegetables for subsistence and only a fifth consider selling their produce compared to nearly half of SES class 3.

Across the board, the majority of households in all three SES classes indicated that they cultivate ornamentals. Participants claimed that the main reason for them cultivating ornamentals in their gardens was to make their yards attractive. This is probably influenced by the European culture as it is irrespective of the socio-economic status class. This statement somehow refutes the people’s main perspective of a garden as a place to grow food or save money.

Lower SES classes produce or buy seed for cultivation purposes. Similarly to the study of Rugalema *et al*. (1994a), people were also buying seeds from the market. However, households of class 3 buy their seed as it is labour intensive and they have the financial means.

All households from SES classes 1 and 2 supplemented their plant needs from the wild. In SES class 3, nearly a fifth does not use plants from the wild at all. This class obviously has the financial means to address such needs with commercial products. SES class 1 uses more than 50% of the plant material that they collect from the wild for energy purposes. The other classes have access to electricity for mainly their cooking needs, as they also prefer the cheaper option of firewood from the wild for heating purposes. Classes 2 and 3 consider plants from the wild most important to address their needs for medicine and building material.

7.5 Summary

The aim of this study was to document and describe the value and use of IKS applied by rural Batswana in Tlhakgameng to manage their homegardens. However, our aim was not specifically addressed due to limitations of the questionnaire. Objectives of this chapter was still achieved, namely to determine socio-economic classes in the study area and to assess the garden management of each socio-economic class. Three socio-economic classes were identified and the garden management of each class was assessed.

The findings of this chapter still support the hypothesis that homegardens are intricate indigenous knowledge systems which are kept according to traditional gardening practices. Homegardens preserve much of the cultural history as they are the sites where many useful plant species have been subjected to intense management regimes over extended periods. Throughout the years gardeners have cultivated and selected the plant species they desire in homegardens (Alvarez-Buylla *et al*., 1989). Homegardens do not depend on high energy inputs such as chemical fertilizers, fuel-powered machinery or pesticides. Combined with cultivation techniques which maintain or increase fertility while conserving soil and water these gardens can be socially and environmentally sustainable food systems based upon the use of indigenous knowledge and resources for self-subsistence (Cleveland & Solori, 1987).

Rural inhabitants in Tlhakgameng define a garden as a place where one can grow grain, fruits or vegetables. The significance of a garden to rural inhabitants is to provide food for their families and saves money by not having to buy market products (e.g. vegetables). Although homegarden production provides a small source of income, it is particularly important for the poor households to overcome adversity and meet basic requirements (e.g. food). The majority of people from all SES classes also cultivate ornamentals irrespective of their class indicating that they are influenced by European culture, which refutes the opinion that they merely view a garden as a place to grow food.

All SES classes were conducting garden activities such as watering, fertilizing, weeding, pruning and removing dead material and pest control. Gardens of households in classes 2 and 3 were characterized by better maintenance practices in comparison to class 1, because they have better access to water whereas participants in class 1 had to travel up to 200m to fetch water from a communal tap. The age of the main gardener was predominantly between 40 and 60 years for both females and males indicating that most gardeners were middle-aged to elderly, however most were found to be females. The techniques of management and high diversity of homegardens reflect the wisdom of traditional knowledge that has evolved over the years and have been transferred from grandparents and parents. Indigenous knowledge is threatened by modern lifestyles which influence people to lack interest and regard it as outdated and worthless.

Households of class 3 were buying seeds for cultivation, whereas households in classes 1 and 2 were producing and buying their own seeds. Many households indicated that they harvest useful plants from the wild, mainly firewood for cooking and heating, medicine, building material and shade. SES class 3 indicated the lowest dependence on wild plant species.

All households of the three SES classes claimed to spend most of their income on food, which explains their eagerness to cultivate food plants. The positive perceptions of the respondents that home gardening has the potential to enhance food security, health and nutrition show that there is a prospect for home gardening if the constraints experienced are addressed. The IKS described by this study demonstrate that properly managed homegardens can contribute to the maintenance of people‘s livelihoods and quality of life, reduce poverty and foster economic growth into the future on a sustainable basis. Our results serve as a baseline for other researchers, because

Tlhakgameng has never been studied before. More research is needed to answer questions such as how rural Batswana manage their homegardens using indigenous knowledge and how different socio-economic classes affect the management of homegardens which was not answered completely by our study.

Chapter 8

Conclusion

8.1 Patterns of plant diversity and species richness

There are relatively few studies in southern African savannas that have attempted to quantify patterns of alpha and beta diversity (Cowling *et al*., 1989), and the relative decline between protected and adjacent non-protected areas, which would provide a measure of the success or failure of protected areas as one strategy to help prevent the decline of biodiversity worldwide (Shackleton, 2000). This is compounded by a lack of standard methodologies and little insight into local-scale patterns of diversity and its determinants, especially in the savanna-urban interface which is characterized by much human activity. Isolated attempts to study plant diversity of South African savannas in populated areas include studies in Bushbuckridge (Shackleton, 2000) and Ganyesa (Davoren, 2009).

Several studies have considered patterns of diversity at spatial scales ranging from one meter-square plots to latitudinal gradients, and at temporal scales ranging from seasonal changes to geological or evolutionary time scales (Currie, 1991; Whittaker *et al*., 2001; Clemants and Moore, 2003; Field *et al*., 2005; Storch *et al*., 2005).

The study of Kent *et al*. (1999) was one of the first studies to systematically record plant species data across an entire city. Similarly, a study of Ganyesa (Davoren, 2009) was pioneering, as it was one of the first in South Africa, followed by this account of Tlhakgameng to analyze the plant species diversity across an entire settlement. The gamma diversity inside the settlement was higher due to high numbers of alien and naturalized species found in homegardens. The alpha diversity was also higher inside the settlement, except for indigenous species separately, where the alpha diversity of natural areas was higher in comparison to other land-use types. Homegardens was found to have the highest beta diversity in comparison with other land-use types. The higher turn-over of species in homegardens is ascribed to the diverse preferences of gardeners which are influenced by their livelihood and aesthetic reasons. Our results confirmed that homegardens contribute greatly to the overall plant species diversity of a settlement.

Alpha diversity was illustrated graphically on IDW maps, while beta diversity was confirmed by NMDS ordinations. The general idea of IDW method is that the attribute values of any given pair of points are related to each other but their similarity is inversely related to the distance between two locations, while NMDS ordinations confirm the level of species turn-over (beta diversity) between four different land-use types in Tlhakgameng. The Ganyesa study of Davoren (2009) was the first one in South Africa to distinguish between alpha, beta and gamma diversity of different land-use types followed by the study of Lubbe *et al*. (2010). The Tlhakgameng study is the third in South Africa, to explicitly distinguish between the alpha, beta and gamma diversity of different land-use types in a rural settlement. The results of all three studies revealed that homegardens have high alpha, beta and gamma diversity at a local scale. Results of Tlhakgameng study confirmed that there is a difference between four land-use types (fallow fields, homegardens, natural areas and wetlands) regarding species diversity, species composition and species richness.

Frequency data was used to calculate diversity indices for all land-use types found in the study area. Homegardens had the highest value for the diversity indices of Shannon-Wiener, Pielou's Evenness, Margalef's Species Richness and Simpson's Index in comparison with other land-use types. The results of this study are preliminary and cannot be used to establish any general patterns, more research is needed to get a clearer picture.

8.2 An analysis of the floristic composition

Several studies have emphasized the significance of homegardens as diverse agroforestry systems and as important *in situ* conservation sites (e.g. Fernandes & Nair, 1986; Blanckaert *et al*., 2004; Das & Das, 2005). This was also true in Tlhakgameng, since the inhabitants were found to cultivate a rich diversity of species in their homegardens for multifunctional puposes e.g. *Bulbine abyssinica* was cultivated for medicinal and ornamental purposes. Homegardens do not only play a role in people's livelihoods, but also in the conservation of species. Some of the cultivated species in homegardens were found to be endemic and threatened according to the South African Red Data list. Therefore, homegardens play a major role in the protection of biodiversity in both rural and urban areas. However, cultivated alien and naturalized species can also negatively affect rural and urban areas by reducing the natural biodiversity.

Most of the time native species are removed or displaced to make a way for the alien taxa. A high percentage of ornamental species was present in homegardens due to western culture which has influenced most of the residents to cultivate this type of species. Numerous studies have shown that the introduction of alien species in urban areas is influenced mainly by people's desire to cultivate the horticultural flora, which is mostly alien and invasive species, or as an unintentional by-product of cultivation (e.g. Wilcove *et al.*, 1998, Miller, 2005, McKinney, 2006, Marco *et al*., 2008) which was also evident in our study. The major contributor to the diversity of urban environments is horticultural floras which are mostly characterized by ornamental plants and vegetables (Gaston *et al*., 2005, Marco *et al*., 2008) it was proven by Tlhakgameng homegardens which were also characterized by ornamentals and vegetables.

Torquebiau (1992) stated that homegardens are sustainable systems that should be promoted not only in tropics or where they are prevalent but also in other geographical areas. This is emphasised by the main function of homegardens in semi-arid Tlhakgameng to supply poor households with staple food, chiefly grains, fruits and vegetables.

8.3 Garden layout and function

The uses of homegardens vary, as some are used for subsistence agriculture and others for the commercial production of food crops (Vogl *et al*., 2003). Several authors mentioned that, in the rural homegarden, gardeners usually grow fruit, vegetables, medicinal, spiritual and ornamental plants (e.g. Lamont *et al*., 1999; Kumar & Nair, 2004). In developing countries, homegardens are mainly kept as a way of supplementing the cereal-based diet of rural households and few gardeners have the objective to increase household income (Ruel, 2001), but merely to save on food expenditure (Martin *et al*., 2000). These gardening systems play an essential role in food and health security (Allen, 1999). Furthermore, the study of Faber *et al*. (2002) in South Africa found that homegardens together with nutrition education and growth monitoring led to an increased vitamin A, riboflavin, vitamin B_6, and vitamin C intakes in children. Homegardens are therefore critical resources for general well-being hence vital to rural people because they provide a wide range of useful products such as food.

The plant diversity in homegardens serves to enhance useful plant diversity and they do not depend on high energy inputs such as chemical fertilizers, fuel-powered machinery or pesticides. Traditional cultivation techniques maintain or increase fertility while conserving soil and water. These gardens can be socially and environmentally sustainable food systems based upon the use of local knowledge and resources for self-subsistence (Cleveland & Soleri, 1987). They are five main use categories in Tswana homegardens, namely food, medicinal, ornamental, shade and hedges.

Very little work has been done on the layout of homegardens of South Africa which makes it difficult to put our findings on garden structure in context. Two other similar studies attempted at constructing a general layout plan for home gardens in South Africa, namely Nemudzudzanyi *et al*. (2010) in KwaZulu-Natal and Coetzee *et al*. (2007) in Gauteng. This study shows that Tswana homegardens constitute an Indigenous Knowledge System with a particular layout and function. Future studies could unravel the economic side of keeping useful plants and how these improve the livelihoods of poor rural communities.

8.4 Garden management systems: IKS

Questionnaires were used to gather information regarding uses of plants, socio-economic status and indigenous knowledge systems of rural inhabitants to manage their homegardens. Our findings revealed that the majority of people are still utilizing indigenous knowledge to manage their homegardens. Even though many mentioned that it has been lost due to modern life styles, perceptions of people who are highly educated consider indigenous knowledge as primitive. By protecting IKS at the local level, it will form the basis for decision making pertaining to vital activities in which food security is included, something that can be particularly effective, as this is an asset that the people control and certainly one with which they are very familiar.

Several authors found that women were more knowledgeable than men and youngsters regarding the management of garden, identification of species and the uses of useful plants (Howard, 2003; Kothari, 2003; Zobolo & Mkabela, 2006; Nemudzudzanyi *et al*., 2010). Utilizing IKS will help increase the sustainability of food production because the integration process provides for mutual learning and adaptation, which in turn contributes to the empowerment of local communities.

IKS can empower local communities to shape their own food security agenda through active participation (Oniang'O *et al*., 2004).

8.5 Outcome of the hyphotheses

8.5.1 Hypothesis 1

Plant diversity patterns of rural settlements are dependent on the type of land-use and homegardens have the highest diversity.

The results of this study confirmed that gamma, α- and β-diversity of homegardens were higher in comparison with other land-use types. Homegardens also had the highest species diversity in comparison to other land-use types.

8.5.2 Hypothesis 2

Homegardens and communal land harbor a wide array of useful and potentially useful plants.

Homegardens sustain a rich and diverse mixture of multipurpose species, which satisfy the various needs of households in Tlhakgameng. Five main plant-use categories were recorded for cultural Tswana homegardens. Products produced from homegardens are primarily consumed by household or sold as a means of generating an income, and include useful species used for food, hedges, ornamentals, medicine and shade.

8.5.3 Hypothesis 3

Inhabitants of poor rural areas keep cultural homegardens to provide a wide array of services to sustain their livelihoods.

Inhabitants of poor rural areas keep cultural homegardens to provide a wide array of services to sustain their livelihoods. Six main micro-gardens (services) were identified for Tswana homegardens, namely food, medicinal, structural, open area, natural area and ornamental. These microgradens are typical for deep rural areas, but are generally absent from peri-urban, westernized gardens.

8.5.4 Hypothesis 4

Homegardens are intricate indigenous knowledge systems which are kept according to traditional gardening practices.

All SES classes were conducting garden activities such as watering, fertilizing, weeding, pruning and removing dead material and pest control. Wealthier households were characterized by better maintenance practices. Most gardeners were middle-aged to elderly, however most were female. The numerous techniques of management and high diversity of homegardens is a reflection of traditional knowledge that has evolved over many years and has been transferred from grandparents and parents.

8.6 Recommendations

South Africa is committed to meet the Millennium Development Goals, set out in the United Nations Millennium declaration of 2000 (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 socio-economic status surveys. More research is needed in South African rural areas to clarify the impact of socio-economic status on species richness, plant diversity and patterns of plant diversity. 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 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 misconceptions exist about the natural environment. Nevertheless, for ecologists to fully understand the role of homegardens in urban environments more integrative studies are required to take all the aspects of homegardens in both rural and urban habitats into consideration should be undertaken. It is therefore recommended that homegardens must be included in all governmental projects aimed to enhance livelihoods of the poor rural people.

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Appendices

Appendix 1: Questionnaire

Questionnaire No: ________________

GPS: ___________________________

PLANT DIVERSITY, SOCIO-ECONOMIC STATUS AND INDIGENOUS KNOWLEDGE SYSTEM SURVEY:

Tlhakgameng (Bophirima Region, North-West Province)

Purpose of the study: To gather information about useful plants in homegardens and communal land.

IMPORTANT NOTES TO FIELDWORKERS

- Please **introduce yourself** to the respondent;
- Tell the respondent that you are **involved in research** in the area;
- Inform the respondent about the **purpose of the study**;
- Explain that results from this research will **benefit the community** by helping them to create their own homegardens to sustain their livelihood;
- Obtain permission from the respondent to ask them questions about their garden (*tshimo*) and socio-economic status;
- Assure the respondent that you have **permission** from the traditional leader;
- Tell the respondent that there are **no right or wrong answers** to the questions, and they are not forced to answer any question if they feel offended (they can withdraw at any stage);
- Please **fill in all the answers** (answers must be in English);
- **Thank the respondent** for his/her participation, and ask if another visit in the future would be acceptable.

For inquiries please contact: Lerato Molebatsi

Contact numbers: 018-299 2505 / 073 264 6663

1. What do you understand by the term ‘garden’ (*tshimo*)?

____

____

2. In your opinion, do you think it‘s important to have a garden/*tshimo*?

____

____

3. Do you grow useful* plants in your garden? If so, for what purpose do you use them?

____

____

*Food (fruit, grain), medicine, firewood, building material, tools, spiritual, etc.

4. What is the age and gender of the main gardener?

____

5. List all garden activities that family members take part in relating to gender and age

Activity	**Gender (male/female)**	**Age**

6. Do you grow ornamental* flowers?

(1) Yes	(2) No

* Ornamental- is a plant grown for its beauty.

7. If yes, why?

____

____

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

Activity	Mark with X	How often?
Water the garden		
Fertilize the garden		
Weed the garden		
Sweep the garden		
Prune hedges/trees		
Remove dead material		
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;
- **Fertilizing** 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 as part of the garden.

9. Where did you learn about gardening?

Parents	1
Grandparents	2
Elsewhere (specify)	3

10. Do you use information provided by your parents or grandparents to manage the garden?

(1) Yes	(2) No

11. If yes, please specify?

___

___

12. In your opinion, do you think it is necessary to use traditional knowledge that has been transferred over generations and explain why?

___

___

13. Do you think that the knowledge gained from past generations is being lost?

(1) Yes	(2) No

14. If yes, what are factors influencing to the disappearance of this knowledge?

___

___

15. What can be done to protect traditional knowledge which is passed from one generation to another?

___

___

16. Do you know persons under the age of 21 with an interest in gardening?

(1) Yes	(2) No

17. If yes, would they like to learn more about gardening?

(1) Yes	(2) No

18. How long have you lived in this house (*ntlo*)?

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

19. How many people live in this house (*ntlo*) on a permanent basis?

____

20. Please indicate the ages of people living in this house on a permanent basis with regard to gender?

Males		**Females**	
Age	Number	Age	Number
< 10		< 10	
11-20		11-20	
21-35		21-35	
36-50		36-50	
>51		>51	

21. Indicate the number of people in your house who are generating an income (earn money).

Type of job	**Male**	**Female**
Permanent job		
Temporary job		

22. Do you house unemployed persons between the ages of 18-60 who can't find a job?

(1) No	(2) Yes

23. Age and gender of unemployed people living with you?

Gender	**Age**

24. In what type of a house (*ntlo*) do you live?

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

25. How many rooms does your house (*ntlo*) have?

____

26. Do you own/ rent this house (*ntlo*)?

Rent	1
Own	2

27. Do you have a toilet (*ntlwana*)?

(1) No	(2) Yes

28. If yes, where is it situated?

(1) Outside the house	(2) Inside the house

29. What type of light do you use at night?

Fire (burn wood)	1
Candles	2
Paraffin (lamps)	3
Electricity	4
Other	

Please specify "other"?

____

30. To stay warm during cold weather, what do you use?

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

Please specify "other"?

---

31. What type of energy source do you use to cook?

Wood fire	1
Paraffin stove	2
Gas stove	3
Electricity stove	4
Other	

Please specify "other"?

---

32. Where do you fetch water for domestic use?

Natural source (river/stream or dam/pan)	1
Communal tap water	2
Tap water (in your yard/'*patlelo*')	3
Tap water (inside your house/'*ntlo'*)	4

33. Where do you get the water that you use in your garden (*tshimo*)?

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

34. How far is the water source that you use to water your garden?

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

35. What mode of transport do you use to fetch water for the garden?

Carry in buckets	1
Wheelbarrow	2
Donkey cart	3
Other	

Please specify "other"

____

36. Do you buy or produce your own food (e.g. vegetables)?

Produce/grow	1
Buy and grow	2
Buy	3
None	

37. Why do you grow fruits/vegetables?

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

38. If you grow vegetables, where do you get your seeds?

Get for free	1
Produce	2
Buy	3

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

(1) Yes	(2) No

40. If yes, what do you use them for?

____

____

41. Which of the following animals do you have?

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

42. Please indicate the highest level of education of your family members living in your house?

Level of education	Number of males (M)	Number of females (F)
(1) None		
(2) Primary school		
(3) Secondary school (excluding Grade 12)		
(4) Grade 12		
(5) A tertiary qualification		

43. Where do you get your main source of income (money) for living?

Family/Neighbour support	1
Temporary job	2
Government grant	3
Informal business	4
Own business	5
Permanent job	6
Other	

Please specify "other"

____

44. Please indicate the mode of transport that you use most often?

None	
Bicycle	1
Donkey car	2
Own motor car	3
Other	

45. What is the combined monthly income of all working members in the household?

R 0 – 500	1
R 500 – 1000	2
R 1000 – 1500	3
R 1500– 2000	4
More than R 5000	5

46. Please indicate from the highest to the lowest with relation to your monthly expenditure? (Use the number system 1-9 to indicate the expenditure)

Items	**Numbers**
Food	
Housing	
Medical expenses	
Transport	
Clothing	
School	
Insurance	
Remittances/support to others elsewhere	
Other	

In case of "other" please specify

____

Appendix 2: Climate data

Table A1: The total and average rainfall data of the Tlhakgameng area from 2004 to 2008 (ARC-ISCW, 2009).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
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
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 Tlhakgameng area from 2004 to 2008 (ARC-ISCW, 2009).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
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
Average	32.3	31	32.5	32.5	23	25.2	20.5	18	11.7	14.6	19	19	270.8	22.6

Table A3: The maximum daily relative humidity (%) of the Tlhakgameng area from 2004 to 2008 (ARC-ISCW, 2009).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
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
Average	88.7	79.6	91	92.9	84	82.3	76	69.3	60.6	71.1	74.2	73.2	930.6	77.6

Table A4: The average daily temperature (^{o}C) of the Tlhakgameng area from 2004 to 2008 (ARC-ISCW, 2009).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
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	219.1	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	223.6	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	17.7
2008		23.1	19.5	15.7	14.9	10.6	9.9	14	15.6	21.7	23	25	193	17.4
Average	24	23	20.3	16.7	13.5	10.3	9.9	13.2	17.1	21.3	22.8	24	215.5	18

Table A5: The maximum daily temperature (^{o}C) of the Tlhakgameng area from 2004 to 2008 (ARC-ISCW, 2009).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
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
Average	31.6	29.8	27.7	25.3	23.1	19.9	20	23.2	27.2	29.16	30.8	32	320.1	26.7

Table A6: The minimum daily temperature (^{o}C) of the Tlhakgameng area from 2004 to 2008 (ARC-ISCW, 2009).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
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
Average	17.4	16.5	14	9.4	5.2	1.6	0.3	3.6	7	12.14	14.9	16	118	9.8

Appendix 3: List of voucher specimens

Abelia chinensis R.Br.*, *Siebert 3463*, Perennial, small evergreen shrub.

Abelia x grandiflora (Andre) Rehder*, *Siebert 3330*, Perennial, small evergreen shrub.

Acacia baileyana F.Muell.*, *Siebert 3333*, Perennial, medium evergreen tree.

Acacia caffra (Thunb.) Willd., *Siebert 3411*, Perennial, deciduous tree.

Acacia erioloba E. Mey., *Davoren & Siebert 219*, Perennial, evergreen tree.

Acacia hebeclada DC. subsp. *hebeclada*, *Davoren 13*, Perennial, tree or shrub.

Acacia karroo Hayne, *Davoren & Siebert 176*, Perennial, tree or shrub.

Acacia melanoxylon R.Br.*, *Siebert 3316*, Perennial, large evergreen tree.

Acacia mellifera (Vahl) Benth. subsp. *mellifera*., *Molebatsi & Siebert 86*, Perennial, shrub or tree.

Acacia robusta Burch. subsp. *clavigera* (E.Mey.) Brenan., *Molebatsi & Siebert 40*, Perennial, tree.

Acacia tortilis (Forssk.) Hayne subsp. *heteracantha* (Burch.) Brenan., *Molebatsi & Siebert 88*, Perennial, shrub or tree.

Acanthosicyos naudinianus (Sond.) C.Jeffrey, *Davoren & Siebert 141*, Perennial, prostrate herb.

Acanthospermum glabratum (DC.) Wild.*, *Davoren & Siebert 343*, Annual, prostrate herb.

Acanthospermum hispidum DC.*, *Davoren & Siebert 344*, Annual, erect herb.

Acanthus mollis L.*, *Siebert 3915*, Perennial, herb.

Acca sellowiana (Berg) Burret*, *Siebert 3413*, Perennial, small evergreen tree.

Acer buergerianum Miq.*, *Siebert 3373*, Perennial, medium deciduous tree.

Acer negundo L.*, *Siebert 3374*, Perennial, medium deciduous tree.

Achillea millefolium L.*, *Molebatsi & Siebert 63*, Perennial, herb.

Achyranthes aspera L. var. *aspera**, *Davoren & Siebert 68*, Perennial, erect herb.

Acrotome inflata Benth., *Davoren & Siebert 195*, Annual, erect herb.

Aerva leucura Moq., *Davoren & Siebert 73*, Perennial, erect herb.

Agapanthus praecox Will. subsp. *orientalis* (F.M.Leight.) F.M.Leight., *Siebert 3988*, Perennial, herb.

Agave americana L. subsp. *americana* var. *americana**, *Davoren & Siebert 341*, Evergreen, succulent shrub.

Ailanthus altissima (Mill.) Swingle.*, *Molebatsi & Siebert 60*, Perennial, tree.

Alocasia macrorrhiza (L.) Schott.*, *Siebert 3932*, Perennial, succulent, herb.

Aloe grandidentata Salm-Dyck, *Davoren & Siebert 84*, Perennial, succulent herb.

Aloe maculata All. x *striata* Haw., *Molebatsi & Siebert 97*, Perennial, succulent herb.

Alstroemeria psittacina Lehn.*, *Siebert 3935*, Perennial, herb.

Alternanthera pungens Kunth.*, *Molebatsi & Siebert 16*, Perennial, herb.

Amaranthus hybridus L. subsp. *cruentus* (L.) Thell.*, *Van der Walt 2B*, Annual, herb.

Amaranthus hybridus L. subsp. *hybridus* var. *hybridus**, *Davoren 37*, Annual, erect herb.

Amaranthus thunbergii Moq., *Davoren & Siebert 270*, Annual, erect herb.

Amaranthus viridis L., *Lubbe & Siebert 126*, Perennial, herb.

Ambrosia psilostachya DC.*, *Siebert 3959*, Perennial, herb.

Ammocharis coranica (Ker Gawl.) Herb., *Molebatsi & Siebert 28*, Perennial, geophyte.

Anisodontea julii (Burch ex DC.) Bates subsp. *julii*, *Lubbe & Siebert 31*, Perennial, shrub.

Anredera cordifolia (Ten.) Steenis*, *Lubbe & Cilliers* 117, Perennial, climber, succulent.

Anthepora pubescens Nees, *Davoren 44*, Perennial, graminoid.

Anthospermum hispidulum E.Mey. ex Sond., *Davoren & Siebert 267*, Perennial, erect herb.

Anthospermum rigidum Eckl. & Zeyh. subsp. *rigidum*., *Davoren & Siebert 94*, Perennial, erect herb.

Antigonon leptopus Hook. & Arn.*, *Molebatsi & Siebert 53*, Perennial, vine, climber.

Antizoma angustifolia (Burch.) Miers ex Harv., *Davoren & Siebert168*, Perennial, scrambling herb.

Aponogeton junceus Lehm., *Davoren & Siebert 336*, Perennial, geophyte.

Aptenia cordifolia (L.f.) Schwantes., *Lubbe & Siebert 49*, Perennial, succulent.

Aptosimum elongatum Engl., *Davoren & Siebert 65*, Perennial, prostrate herb.

Araucaria bidwillii Hook.*, *Siebert 3351*, Perennial, large evergreen tree.

Arbutus unedo L.*, *Siebert 3359*, Perennial, medium evergreen tree.

Arctotis arctotoides (L.f.) O.Hoffm., *Davoren & Siebert 284*, Perennial, procumbent herb.

Arctotis venusta Norl., *Davoren & Siebert 224*, Annual, erect herb.

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

Argyranthemum frutescens (L.) Sch.Bip.*, *Siebert 3981*, Perennial, herb.

Aristida congesta Roem. & Schult. subsp. *barbicollis* (Trin. & Rupr.) De Winter, *Davoren & Siebert 228*, Perennial, graminoid.

Aristida diffusa Trin. subsp. *burkei* (Stapf) Melderis, *Davoren & Siebert 225*, Perennial, graminoid.

Aristida meridionalis Henrard, *Davoren & Siebert 231*, Perennial, graminoid.

Aristida mollissima Pilg. subsp. *argentea* (Schweick.) Melderis., *Molebatsi & Siebert 7*, Perennial, graminoid.

Aristida stipitata Hack. subsp. *graciliflora* (Pilg.) Melderis, *Davoren & Siebert 243*, Perennial, graminoid.

Artemisia abysinthium L.*, *Lubbe & Siebert 150*, Perennial, herb.

Artemisia afra Jacq.ex Willd., *Molebatsi & Siebert 36*, Perennial,shrub or herb.

Arundinaria pygmaea (Miq.) Asch & Graebn.*, *Lubbe & Siebert 47,* Perennial, graminoid

Asparagus laricinus Burch., *Davoren & Siebert 109*, Perennial, deciduous, shrub.

Asparagus racemosus Willd., *Molebatsi & Siebert 9*, Perennial, climber or shrub.

Asparagus suaveolens Burch., *Davoren & Siebert 185*, Perennial, deciduous, dwarf shrub.

Aster laevis L.*, *Davoren & Siebert 192*, Perennial, rosette herb.

Aster squamatus (Spreng.) Hiern.*, *Lubbe & Siebert 67*, Annual, herb.

Atriplex nummularia Lindl. subsp. *nummularia**, *Davoren & Siebert 271*, Perennial, evergreen, shrub.

Atriplex semibaccata R.Br. var. *typica* Aellen*, *Davoren & Siebert 312*, Perennial, scandent herb.

Arachis hypogaea L.*, *Molebatsi & Siebert 70*, Annual, herb.

Arundo donax L.*, *Molebatsi & Siebert 33*, Perennial, graminoid.

Barleria macrostegia Nees, *Davoren & Siebert 162*, Perennial, prostrate herb.

Barleria obtusa Nees, *Siebert 3945,* Perennial, dwarf shrub.

Berberis julianae C.K.Schneid.*, *Siebert 3315*, Perennial, small evergreen shrub.

Berberis thunbergii DC.*, *Siebert 3412*, Perennial, small deciduous shrub.

Bergia decumbens Planch.ex Harv., *Lubbe* & *Siebert 118*, Perennial, small shrub.

Berula erecta (Huds.) Coville subsp. *erecta*, *Siebert 3924*, Annual, herb.

Betula pendula Roth.*, *Siebert 3393*, Perennial, small deciduous tree.

Bidens bipinnata L.*, *Davoren & Siebert 308*, Annual, erect herb.

Blepharis integrifolia (L.f.) E.Mey. ex Schinz var. *integrifolia*, *Davoren & Siebert 183*, Perennial, prostrate herb.

Boerhavia cordobensis Kuntze*, *Davoren & Siebert 150*, Annual, decumbent herb.

Boerhavia diffusa L. var. *diffusa**, *Davoren & Siebert 190*, Perennial; decumbent herb.

Boscia foetida Schinz subsp. *minima* Tölken, *Davoren & Siebert 254*, Perennial, deciduous dwarf shrub.

Bougainvillea glabra Choisy*, *Davoren & Siebert 191*, Perennial, deciduous climbing shrub or vine.

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

Brachiaria marlothii (Hack.) Stent., *Davoren & Siebert 209*, Annual, graminoid.

Brachiaria nigropedata (Ficalho & Hiern) Stapf, *Davoren & Siebert 232*, Perennial, graminoid.

Brachychiton populneus (Schott & Endl.) R.Br.*, *Siebert 3356*, Perennial, medium deciduous tree.

Breynia disticha J.R. & G. Forst.*, *Molebatsi & Siebert 35*, Perennial, shrub.

Bromus catharticus Vahl.*, *Lubbe & Cilliers 106,* Annual or Perennial, graminoid.

Brunfelsia pauciflora (Cham. & Schltdl.) Benth.*, *Siebert 3352*, Perennial, evergreen small deciduous shrub.

Brunsvigia sp., *Davoren & Siebert 262*, Perennial; geophyte.

Buddleja saligna Willd., *Siebert 3360*, Perennial, large evergeen shrub.

Buddleja salviifolia (L.) Lam., *Siebert 3327*, Perennial, small evergreen tree.

Bulbine abyssinica A.Rich., *Davoren & Siebert 61*, Perennial, geophyte.

Bulbine capitata Poelln., *Lubbe & Siebert 146*, Perennial, geophyte, succulent & herb.

Bulbine frutescens (L.) Willd. *Siebert 3972,* Perennial, dwarf shrub, succulent.

Bulbine narcissifolia Salm-Dyck, *Davoren 403,* Perennial, succulent geophyte.

Bulbostylis hispidula (Vahl) R.W.Haines subsp. *pyriformis* (Lye) R.W.Haines., *Davoren & Siebert 323*, Annual, cyperoid herb.

Bulbostylis humulis (Kunth) C.B.Clarke, *Davoren & Siebert 181*, Annual, cyperoid herb.

Butia capitata (Mart.) Becc.*, *Siebert 3446*, Perennial, small evergreen tree or shrub.

Buxus sempervirens L.*, *Siebert 3305*, Perennial, large evergreen shrub.

Cadaba aphylla (Thunb.) Wild., *Molebatsi & Siebert 82*, Perennial, tree or shrub.

Caesalpinia gilliesii (Wall. ex Hook.) Benth.*, *Davoren 32*, Perennial, deciduous shrub or vine.

Calliandra brevipes Benth.*, *Lubbe & Siebert 94*, Perennial, shrub.

Callistemon citrinus (Curtis) Stapf.*, *Siebert 3332*, Perennial, small evergreen tree or shrub.

Callistemon viminalis (Sol. ex Gaertn.) Cheel.*, *Siebert 3355*, Perennial, small evergreen tree or shrub.

Camellia japonica L.*, *Siebert 3375*, Perennial, small evergreen shrub or tree.

Campanula carpatica Jacq.*, *Lubbe & Siebert 95*, Perennial, herb.

Campsis grandiflora (Thunb.) K.Schum.*, *Lubbe & Cilliers 113*, Perennial, creeper, shrub.

Canna x *generalis* L. H. Bailey*, *Siebert 3931*, Perennial, herb.

Cannabis sativa L. var. *sativa**, *Molebatsi & Siebert 85*, Annual, herb.

Casuarina cunninghaqmiana Miq.*, *Molebatsi & Siebert 61*, Perennial, tree.

Carya illinoinesis (Wangenh.) K.Koch*, *Lubbe & Siebert 4*, Perennial, tree.

Catalpa bignonioides Walter*, *Siebert 3453*, Perennial, large deciduous tree.

Cedrus deodara (Roxb. ex Lambert) G.Don*, *Siebert 3344*, Perennial, large evergreen tree.

Celtis africana Burm.f., *Lubbe & Siebert 128*, Perennial tree or shrub.

Celtis australis L.*, *Siebert 3392*, Perennial, medium deciduous tree.

Celtis sinensis Pers.*, *Lubbe & Siebert 129*, Perennial, deciduous tree.

Centaurea cyanus L.*, *Lubbe & Siebert 19*, Annual, herb.

Ceratonia siliqua L.*, *Siebert 3372*, Perennial, medium evergreen tree.

Ceratostigma willmottianum Stapf. *, *Lubbe & Siebert 55*,Perennial, shrub or herb.

Cercis siliquastrum L.*, *Siebert 3430*, Perennial, medium deciduous tree.

Cestrum nocturnum L.*, *Siebert 3415*, Perennial, small evergreen shrub or tree.

Cestrum parqui L'Her.*, *Lubbe & Siebert 41*, Perennial, tree or shrub.

Chamaecrista biensis (Steyaert) Lock, *Davoren & Siebert 143*, Perennial, erect herb.

Chamaecyparis lawsoniana (A. Murray) Parl.*, *Lubbe & Siebert 26*, Perennial, evergreen tree.

Chamaecyparis obtusa (Siebold & Zucc.) Endl.*, *Lubbe & Siebert 32*, Perennial, evergreen tree.

Chascanum adenostachyum (Schauer) Moldenke, *Lubbe & Siebert 148*, Perennial, herb.

Chascanum hederaceum (Sond.) Moldenke var. *natalense* (H.Pearson) Moldenke, *Molebatsi & Siebert 52*, Perennial, herb.

Chenopodium album L.*, *Lubbe & Siebert 6*, Annual, herb.

Chenopodium carinatum R.Br.*, *Molebatsi & Siebert 29*, Annual, herb.

Chenopodium mucronatum Thunb., *Lubbe & Siebert 13*, Annual, herb.

Chenopodium multifidum L.*, *Davoren & Siebert 332*, Perennial, erect herb.

Chloris virgata Sw., *Davoren & Siebert 333*, Annual, graminoid.

Chlorophytum comosum (Thunb.) Jacq., *Siebert 3914*, Perennial, herb.

Chlorophytum cooperi (Baker.) Nordal., *Lubbe & Siebert 147*, Perennial, herb.

Chlorophytum fasciculatum (Baker) Kativu, *Davoren & Siebert 326*, Perennial, Rosette herb.

Chrysocoma obtusata (Thunb.) Ehr.Bayer, *Davoren 11*, Perennial, evergreen dwarf shrub.

Cichorium intybus L. subsp. *intybus**, *Lubbe & Siebert 38*, Perennial, herb.

Ciclospermum leptophyllum (Pers.) Sprague.*, *Molebatsi & Siebert 79*, Annual, herb.

Cinnamomum camphora (L.) Nees & Eberm.*, *Siebert 3307*, Perennial, large evergreen tree.

Citrillus lanatus (Thunb.) Matsum. & Nakai, *Davoren & Siebert 121*, Annual, prostrate herb.

Citrus limon (L.) Burm.f.*, *Siebert 3920*, Perennial, shrub or tree.

Citrus reticulata Blanco.*, *Lubbe & Siebert 35*, Perennial, shrub or tree.

Citrus sinensis (L.) Osbeck.*, *Siebert 3919*, Perennial, evergreen tree.

Clematis brachiata Thunb., *Davoren & Siebert 400*, Perennial, climbing herb.

Clematis campaniflora Brot.*, *Lubbe & Cilliers* 108, Perennial, vine.

Cleome gynandra L., *Davoren 377*, Annual, erect herb.

Cleome rubella Burch., *Davoren & Siebert 269*, Annual, erect herb.

Coccinia sessilifolia (Sond.) Cogn., *Davoren & Siebert 71*, Perennial, climbing herb.

Coleonema pulchellum I. Williams., *Lubbe & Siebert 101*, Perennial, shrub, dwarf shrub.

Combretum erythrophyllum (Burch.) Sond. *Siebert 3339*, Perennial, large semi-deciduous tree.

Commelina africana L. var. *barberae* (C.B.Clarke) C.B.Clarke., *Davoren 407*, Perennial, erect herb.

Commelina benghalensis L., *Davoren & Siebert 338*, Perennial, semi-erect herb.

Commelina livingstonii C.B.Clarke, *Davoren & Siebert 300*, Perennial, semi-scandent herb.

Commelina subulata Roth., *Molebatsi & Siebert 5*, Annual, herb.

Convolvulus sagitattus Thunb., *Lubbe & Siebert 78*, Perennial, herb.

Conyza albida Spreng.*, *Davoren & Siebert 64*, Annual, erect herb.

Conyza podocephala DC., *Siebert 3954*, Perennial, herb.

Cordyline australis (G.Forst.) Hook.f.*, *Siebert 3354*, Perennial, small evergreen tree.

Coronopus integrifolius (L.) Sm.*, *Molebatsi & Siebert 18*, Biennial, herb.

Cosmos bipinnatus Cav.*, *Molebatsi & Siebert* 46, Annual, herb.

Cotoneaster franchetii Boiss.*, *Lubbe & Siebert 59*, Perennial, shrub.

Cotoneaster frigidus Wall. ex Lindl.*, *Siebert 3321*, Perennial, large evergreen shrub.

Cotoneaster horizontalis Decne.*, *Siebert 3383*, Perennial, large evergreen shrub.

Cotoneaster pannosus Franch.*, *Lubbe & Siebert 84*, Perennial, shrub.

Crassula lanceolata (Eckl. & zeyh.) Endl. Ex Walp. subsp. *lanceolata*, *Molebatsi & Siebert 24*, Perennial, succulent herb.

Crataegus pubescens (Kunth.) Steud. forma *stipulacea* (Loudon) Stapf.*, *Lubbe & Siebert 42*, Perennial, shrub or tree.

Crotalaria lotoides Benth., *Davoren 350*, Perennial, erect Herb.

Crotalaria orientalis Burtt Davy ex I.Verd. subsp. *orientalis*, *Davoren & Siebert 87*, Perennial, Deciduous dwarf shrub or herb.

Crotalaria sphaerocarpa Perr. ex DC. subsp. *sphaerocarpa*, Davoren & Siebert 58, Annual, erect herb.

Cryptomeria japonica (L.f.) D.Don*, *Siebert 3314*, Perennial, large evergreen tree.

Cucumis myriocarpus Naudin subsp. *leptodermis* (Schweick.) C.Jeffrey & P. Halliday, *Davoren & Siebert 268*, Annual, prostrate herb.

Cucumis myriocarpus Naudin subsp. *myriocarpus*, *Davoren & Siebert 111*, Annual, prostrate herb.

Cuphea micropetala Kunth.*, *Siebert 3462*, Perennial, small evergreen shrub.

Cupressus macrocarpa Hartw.*, *Lubbe & Siebert 25*, Perennial, evergreen tree

Cupressus sempervirens L. var. *sempervirens**, *Siebert 3337*, Perennial, large evergreen tree.

Cussonia paniculata Eckl. & Zeyh. var. *sinuata* (Reyneke & Kok) De Winter, *Siebert 3444*, Perennial, medium deciduous tree.

Cycas revoluta Thunb.*, *Siebert 3991*, Perennial, shrub or tree.

Cydonia oblonga Mill.*, *Lubbe & Siebert 27*, Perennial, tree, shrub.

Cynodon dactylon (L.) Pers., *Davoren & Siebert 245*, Perennial, graminoid.

Cynodon hirsutus Stent, *Davoren & Siebert 329*, Perennial, graminoid.

Cyperus albostriatus Schrad., *Lubbe & Siebert 66*, Perennial, cyperoid, mesophyte, herb.

Cyperus difformis L., *Davoren & Siebert 319*, Annual, cyperoid herb.

Cyperus esculentus L. var. *esculentus*, *Siebert 3984*, Perennial, geophyte, herb.

Cyperus indecorus Kunth var. *decurvatus* (C.B. Clarke) Kük., *Davoren & Siebert 100*, Perennial, cyperoid herb.

Cyperus margaritaceus Vahl var. *Margaritaceus*, *Davoren & Siebert 155*, Perennial, cyperoid herb.

Cyperus marginatus Thunb., *Davoren & Siebert 287*, Perennial, cyperoid herb.

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

Dahlia imperialis Roezl ex Ortgies.*, *Lubbe & Siebert 63*, Perennial, tree.

Dais cotinifolia L., *Siebert 3992*, Perennial, tree.

Datura inoxia Mill.*, *Davoren & Siebert 199*, Annual, erect herb.

Delosperma cooperi (Hook.f.) L.Bolus, *Siebert 3937*, Perennial, dwarf shrub, succulent.

Delosperma herbeum (N.E.Br.), *Lubbe* & *Siebert 142*, Perennial, succulent.

Dianthus barbatus L.*, *Lubbe & Siebert 12*, Perennial, herb.

Dianthus mooiensis F.N. Williams subsp. Kirkii (Burtt Davy) S.S.Hooper, *Lubbe & Siebert 152*, Perennial, herb.

Diascia integerrima E.Mey.ex Benth., *Siebert 3970*, Perennial, herb, scrumbler.

Dicerocaryum eriocarpum (Decne.) Abels, *Davoren & Siebert 215*, Perennial, prostrate herb.

Dicoma macrocephala DC., *Davoren & Siebert 92*, Perennial, procumbent herb.

Dicoma schinzii O.Hoffm., *Davoren & Siebert 133*, Perennial, prostrate herb.

Dietes bicolor (Steud.) Sweet ex Klatt., *Siebert 3971*, Perennial, herb.

Digitaria eriantha Steud., *Davoren & Siebert 237*, Perennial, graminoid.

Diospyros kaki L.f.*, *Lubbe & Siebert 75*, Perennial, shrub or tree.

Diospyros lycioides Desf. subsp. *guerkei* (Kuntze) De Winter, *Davoren & Siebert 70*, Perennial, deciduous shrub or tree.

Diospyros lycioides Desf. subp. *lycioides*, *Molebatsi & Siebert 91*, Perennial, shrub.

Dipcadi marlothii Engl., *Davoren & Siebert 298*, Perennial, geophyte.

Dodonaea viscosa Jacq. var. *angustifolia* (L.f.) Benth., *Siebert 3329*, Perennial, small tree.

Dodonaea viscosa Jacq. var. *viscosa*, *Davoren 33*, Perennial, evergreen tree or shrub.

Dovyalis caffra (Hook.f. & Harv.) Hook.f., *Davoren 352*, Perennial, deciduous, evergreen tree.

Drimiopsis maculata Lindl. & Paxton., *Molebatsi & Siebert 58*, Perennial, geophyte.

Duchesnea indica (Andrews) Focke.*, *Siebert 3918*, Perennial, herb.

Duranta erecta L.*, *Molebatsi & Siebert 48*, Perennial, shrub.

Dyschoriste transvaalensis C.B.Clarke., *Molebatsi & Siebert 83*, Perennial, dwarf shrub or shrub.

Echeveria elegans A.Berger.*, *Siebert 3980*, Annual, succulent herb.

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

Ehrharta erecta Lam. var. *erecta*, *Lubbe & Cilliers 105*,Perennial, graminoid.

Elaeagnus pungens Thunb.*, *Siebert 3397*, Perennial, large evergreen shrub.

Elephantorrhiza elephantina (Burch.) Skeels, *Davoren & Siebert 90*, Perennial, uffrutex.

Eleutherine bulbosa (Mill.) Urb.*, *Davoren & Siebert 295*, Perennial, geophyte.

Emex australis Steinh., *Davoren & Siebert 56*, Annual, erect herb.

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

Eragrostis aspera (Jacq.) Nees, *Lubbe 165*, Annual, graminoid.

Eragrostis barrelieri Daveau, *Lubbe 166*, Annual, graminoid.

Eragrostis biflora Hack. ex Schinz, *Davoren & Siebert 235*, Annual, graminoid.

Eragrostis lehmanniana Nees var. *lehmanniana*, *Davoren & Siebert 241*, Perennial, graminoid.

Eragrostis superba Peyr., *Molebatsi & Siebert 81*, Perennial, graminoid.

Eragrostis trichophora Coss. & Durieu, *Davoren 23*, Perennial, graminoid.

Eragrostis viscosa (Retz.) Trin., *Davoren & Siebert 325*, Annual, graminoid.

Eragrostis x pseud-obtusa De Winter, *Davoren & Siebert 291*, Perennial, graminoid.

Eriobotrya japonica (Thunb.) Lindl.*, *Siebert 3324*, Perennial, small evergreen tree.

Eriospermum porphyrium Archibald, *Davoren & Siebert 170*, Perennial, geophyte.

Erythrina lysistemon Hutch., *Molebatsi & Siebert 43*, Perennial, tree.

Escallonia rubra (Ruiz & Pav.) Pers. var. *macrantha* (Hook. & Arn.) Reiche*, *Siebert 3425*, Perennial, small evergreen shrub.

Eucalyptus sideroxylon A.Cunn.*, *Siebert 3471*, Perennial, large evergreen tree.

Euclea crispa (Thunb.) Guerke subsp. *crispa*, *Siebert 3342*, Perennial, small evergreen tree.

Euonymus japonicus Thunb.*, *Siebert 3313*, Perennial, large evergreen tree or shrub.

Euphorbia inaequilatera Sond. var. *inaequilatera*, *Davoren & Siebert 108*, Annual, prostrate herb or dwarf shrub.

Euphorbia prostrata Aiton*, *Davoren & Siebert 297*, Annual, prostrate herb.

Euphorbia serpens Kunth*, *Davoren & Siebert 227*, Annual, prostrate herb.

Euryops chrysanthemoides (DC.) B.Nord., *Lubbe & Siebert 1*, Perennial, shrub.

Felicia amelloides (L.) Voss., *Siebert 3912*, Perennial or biennial, herb or shrub.

Felicia muricata (Thunb.) Nees subsp. *muricata*, *Davoren & Siebert 187*, Perennial, evergreen, dwarf shrub.

Festuca arundinacea Schreb.*, *Lubbe & Siebert 116*, Perennial, graminoid.

Ficus carica L.*, *Molebatsi & Siebert 54*, Perennial, shrub or tree.

Ficus benjamina L.*, *Siebert 3403*, Perennial, large evergreen tree or shrub.

Ficus pumila L.*, *Lubbe & Siebert 71*, Perennial, evergreen climber, herb.

Flaveria bidentis (L.) Kuntze*, *Davoren 373*, Annual, erect herb.

Fraxinus angustifolia Vahl.*, *Molebatsi & Siebert 41*, Perennial, tree.

Fraxinus pennsylvanica Marsh.*, *Siebert 3391*, Perennial, medium deciduous tree.

Fraxinus velutina Torr. var. *velutina**, *Siebert 3385*, Perennial, large deciduous tree.

Freylinia tropica S.Moore, *Siebert 3930*, Perennial, shrub.

Gaillardia aristata Pursh.*, *Molebatsi & Siebert 45*, Perennial, herb.

Gardenia angusta (L.) Merr.*, *Siebert 3449*, Perennial, small evergreen shrub.

Gaura lindheimeri Engelm. & A. Gray.*, *Lubbe & Siebert 54*, Perennial, herb.

Gazania krebsiana Less. subsp. *serrulata* (DC.) Roessler, *Davoren 8*, Perennial, rosette herb.

Geigeria burkei Harv. subsp. *burkei* var. *zeyheri* (Harv.) Merxm., *Davoren & Siebert 86*, Perennial, herb.

Geigeria burkei Harv. subsp. *fruticulosa* Merxm., *Davoren 9*, Perennial, herb.

Geranium macrorrhizum L.*, *Siebert 3940*, Perennial, herb.

Ginkgo biloba L.*, *Siebert 3358*, Perennial, large deciduous tree.

Gisekia africana (Lour.) Kuntze var. *africana*, *Davoren & Siebert 184*, Annual, prostrate herb.

Gisekia pharnacioides L. var. *pharnacoides*, *Davoren & Siebert 201*, Annual, prostrate herb.

Gladiolus dalenii Van Geel subsp. *dalenii*, *Siebert 3944*, Perennial, herb, geophyte.

Gladiolus permeabilis D.Delaroche subsp. *edulis* (Burch. ex Ker Gawl.) Oberm., *Davoren & Siebert 152*, Perennial, geophyte.

Gleditsia triacanthos L.*, *Siebert 3404*, Perennial, medium deciduous shrub or tree.

Gnaphalium nelsonii Burtt Davy, *Davoren & Siebert 107*, Perennial, decumbent herb.

Gnidia burchellii (Meisn.) Gilg, *Davoren & Cilliers 51*, Perennial, deciduous, dwarf shrub.

Gnidia polycephala (C.A.Mey.) Gilg, *Davoren & Cilliers 50*, Perennial, deciduous, dwarf shrub.

Gomphocarpus fruticosus (L.) Aiton f. subsp. *decipiens* (N.E.Br.) Goyder & Nicholas, *Davoren & Siebert 115*, Perennial, herb or deciduous dwarf shrub.

Gomphostigma virgatum (L.f.) Baill., *Siebert 3921*, Perennial, shrub, dwarf shrub or herb.

Gomphrena celosioides Mart.*, *Davoren & Siebert 278*, Perennial, prostrate herb.

Grevillea rosmarinifolia A.Cunn.*, *Lubbe & Siebert 52*, Perennial, shrub.

Grevillea robusta A.Cunn.*, *Molebatsi & Siebert 30*, Perennial, tree.

Grewia flava DC., *Davoren & Siebert 172*, Perennial, deciduous, shrub.

Grewia occidentalis L. var. *occidentalis*. *Siebert 3451*, Perennial, evergreen small tree or large deciduous shrub.

Guilleminea densa (Willd. ex Roem. & Schult.) Moq.*, *Davoren & Siebert 276*, Perennial, prostrate herb.

Gymnosporia polyacantha (Sond.) Szyszyl. subsp. *vaccinifolia* (P. Conrath) M.Jordaan., *Molebatsi & Siebert 94*, Perennial, tree or shrub.

Halleria lucida L., *Siebert 3361*, Perennial, small deciduous tree or shrub.

Harpagophytum procumbens (Burch.) DC. ex Meisn. subsp. *procumbens*, *Davoren 16*, Perennial, Prostrate herb.

Hebe salicifolia (G. Forst.) Pennell.*, *Lubbe & Siebert 51*, Perennial, evergreen shrub.

Hedera canariensis Willd.*, *Siebert 3419*, Perennial, evergreen climber, vine.

Hedera helix L. var. *helix**, *Lubbe & Siebert 2*, Perennial, evergreen climber, vine.

Helichrysum argyrosphaerum DC., *Davoren & Siebert 386*, Annual, decumbent herb.

Helichrysum caespititium (DC.) Harv., *Davoren & Siebert 145*, Perennial, creeping herb.

Helichrysum cerastioides DC. var. *cerastioides*, *Davoren & Siebert 144*, Perennial, erect herb.

Helichrysum rugulosum Less., *Lubbe & Siebert 122*, Perennial, herb.

Heliotropium ciliatum Kaplan, *Davoren 21*, Perennial, erect herb.

Heliotropium lineare (A.DC.) Gürke., *Davoren & Siebert 139*, Perennial, erect herb.

Heliotropium nelsonii C.H.Wright., *Davoren 38*, Perennial, erect herb.

Hemerocallis aurantiaca Baker.*, *Siebert 3910*, Perennial, herb.

Hemerocallis lilioasphodelus L.*, *Siebert 3943*, Perennial, herb.

Hermannia comosa Burch. ex DC., *Davoren & Siebert 57*, Perennial, erect herb.

Hermannia linnaeoides (Burch.) K.Schum., *Davoren & Siebert 292*, Perennial, prostrate herb.

Hermannia modesta (Ehrenb.) Mast., *Davoren & Siebert 296*, Perennial, erect herb.

Hermannia quartiniana A.Rich., *Davoren & Siebert 256*, Perennial, prostrate herb.

Hermannia stellulata (Harv.) K.Schum., *Davoren 25*, Perennial, prostrate herb.

Hermannia tomentosa (Turcz.) Schinz ex Engl., *Davoren 20*, Perennial, trailing herb.

Herniaria erckertii Herm. subp. *erckertii* var. *erckertii*, *Molebatsi & Siebert 39*, Perennial, herb.

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

Hibiscus pusillus Thunb., *Davoren 346*, Perennial, erect herb.

Hibiscus rosa-sinensis L.*, *Siebert 3450*, Perennial, small deciduous tree or shrub.

Hibiscus syriaca L.*, *Lubbe & Siebert 43*, Perennial, shrub.

Hibiscus trionum L.*, *Davoren & Siebert 213*, Annual, erect herb.

Houttuynia cordata Thunb.*, *Lubbe & Siebert 56*, Perennial, herb.

Hydrangea macrophylla (Thunb.) Ser.*, *Siebert 3379*, Perennial, small deciduous shrub.

Hydrangea quercifolia Bertram.*, *Lubbe & Siebert 124*, Perennial, shrub.

Hymenosporum flavum (Hook.) R.Br. ex F.Meull.*, *Siebert 3433*, Perennial, small evergreen tree or shrub.

Hypericum calycinum L.*, *Lubbe & Siebert 53*, Perennial, prostrate, shrub.

Hypertelis salsoloides (Burch.) Adamson var. *mossamendesis* (Welw. ex Hiern) Gonc. *Davoren & Siebert 313*, Perennial, succulent herb.

Iberis sempervirens L.*, *Lubbe & Sibert 99*, Perennial, shrub.

Iberis umbellata L.*, *Lubbe 168*, Annual, herb.

Ilex aquifolium L.*, *Siebert 3322*, Perennial, small evergreen tree or shrub.

Ilex crenata Thunb.*, *Siebert 3388*, Perennial, large evergreen tree or shrub.

Indigofera alternans DC. var. *alternans*., *Molebatsi & Siebert 90*, Perennial, herb.

Indigofera daleoides Benth. ex Harv. var. *daleoides*, *Davoren & Siebert 149*, Perennial, erect herb.

Indigofera filipes Benth. ex Harv., *Davoren & Siebert 129*, Perennial, erect herb.

Indigofera heterotricha DC., *Davoren & Siebert 391*, Perennial, deciduous dwarf shrub or herb.

Indigofera rhytidocarpa Benth. ex Harv. subsp. *rhytidocarpa*, *Davoren & Siebert 279*, Annual, erect herb.

Ipomoea albivenia (Lindl.) Sweet., *Molebatsi & Siebert 19*, Perennial, climber ,shrub.

Ipomoea batatas (L.) Lam.*, *Siebert 3928*, Annual or Perennial, herb.

Ipomoea bolusiana Schinz, *Davoren & Siebert 116*, Perennial, scandent herb.

Ipomoea hochstetteri House, *Davoren 405*, Annual, climbing herb.

Ipomoea obscura (L.) Ker Gawl. var. *obscura*, *Davoren & Siebert 105*, Perennial, scrambling herb.

Ipomoea ommaneyi Rendle, *Davoren & Siebert 89*, Perennial, trailing herb.

Ipomoea purpurea (L.) Roth.*, *Siebert 3301*, Annual, climber, herb.

Iresine herbstii Lindl.*, *Davoren & Siebert 62*, Perennial, erect herb.

Jamesbrittenia atropurpurea (Benth.) Hilliard subsp. *atropurpurea*, *Davoren & Siebert 340*, Perennial, erect shrub.

Jamesbrittenia aurantiaca (Burch.) Hilliard, *Davoren & Siebert 286*, Perennial, erect herb.

Jasminum humile L.*, *Lubbe & Siebert 83*, Perennial, shrub.

Jatropha multifida L., *Molebatsi & Siebert 34*, Perennial, shrub.

Juncus effusus L., *Siebert 3985*, Perennial, herb.

Kalanchoe longiflora Schltr. ex J.M.Wood., *Molebatsi & Siebert 47*, Perennial, dwarf shrub, succulent.

Kalanchoe rotundifolia (Haw.) Haw., *Davoren 374*, Perennial, succulent, herb.

Kerri japonica (L.) DC.*, *Lubbe 159*, Perennial, deciduous shrub.

Kiggelaria africana L., *Siebert 3362*, Perennial, medium evergreen tree or shrub.

Kleinia longiflora DC., *Molebatsi & Siebert 64*, Perennial, succulent shrub.

Kohautia subverticillata (K.Schum.) D.Mantell subsp. *subverticillata*, *Davoren & Siebert 327*, Perennial, erect herb.

Kyllinga alba Nees, *Davoren & Siebert 180*, Perennial, cyperoid herb.

Kyphocarpa angustifolia (Moq.) Lopr., *Davoren & Siebert 182*, Annual, erect herb.

Lactuca inermis Forssk., *Molebatsi & Siebert 87*, Perennial, herb.

Lagerstroemia indica L.*, *Siebert 3363*, Perennial, small deciduous shrub or tree.

Lamium galeobdolon Crantz*, *Lubbe & Siebert 46*, Perennial, herb.

Lampranthus roseus (Willd.) Schwantes, *Davoren & Siebert 197*, Perennial, decumbent succulent herb.

Lantana camara L.*, *Molebatsi & Siebert 51*, Perennial, shrub.

Lantana rugosa Thunb., *Lubbe & Siebert 149*, Perennial, deciduous dwarf shrub.

Lapeirousia plicata (Jacq.) Diels subsp. *plicata*, *Davoren 370*, Perennial, geophyte.

Laurus nobilis L.*, *Siebert 3319*, Perennial, large evergreen shrub.

Lavandula angustifolia Mill. var. *angustifolia**, *Lubbe 160*, Perennial, herb.

Lavandula latifolia Medik.*, *Siebert 3922*, Annual, herb.

Lavandula stoechas L.*, *Siebert 3923*, Perennial, shrub.

Ledebouria macowanii (Baker) S.Venter, *Davoren 43*, Perennial, geophyte.

Ledebouria marginata (Baker) Jessop., *Molebatsi & Siebert 22*, Perennial, geophyte.

Lepidium bonariense L.*, *Siebert 3488*, Annual, herb.

Leptospermum scoparium J.R. & G. Forst.*, *Lubbe & Siebert 100*, Perennial, tree or shrub.

Leucaena leucocephala (Lam.) de Wit subsp. *leucocephala**, *Molebatsi & Siebert 67*, Perennial, tree or shrub.

Leucanthemum maximum (Ramond) DC.*, *Lubbe & Siebert 45*, Annual, herb.

Leucas capensis (Benth.) Engl., *Davoren & Siebert 306*, Perennial, deciduous dwarf shrub.

Leucosidea sericea Eckl. & Zeyh., *Siebert 3343*, Perennial, small evergreen tree or shrub.

Ligustrum ibota Siebold & Zucc.*, *Siebert 3318*, Perennial, large evergreen shrub.

Ligustrum lucidum Aiton*, *Siebert 3310*, Perennial, medium evergreen tree or shrub.

Limeum fenestratum (Fenzl) Heimerl var. *fenestratum*, *Davoren & Siebert 140*, Annual, erect herb.

Limeum pauciflorum Moq., *Molebatsi & Siebert 37*, Perennial, herb.

Limeum sulcatum (Klotzsch) Hutch. var. *sulcatum*, *Davoren & Siebert 205*, Annual, erect herb.

Limeum viscosum (J.Gay) Fenzl subsp. *viscosum* var. *kraussii* Friedrich, *Davoren & Siebert 302*, Annual, creeping, herb.

Limeum viscosum (J.Gay) Fenzl subsp. *viscosum* var. *viscosum*, *Davoren & Siebert 222*, Annual, herb, creeper.

Linaria maroccana Hook.f.*, *Lubbe & Cilliers 111*, Annual, herb.

Lippia scaberrima Sond., *Davoren & Siebert 259*, Perennial, erect herb.

Liquidambar styraciflua L.*, *Siebert 3429*, Perennial, large deciduous tree.

Liriodendron tulipifera L.*, *Siebert 3452*, Perennial, small deciduous tree.

Liriope muscari (Decne.) L.H. Bailey.*, *Siebert 3982*, Perennial, herb.

Lithospermum cinereum A.DC., *Davoren & Siebert 97*, Perennial, erect herb.

Litogyne gariepina (DC.) Anderb., *Davoren & Siebert 318*, Perennial, herb or evergreen dwarf shrub.

Lonicera sempervirens L.*, *Lubbe & Siebert 18*, Perennial, vine.

Lotononis calycina (E.Mey.) Benth., *Davoren & Siebert 177*, Perennial, erect herb.

Lotononis listii Polhill, *Davoren & Siebert 293,* Perennial, creeping herb.

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

Lycium cinereum Thunb., *Davoren 381,* Perennial, deciduous, dwarf shrub.

Lycium horridum Thunb., *Davoren & Siebert 156*, Perennial, deciduous, dwarf shrub.

Lycopersicon esculentum Mill. var. *esculentum**, *Siebert 3917,* Annual or perennial, herb.

Macfadyena unguis-cati (L.) A.H.Gentry*, *Siebert 3377*, Perennial, deciduous climber, vine.

Mackaya bella Harv., *Siebert 3973,* Perennial, tree, shrub.

Magnolia grandiflora L.*, *Siebert 3309,* Perennial, medium evergreen tree.

Mahonia aquifolium Nutt.*, *Siebert 3335*, Perennial, small evergreen shrub.

Mahonia lomariifolia Takeda*, *Siebert 3338*, Perennial, small evergreen shrub.

Malephora crocea (Jacq.) Schwantes, *Siebert 3939,* Perennial, succulent.

Malva neglecta Wallr.*, *Lubbe & Siebert 17*, Perennial, herb.

Malva parviflora L. var. *parviflora**, *Lubbe & Siebert 21*, Annual, occ. perennial, herb

Malva sylvestris L.*, *Lubbe & Siebert 10,* Biennial, herb.

Malva verticillata L. var. *verticillata**, *Davoren 379,* Annual, erect herb.

Marsilea macrocarpa C.Presl, *Davoren & Siebert 317*, Perennial, hydrophytic fern.

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

Medicago sativa L.*, *Siebert 3989*, Perennial, herb.

Melaleuca armillaris Sm.*, *Lubbe 169*, Perennial, tree or shrub.

Melhania acuminata Mast. var. *acuminata*., *Davoren & Siebert 216*, Perennial, erect herb.

Melia azedarach L.*, *Siebert 3365*, Perennial, large deciduous tree.

Melianthus comosus Vahl, *Siebert 3387*, Perennial, small deciduous shrub or tree.

Melilotus alba Desr.*, *Siebert 3950*, Annual, herb.

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

Melinis repens (Willd.) Zizka subsp. *repens, Davoren 27*, Annual, graminoid.

Melolobium calycinum Benth., *Davoren 380*, Perennial, deciduous dwarf shrub.

Menodora africana Hook., *Lubbe & Siebert 121,* Perennial, dwarf shrub or herb.

Mentha spicata L.*, *Siebert 3929,*Perennial, herb.

Merremia verecunda Rendle, *Davoren & Siebert 257*, Annual, scrambling herb.

Mirabilis jalapa L.*, *Davoren & Siebert 301*, Perennial, herb.

Modiola caroliniana (L.) G. Don.*, *Lubbe & Siebert 80*, Annual, herb.

Mollugo cerviana (L.) Ser. ex DC. var. *cerviana*, *Davoren & Siebert 151*, Annual, rosette herb.

Momordica balsamina L., *Davoren & Siebert 103*, Perennial, climbing herb.

Monechma divaricatum (Nees) C.B.Clarke, *Davoren & Cilliers 54*, Perennial, dwarf shrub.

Monsonia angustifolia E.Mey. ex. A.Rich., *Davoren 360*, Annual, erect herb.

Morus alba L.*, *Siebert 3371*, Perennial, medium deciduous tree or shrub.

Mundulea sericea (Willd.) A.Chev., *Davoren & Siebert 261*, Perennial, tree or shrub.

Myrtus communis L. var. *communis**, *Lubbe & Siebert 70*, Perennial, tree or shrub.

Nandina domestica Thunb.*, *Siebert 3304*, Perennial, small evergreen shrub.

Nerine laticoma (Ker Gawl.) T.Durand & Schinz, *Davoren & Siebert 247*, Perennial, geophyte.

Nerium oleander L.*, *Siebert 3366*, Perennial, large evergreen shrub.

Nicotiana glauca Graham*, *Davoren & Siebert 194*, Perennial, evergreen shrub, occ. tree.

Nicotiana tabacum L.*, *Molebatsi & Siebert 73*, Annual, occ. Perennial, shrub or herb.

Nidorella resedifolia DC. subsp. *resedifolia*, *Davoren & Siebert 137*, Annual, erect herb.

Nierembergia linarifolia Graham var. *glabriuscula* (Dunal) Cocucci & Hunz.*, *Lubbe & Cilliers 125*, Perennial, herb.

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

Nothoscordum borbonicum Kunth*, *Lubbe & Siebert 14*, Perennial, geophyte.

Ocimum angustifolium Benth., *Davoren & Siebert 260*, Perennial, erect herb.

Oenothera rosea L'H, r. ex Aiton*, *Siebert 3958*, Perennial, herb.

Olea europaea L. subsp. *africana* (Mill.) P.S.Green. *Siebert 3341*, Perennial, medium evergreen tree or shrub.

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

Opuntia imbricata (Haw.) DC.*, *Davoren & Siebert 328*, Perennial, evergreen, succulent shrub.

Orbea lutea (N.E.Br.) Bruyns subsp. *lutea*, *Davoren & Siebert 299*, Perennial, succulent herb.

Ornithogalum prasinum Lindl., *Molebatsi & Siebert 2*, Perennial, geophyte.

Ornithogalum tenuifolium F. Delaroche subsp. *tenuifolium*, *Molebatsi & Siebert 93*, Perennial, geophyte.

Ornithoglossum dinteri K.Krause, *Davoren & Siebert 114*, Perennial, geophyte.

Ornithoglossum vulgare B.Nord., *Davoren 47*, Perennial, geophyte.

Orthanthera jasminiflora (Decne.) Schinz, *Davoren & Siebert 91*, Perennial, creeping herb.

Osteospermum muricatum E.Mey. ex DC. subsp. *muricatum*, *Davoren 406*, Perennial, erect herb.

Oxalis articulata Sav. subsp. *articulata, Siebert 3913,* Perennial, geophyte.

Oxalis depressa Eckl. & Zeyh.*, *Davoren & Siebert 305*, Perennial, geophyte.

Oxygonum dregeanum Meisn. subsp. *canescens* (Sond.) Germish. var. *canescens*, *Davoren & Siebert 126*, Annual, erect herb.

Panicum coloratum L. var. *coloratum*, *Davoren & Siebert 288*, Perennial, graminoid.

Parkinsonia aculeata L.*, *Lubbe & Siebert 34*, Perennial, tree, shrub.

Parthenocissus quinquefolia (L.) Planch.*, *Siebert 3405,* Perennial, deciduous climber, vine.

Paspalum distichum L., *Davoren & Siebert 322*, Perennial, graminoid.

Passiflora X *allardii* Lynch.*, *Siebert 3942*, Perennial, herb.

Pavonia burchellii (DC.) R.A.Dyer., *Davoren & Siebert 163*, Perennial, deciduous, dwarf shrub.

Pelargonium hortorum *, *Molebatsi & Siebert 55*, Perennial, shrub or herb.

Pelargonium reniforme Curtis subsp. *reniforme, Siebert 3934,* Perennial, dwarf shrub.

Peltophorum africanum Sond., *Siebert 3440,* Perennial, medium deciduous tree.

Pennisetum clandestinum Hochst. Ex Chiov.*, *Molebatsi & Siebert 74*, Perennial, graminoid.

Pentarrhinum insipidum E. Mey., *Van der Walt 4B*, Perennial, climber.

Pentzia calcarea Kies, *Davoren & Siebert 82*, Perennial, suffrutex.

Pentzia globosa Less., *Davoren & Siebert 99*, Perennial, evergreen dwarf Shrub.

Pergularia daemia (Forssk.) Chiov. var. *daemia*, *Davoren & Siebert 164*, Perennial, scrambling herb.

Petrea volubilis L.*, *Siebert 3435*, Perennial, deciduous climber, vine or shrub.

Phaseolus vulgaris L. var. *vulgaris**, *Siebert 3916,* Annual, herb, shrub.

Philodendron selloum K.Koch.*, *Siebert 3974*, shrub.

Phormium tenax J.R. & G.Forst.*, *Siebert 3987,* Perennial, shrub or herb.

Photinia glabra (Thunb.) Maxim.*, *Siebert 3350,* Perennial, large evergreen shrub.

Phyllanthus maderaspatensis L., *Davoren & Siebert 154,* Annual, erect herb.

Phyllanthus parvulus Sond. var. *garipensis* (E.Mey. ex Drège) Radcl.-Sm., *Davoren & Siebert 307,* Perennial, dwarf shrub or herb.

Physalis angulata L.*, *Siebert 3955*, Annual, herb.

Physalis viscosa L.*, *Lubbe & Siebert 9,* Perennial, herb.

Pinus halepensis Mill. var. *halepensis**, *Siebert 3320*, Perennial, large evergreen tree.

Pittosporum tenuifolium Gaertn.*, *Siebert 3423*, Perennial, small evergreen tree.

Plantago lanceolata L.*, *Lubbe & Siebert 132*, Perennial, herb.

Plantago major L.*, *Siebert 3956*, Perennial, herb.

Plantanus occidentalis L.*, *Lubbe & Siebert 64*, Perennial, tree.

Platanus hybrida Brot.*, *Siebert 3378*, Perennial, large deciduous tree.

Platanus wrightii S.Watson*, *Siebert 3454*, Perennial, large deciduous tree.

Plectranthus ciliatus E.Mey.ex Benth., *Siebert 3986*, Perennial, herb.

Plectranthus neochilus Schltr., *Lubbe & Siebert 50*, Annual, occ. Perennial, herb, succulent.

Plumbago auriculata Lam., *Siebert 3328*, Perennial, small evergreen shrub.

Poa annua L.*, *Lubbe & Siebert 7*, Annual, graminoid.

Poa pratensis L.*, *Lubbe 167*, Perennial, graminoid.

Podocarpus elongatus (Aiton) L'Her. ex Pers., *Siebert 3346*, Perennial, large evergreen tree or shrub.

Podocarpus falcatus (Thunb.) R.Br. ex Mirb.,*Siebert 3353*, Perennial, large evergreen tree.

Podocarpus henkelii Stapf ex Dallim. & Jacks., *Siebert 3308*, Perennial, large evergreen tree.

Podocarpus latifolius (Thunb.) R.Br. ex Mirb., *Siebert 3331*, Perennial, large evergreen tree.

Podranea ricasoliana (Tanfani) Sprague, *Lubbe & Siebert 68*, Perennial, scrambler, occ. Shrub.

Pogonarthria squarrosa (Roem. & Schult.) Pilg., *Davoren & Siebert 230*, Perennial, graminoid.

Polygala leptophylla Burch. var. *leptophylla*, *Davoren & Siebert 130*, Perennial, erect herb.

Polygala myrtifolia L.var. *myrtifolia*, *Siebert 3927*, Perennial, shrub.

Populus deltoideus Bartram ex Marsh subsp. *wislizenii* (S.Watson) Eckenw.*, *Siebert 3410*, Perennial, medium deciduous tree.

Portulaca grandiflora Hook., *Davoren & Siebert 246*, Annual, prostrate succulent herb.

Portulaca kermesina N.E.Br., *Davoren & Siebert 223*, Annual, prostrate succulent herb.

Portulaca oleracea L.*, *Davoren 363*, Annual, prostrate succulent herb.

Portulaca quadrifida L.*, *Davoren & Siebert 77*, Annual, prostrate succulent herb.

Primula obconica Hance.*, *Lubbe & Cilliers 115*, Annual or perennial, herb.

Prosopis glandulosa Torr. var. *torreyana* (Benson) Johnst.*, *Davoren & Siebert 200*, Perennial, deciduous tree.

Prunus armeniaca L.*, *Siebert 3420*, Perennial, small deciduous tree.

Prunus cerasifera Ehrh.*, *Siebert 3357*, Perennial, small deciduous tree.

Prunus persica (L.) Batsch. var. *persica**, *Siebert 3441*, Perennial, small deciduous tree.

Prunus x domestica L.*, *Siebert 3434*, Perennial, small deciduous tree.

Pseudognaphalium lutea-album (L.) Hillard & B.L. Burtt*, *Siebert 3949*, Annual, herb.

Ptycholobium plicatum (Oliv.) Harms subsp. *plicatum*, *Molebatsi & Siebert 27*, Perennial, dwarf shrub, herb.

Punica granatum L.*, *Siebert 3414*, Perennial, small evergreen tree or shrub.

Pupalia lappacea (L.) A.Juss. var. *lappacea*, *Davoren 345*, Annual, scandent herb.

Pyracantha coccinea M.Roem.*, *Siebert 3317*, Perennial, large evergreen shrub.

Pyracantha crenulata (D.Don) M.Roem.*, *Lubbe & Siebert 30*, Perennial, shrub.

Pyrus communis L.*, *Siebert 3456*, Perennial, small deciduous tree.

Quercus acutissima Carruth.*, *Siebert 3432*, Perennial, medium deciduous tree.

Quercus palustris Du Roi*, *Siebert 3401*, Perennial, medium deciduous tree.

Quercus reticulata Humb. & Bonpl.*, *Siebert 3428*, Perennial, large evergreen tree.

Quercus robur L.*, *Siebert 3367*, Perennial, large deciduous tree.

Ranunculus multifidus Forssk., *Siebert 3957*, Perennial, herb.

Raphiolepis indica Lindl.*, *Siebert 3408*, Perennial, small evergreen shrub.

Raphionacme hirsuta (E.Mey.) R.A.Dyer., *Lubbe & Siebert 141*, Perennial, geophyte, herb.

Requienia sphaerosperma DC., *Davoren 408*, Perennial, trailing herb.

Rhamnus prinoides L'Her., *Siebert 3347*, Perennial, small evergreen tree or shrub.

Rhigozum brevispinosum Kuntze., *Molebatsi & Siebert 8*, Perennial, shrub or tree.

Rhus erosa Thunb., *Siebert 3348*, Perennial, large evergreen shrub.

Rhus lancea L.f., *Davoren & Siebert 75*, Perennial, medium evergreen tree, or shrub.

Rhus leptodictya Diels, *Siebert 3368*, Perennial, small evergreen tree or shrub.

Rhus pendulina Jacq., *Siebert 3390*, Perennial, small evergreen tree, shrub.

Rhus pyroides Burch. var. *pyroides*, *Siebert 3389*, Perennial, medium deciduous tree, shrub.

Rhynchosia confusa Burtt Davy, *Davoren & Siebert 310*, Perennial, climbing herb.

Rhynchosia minima (L.) DC. var. *minima*, *Davoren 30*, Perennial, climbing herb.

Robinia pseudoacacia L.*, *Siebert 3418*, Perennial, small deciduous shrub or tree.

Rosa banksiae R.Br. var. *banksiae**, *Siebert 3467*, Perennial, deciduous climber, shrub.

Rosa x rehderiana Blackb.*, *Siebert 3457*, Perennial, small deciduous shrub.

Rosmarinus officinalis L. var. *officinalis**, *Siebert 3409*, Perennial, small evergreen shrub.

Ruschia ruralis (N.E.Br.) Schwantes, *Molebatsi & Siebert 4,* Perennial, succulent.

Ruta graveolens L., *Molebatsi & Siebert 42,* Perennial, dwarf shrub or shrub, herb.

Salix babylonica L. var. *pekinensis* Henry*, *Lubbe & Siebert 23*, Perennial, decidous tree.

Salvia disermas L., *Davoren & Siebert 285*, Perennial, erect herb.

Salvia farinacea Benth., *Lubbe & Siebert 77,* Perennial, herb.

Salvia greggii A. Gray*, *Siebert 3941*, Perennial, herb.

Salvia leucantha Cav.*, *Lubbe & Siebert 33,* Perennial, herb.

Salvia microphylla Kunth.*, *Davoren & Siebert 383*, Perennial, evergreen dwarf shrub.

Salvia runcinata L.f., *Davoren & Siebert 96*, Perennial, erect herb.

Salvia splendens Sellow ex Roem. Schult., *Lubbe & Siebert 96,* Perennial, herb or shrub.

Sambucus nigra L. subsp. *nigra**, *Davoren & Siebert 294,* Perennial, deciduous, shrub.

Sansevieria aethiopica Thunb., *Davoren & Siebert 252,* Perennial, succulent geophyte.

Saponaria officinalis L.*, *Siebert 3925*, Perennial, herb.

Schinus molle L.*, *Davoren & Siebert 272,* Perennial, evergreen large tree.

Schinus terebinthifolius Raddi var. *acutifolius* Engl.*, *Siebert 3306*, Perennial, medium evergreen tree.

Schkuhria pinnata (Lam.) Cabrera*, *Davoren & Siebert 67,* Annual, erect herb.

Schmidtia pappophoroides Steud., *Davoren & Siebert 239*, Perennial, graminoid.

Schoenoplectus corymbosus (Roem & Schult.) J. Raynal., *Siebert 3947,* Perennial, cyperoid herb.

Schoenoplectus muricinux (C.B.Clarke) J.Raynal, *Davoren & Siebert 316*, Perennial, cyperoid herb.

Sciadopitys verticillata (Thunb.) Siebold & Zucc.*, *Lubbe & Siebert 29,* Perennial, evergreen tree.

Sebaea grandis (E.Mey.) Steud., *Davoren & Siebert 118,* Annual, erect herb.

Selago mixta Hillard, *Davoren & Siebert 110*, Perennial, erect herb.

Senecio tamoides DC., *Davoren & Siebert 384,* Perennial, evergreen climber shrub or herb, succulent.

Senecio venosus Harv. *Lubbe & Siebert 157*, Perennial, herb.

Senna italica Mill. subsp. *arachoides* (Burch.) Lock, *Davoren 3*, Perennial, herb.

Sericorema remotiflora (Hook.f.) Lopr., *Molebatsi & Siebert 6,* Perennial, herb.

Sesamum capense Burm.f., *Davoren & Siebert 203,* Annual, erect herb.

Sesamum triphyllum Welw. ex Asch. var. *triphyllum*, *Davoren & Siebert 210*, Annual, erect herb.

Setaria pumila (Poir.) Roem. & Schult., *Davoren & Siebert 388,* Annual, graminoid.

Sida acuta Burm.f. var. *acuta, Davoren & Siebert 212,* Annual, erect herb.

Sida chrysantha Ulbr., *Davoren & Siebert 153*, Perennial, decumbent herb.

Sida cordifolia L., *Davoren & Siebert 98*, Annual, occ. Perennial, deciduous, dwarf shrub.

Sida rhombifolia L. subsp. *rhombifolia*, *Lubbe & Siebert 134*, Annual, biennial, dwarf shrub, herb.

Sida spinosa L. var. *spinosa*, *Lubbe & Siebert 135*, Annual, occ. Perennial, dwarf shrub, herb.

Sisymbrium turczaninowii Sond.*, *Lubbe & Siebert 37*, Annual, herb.

Smodingium argutum E.Mey.ex Sond., *Siebert 3464*, Perennial, small deciduous tree, scrambler.

Solanum elaeagnifolium Cav.*, *Lubbe & Siebert 40*, Perennial, herb or subshrub.

Solanum nigrum L.*, *Davoren & Siebert 214*, Annual, erect herb.

Solanum panduriforme E.Mey., *Davoren 365*, Perennial, erect herb.

Solanum rantonnetii Carri Šre.*, *Davoren 402*, Perennial, evergreen shrub.

Solanum supinum Dunal var. *supinum*, *Davoren & Siebert 76*, Perennial, erect herb.

Solanum wrightii Benth.*, *Lubbe 162*, Perennial, shrub.

Solidago canadensis L.*, *Davoren & Siebert 193*, Perennial, rosette herb.

Sonchus nanus Sond.ex Harv., *Molebatsi & Siebert 80*, Perennial, herb.

Sonchus oleraceus L.*, *Davoren 38*2, Annual, erect herb.

Spartium junceum L.*, *Siebert 3417*, Perennial, large evergreen shrub.

Spermacoce senensis (Klotzsch) Hiern, *Davoren 39*, Annual, erect herb.

Spiraea arguta Hoffm.-Grob.*, *Davoren & Siebert 69*, Perennial, shrub.

Spiraea cantonensis Lour.*, *Siebert 3380*, Perennial, small evergreen shrub.

Sporobolus africanus (Poir.) A.Robyns & Tournay, *Lubbe 164*, Perennial, graminoid.

Sprekelia formosissima Herb.*, *Lubbe & Siebert 20*, Perennial, geophyte.

Stachys byzantina C. Koch.*, *Lubbe & Siebert 81*, Perennial, creeper, herb.

Stachys spathulata Burch.ex. Benth., *Lubbe & Siebert 137*, Perennial, herb.

Stellaria media (L.) Villi.*, *Lubbe & Siebert 8*, Annual, herb.

Stipagrostis uniplumis (Licht.) De Winter var. *neesii* (Trin. & Rupr.) De Winter., *Molebatsi & Siebert 59*, Perennial, graminoid.

Strelitzia reginae Aiton, *Siebert 3443*, Perennial, large evergreen shrub.

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

Styphnolobium japonicum (L.) Schott.*, *Lubbe & Siebert 61*, Perennial, tree.

Sutera cordata (Thunb.) Kuntze, *Lubbe & Siebert 16*, Perennial, herb.

Symphytum officinale L.*, *Lubbe & Siebert 76*, Perennial, herb.

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

Talinum arnotii Hook.f., *Davoren 368*, Annual, prostrate succulent herb.

Talinum crispatulum Dinter ex Poelln., *Davoren & Siebert 221*, Annual, prostrate succulent herb.

Talinum portulacifolium (Forssk.) Asch.ex Schweinf., *Lubbe & Siebert 102*, Annual, occ. Perennial, shrub.

Tamarix ramosissima Ledeb.*, *Siebert 3466*, Perennial, large evergreen shrub or tree.

Tanacetum parthenium (L.) Sch. Bip.*, *Lubbe 161*, Annual, herb.

Tarchonanthus camphoratus L., *Davoren & Siebert 189*, Perennial, evergreen tree or shrub.

Taxodium distichum (L.) A.Rich. var. *distichum**, *Siebert 3402*, Perennial, large deciduous tree.

Tecomaria capensis (Thunb.) Lindl., *Siebert 3369*, Perennial, small deciduous shrub.

Tephrosia burchellii Burtt Davy, *Davoren & Siebert 135*, Annual, scandent herb.

Tephrosia lupinifolia DC., *Davoren & Siebert 124*, Annual, trailing herb.

Terminalia sericea Burch. ex DC., *Molebatsi & Siebert 95*, Perennial, tree.

Teucrium trifidum Retz., *Davoren & Siebert 389*, Perennial, erect herb.

Thunbergia alata Bojer ex Sims, *Siebert 3933*, Perennial, climber, herb.

Tipuana tipu (Benth.) Kuntze*, *Siebert 3442*, Perennial, large deciduous tree.

Trachelospermum jasminoides Lam.*, *Siebert 3400*, Perennial, small evergreen shrub, vine.

Trachyandra laxa (N.E.Br.) Oberm. var. *laxa*, *Davoren & Siebert 123*, Perennial, rosette herb.

Trachyandra saltii (Baker) Oberm. var.*saltii*, *Davoren & Siebert 283*, Perennial, geophyte.

Trachycarpus fortunei (Hook.) H.Wendl.*, *Siebert 3445*, Perennial, small evergreen tree.

Tradescantia pallida (Rose) D.R.Hunt.*, *Molebatsi & Siebert 62*, Perennial, herb.

Tragopogon dubius Scop.*, *Siebert 3983*, Biennil, herb.

Tragus koelerioides Asch., *Davoren & Siebert 250*, Perennial, graminoid.

Tragus racemosus (L.) All., *Davoren & Siebert 242*, Annual, graminoid.

Tribulus terrestris L., *Davoren & Siebert 330*, Annual, prostrate herb.

Tripteris aghillana DC. var. *aghillana*., *Lubbe & Siebert 139*, Perennial, succulent, herb.

Triraphis schinzii Hack., *Davoren 367*, Perennial, graminoid.

Triumfetta sonderi Ficalho & Hiern, *Lubbe & Siebert 154*, Perennial, dwarf shrub.

Trochomeria hookeri Harv., *Molebatsi & Siebert 11*, Perennial, climber, prostrate, herb.

Tulbaghia natalensis Baker, *Lubbe & Siebert 127*, Perennial, herb.

Ulmus parvifolia Jacq.*, *Siebert 3370*, Perennial, medium deciduous tree.

Ulmus procera Salisb.*, *Siebert 3399*, Perennial, medium deciduous tree.

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

Verbena aristigera S.Moore.*, *Molebatsi & Siebert 75*, Perennial, herb.

Verbena bonariensis L.*, *Davoren & Siebert 320*, Annual, erect herb.

Verbena officinalis L.*, *Siebert 3948*, Annual, herb.

Verbesina encelioides (Cav.) Benth. & Hook. var. *encelioides**, *Davoren & Siebert 204*, Annual, erect herb.

Vernonia galpinii Klatt., *Lubbe & Siebert 153*, Perennial, herb.

Vernonia oligocephala (DC.) Sch.Bip.ex Walp., *Lubbe & Siebert 140*, Perennial, herb.

Vernonia poskeana Vatke & Hildebr. subsp. *botswanica* G.V.Pope, *Davoren & Siebert 397*, Annual, erect herb.

Vernonia steetziana Oliv. & Hiern., *Davoren & Siebert 146*, Annual, erect herb.

Viburnum odoratissimum Ker Gawl. var. *odaratissimum**, *Siebert 3427*, Perennial, large evergreen shrub.

Viburnum sinensis Zeyh. ex Colla*, *Siebert 3312*, Perennial, large evergreen shrub.

Viburnum suspensum Lindl.*, *Siebert 3325*, Perennial, large evergreen shrub.

Viburnum tinus L.*, *Siebert 3326*, Perennial, large evergreen shrub.

Viola odorata L.*, *Siebert 3990*, Perennial, herb.

Viola tricolor L.*, *Lubbe & Siebert 11*, Annual, rarely perennial, herb.

Vitex agnus-castus L.*, *Lubbe 163*, Perennial, tree or shrub.

Vitex trifolia L. var. *trifolia**, *Molebatsi & Siebert 31*, Perennial, shrub or tree.

Vitis vinifera L.*, *Siebert 3407*, Perennial, deciduous climber, shrub or vine.

Wahlenbergia denticulata (Burch.) A.DC. var. *denticulata*, *Davoren & Siebert 157*, Perennial, erect herb.

Wahlenbergia undulata (L.f.) A.DC., *Davoren & Siebert 106*, Perennial, erect herb.

Waltheria indica L., *Davoren & Siebert 390*, Annual, erect herb.

Weigelia florida (Bunge) A.DC.*, *Siebert 3395*, Perennial, small deciduous shrub.

Wisteria sinensis (Sims) Sweet*, *Siebert 3439*, Perennial, deciduous climber, vine.

Xanthium spinosum L.*, *Davoren 348*, Annual, erect herb.

Xanthium strumarium L.*, *Davoren & Siebert 266*, Annual, erect herb.

Zinnia elegans Jacq.*, *Molebatsi & Siebert 44,* Annual, herb.

Zinnia peruviana (L.) L.*, *Davoren & Siebert 161*, Annual, erect herb.

Ziziphus mucronata Willd. subsp. *mucronata*, *Davoren 14,* Perennial, deciduous tree.

Ziziphus zeyheriana Sond., *Davoren & Siebert 55,* Perennial, deciduous dwarf shrub.

Zornia milneana Mohlenbr., *Davoren & Siebert 138,* Perennial, erect herb.