

Health clinic gardens in North-West Province, South Africa, as complex social-ecological systems

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PREFACE AND ACKNOWLEDGEMENTS

Living in South Africa gave me the opportunity to grow up with diversity – diversity of cultures, diversity of personalities and beliefs, diversity of rich and poor, diversity of flora and fauna and an incredible amount of different biomes. Having this privilege, I learned many life-lessons I believe I would not have learned growing up in a different setting. It taught me the value of diversity and species richness and its crucial role in adaptation and survival. South Africa has a fascinating wealth, not measured in economic status but measured in a unique mix of fauna and flora, human races and cultures, geology and biomes. It is also a great pleasure and privilege to be part of studies on the intricate ecology and sociology associated with this country.

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ABSTRACT

The world's urban population (54%) is currently increasing. The fastest growth rates are expected to occur in urban areas of Africa and Asia. Since urban areas will continue to expand, ecological studies should also take social influences into consideration. Changes in social-ecological systems are often studied by using a resilience thinking approach. The diversity of biophysical and social factors can play an important role in maintaining resilience of a social-ecological system. Complex or "wicked" problems can occur at the interface of social and ecological systems which contain many interacting factors making it difficult to solve. Poverty, food and nutrition security and biodiversity loss are some of South Africa's main "wicked" problems. Although food is available in most parts of South Africa, the nutrient content of the food consumed is not sufficient. Health clinics were established across South Africa (in urban and rural areas) to provide free health care, but their gardens may also have several advantages. The first aim of this study was to determine the plant species composition, floristic and functional diversity at each health clinic garden and to compare it to home/domestic gardens in the North-West Province as well as over the different local municipalities of the Bojanala District Municipality. The second aim was to determine the resource diversity (social and physical) of these gardens and to compare them over the different local municipalities. The third aim was to determine the perceptions of the different stakeholders on ecosystem services and disservices at health clinic gardens. A subset of best practice clinics was also identified which can contribute towards developing a management framework to ensure a more resilient system of health clinic gardens in South Africa. Results showed that health clinic gardens are similar to home/domestic gardens in the North-West Province regarding dominant families, dominant genera and species representation except for the greater diversity of exotic ornamental species and endangered species present in home/domestic gardens. No clear difference could be found between local municipalities according to plant species composition. There was greater physical and social resource diversity at Moses Kotane and Moretele Local municipalities than at Rustenburg (physical) and Madibeng (social) Local municipalities. Although the individual perceptions of the stakeholders differed according to their role at the clinic garden, results showed that food and sense of place (as well as the spiritual value of the garden) were overall perceived as the most important ecosystem services of clinic gardens. Damonsville, Leseding and Reagile clinics obtained the highest score in comparison with other health clinic gardens in the Bojanala District Municipality and are good examples of best practise regarding diversity of natural, social and physical resources as well as perceptions of ecosystem services. It is suggested that the health clinic gardens should be managed using a step-by-step approach, starting with the limitations at the best practice (highest ranking scores) health clinic gardens. Communication between all stakeholders involved at the clinic gardens as

well as with the community is one of the key factors that can contribute to successful management of health clinic gardens.

Key words: Urbanisation, social-ecological systems, resilience, nutrition security, urban gardens, health clinic gardens

OPSOMMING

Die stedelike wêreldbevolking (54%) is tans besig om toe te neem. Die vinnigste groei koers word in Afrika en Asië verwag. Aangesien stedelike omgewings besig is om uit te brei, moet ekologiese studies ook sosiale invloede in ag neem. Veranderinge in sosio-ekologiese sisteme word dikwels bestudeer deur van die veerkragtigheidsbenadering gebruik te maak. Die diversiteit van biofisiese en sosiale faktore kan 'n belangrike rol in die handhawing van veerkragtigheid in 'n sosio-ekologiese sisteem speel. Ingewikkelde, moeilik oplosbare ("wicked") probleme wat baie interaktiewe faktore bevat, kan by die koppelvlak van sosiale en ekologiese sisteme voorkom. Armoede, voedsel- en nutriëntsekerheid asook biodiversiteitsverlies is sommige van hierdie probleme wat tans in Suid-Afrika heers. Alhoewel voedsel in meeste dele van Suid-Afrika beskikbaar is, is die voedingswaarde van die voedsel wat ingeneem word, nie voldoende nie. Gesondheidsklinieke is in stedelike en plaaslike dele van Suid-Afrika gestig om gratis gesondheidsorg te verskaf. Die tuine van hierdie klinieke kan ook verskeie voordele vir die gemeenskap inhou. Die eerste doelwit van hierdie studie was om die plantspesiesamestelling, floristiese en funksionele diversiteit by elke gesondheidskliniektuin te bepaal. Hierdie aspekte van gesondheidskliniektuine is ook met huistuine in die Noordwesprovinsie sowel as oor die verskillende plaaslike munisipaliteite van die Bojanala Distrikmunisipaliteit vergelyk. Die tweede doelwit was om die hulpbrondiversiteit (sosiale en fisiese) van hierdie tuine te bepaal en om dit oor die verskillende plaaslike munisipaliteite te vergelyk. Die derde doelwit was om die persepsies van die verskillende deelnemers aan tuinboupraktyke op ekosisteedienste en -nie-dienste by gesondheidskliniektuine te bepaal. 'n Versameling van "beste praktyk" klinieke, wat kan bydra tot die ontwikkeling van 'n bestuursraamwerk, is geïdentifiseer. Hierdie klinieke het die potensiaal om 'n meer veerkragtige sisteem van gesondheidskliniektuine in Suid-Afrika te verseker. Die resultate het getoon dat gesondheidskliniektuine baie ooreenkomste toon met huistuine in die Noordwesprovinsie in terme van dominante plantfamilies, -genusse en -spesies. Die enigste verskille is 'n groter diversiteit van uitheemse ornamentele spesies en bedreigde spesies wat in huistuine teenwoordig is. Geen duidelike verskil kon tussen plaaslike munisipaliteite volgens plantspesiesamestelling gevind word nie. Daar was 'n groter fisiese en sosiale hulpbrondiversiteit by Moses Kotane en Moretele Plaaslike Munisipaliteite as by Rustenburg (fisiese) en Madibeng (sosiale) Plaaslike Munisipaliteite. Alhoewel die individuele persepsies van die deelnemers volgens hulle rol by die kliniektuine verskil het, het resultate getoon dat voedsel en "sin van plek" (asook die spirituele waarde van die tuin) algeheel as die belangrikste ekosisteedienste van kliniektuine beskou is. Damonsville-, Leseding- en Reagileklinieke het die hoogste puntetelling (in terme van natuurlike, sosiale en fisiese hulpbrondiversiteit, asook persepsies van ekosisteedienste) in vergelyking met die ander gesondheidskliniektuine in die

Bojanala Distrikmunisipaliteit, verkry. Daar word voorgestel dat die gesondheidskliniektuine deur 'n stap-vir-stap benadering bestuur moet word waar daar by die beperkinge van die “beste praktyk” (met die beste puntetelling) gesondheidsklinieke begin word. Kommunikasie tussen alle deelnemers wat betrokke by die kliniektuine is asook met die gemeenskap, is een van die sleutelfaktore wat kan bydra tot die suksesvolle bestuur van gesondheidskliniektuine.

Sleuteltermes: Verstedeliking, sosio-ekologiese sisteme, veerkragtigheid, voedingstofsekuriteit, stedelike tuine, gesondheidskliniektuine.

TABLE OF CONTENTS

PREFACE AND ACKNOWLEDGEMENTS.....	4
ABSTRACT	6
OPSOMMING	8
CHAPTER 1 - INTRODUCTION.....	24
1.1 Problem statement and research rationale.....	24
1.2 Background: The Tswana People	26
1.2.1 Social and economic aspects of the Tswana People	26
1.3 Research aims and objectives.....	27
1.4 Layout and chapter division	28
1.5 Materials and methods.....	28
1.5.1 Study Area.....	28
1.5.2 Overall sampling methods and data analysis	31
1.5.3 Data analysis	33
CHAPTER 2 - LITERATURE REVIEW	36
2.1 Introduction	36
2.2 Urbanisation	36
2.3 Social-ecological systems	37
2.3.1 Social-ecological frameworks	37
2.3.2 Social-ecology in urban environments	38
2.4 Food security.....	38
2.5 Urban agriculture and urban gardens.....	39
2.5.1 Global urban gardening	40

2.5.2 Urban gardening in Africa	40
2.5.3 Plant species composition in urban gardens.....	41
2.6 Complex adaptive systems and resilience	42
2.6.1 Diversity of plant species	43
2.6.2 Resource diversity	43
2.7 Ecosystem services and disservices.....	45
2.8 Summary.....	46
 CHAPTER 3 - PLANT SPECIES COMPOSITION CONTRIBUTING TO THE NATURAL RESOURCE DIVERSITY OF HEALTH CLINIC GARDENS IN THE BOJANALA DISTRICT MUNICIPALITY	 48
3.1. Introduction	48
3.2. Materials and methods.....	51
3.2.1 Sampling and data analysis	51
3.3 Results.....	54
3.3.1 All health clinic gardens	54
3.3.1.1 Dominant families	54
3.3.1.2 Plant genera representation.....	54
3.3.1.3 Plant species representation.....	56
3.3.1.4 Endemic species	57
3.3.1.5 Endangered and protected species	58
3.3.1.6 Invasive species	59
3.3.1.7 Origin of naturalised and cultivated alien species	60
3.3.1.8 Representation of growth forms and Raunkiaer's life-forms	61
3.3.1.9 Species with potential uses.....	63

3.3.2 Comparison of local municipalities:.....	64
3.3.3 Comparison of micro-gardens.....	66
3.4. Discussion	68
3.4.1 Dominant families	68
3.4.2 Dominant genera and plant species representation	69
3.4.3 Endemic species	70
3.4.4 Endangered and protected species	70
3.4.5 Invasive species	71
3.4.6 Origin of naturalised and cultivated alien species	71
3.4.7 Representation of growth forms and Raunkiaer's life-forms.....	71
3.4.8 Species with potential uses	72
3.4.9 Comparison of local municipalities.....	73
3.4.10 Comparison of micro-gardens.....	73
3.5. Conclusion.....	74
 CHAPTER 4 –PHYSICAL AND SOCIAL RESOURCE DIVERSITY AT HEALTH CLINIC GARDENS IN THE BOJANALA DISTRICT MUNICIPALITY, SOUTH AFRICA	 78
4.1. Introduction	78
4.2. Materials and methods.....	81
4.3. Results....	84
4.3.1 Total cover area and available area.....	84
4.3.2 Total physical resources	85
4.3.3 Stakeholder diversity	90
4.3.4 Stakeholder abundance	91

4.3.5 Knowledge about gardening	92
4.3.6 Time spent in the garden	94
4.3.7 Motivations for starting a garden.....	95
4.4 Discussion	96
4.4.1 Total cover area and available areas	96
4.4.2 Total physical resources	96
4.4.3 Stakeholder diversity and abundance	98
4.4.4 Knowledge about gardening	99
4.4.5 Time spent in the garden	99
4.4.6 Motivations for starting a garden.....	100
4.4.7 Constraints & problems in resource provision.....	100
4.5 Conclusion.....	100
 CHAPTER 5 - HEALTH CLINIC GARDENS AS COMMUNITIES OF PRACTICE:	
STAKEHOLDERS' PERCEPTIONS ON ECOSYSTEM SERVICES AND DISSERVICES....	106
5.1. Introduction	106
5.2. Material and methods.....	110
5.3. Results....	113
5.3.1 Comparison of ecosystem services as perceived by stakeholders.....	113
5.3.2 Comparison of ecosystem disservices as perceived by the stakeholders	116
5.3.3 Difference in stakeholders' perceptions	117
5.3.4 Themes derived from open questions.....	118
5.4. Discussion	119
5.4.1 Comparison of ecosystem services as perceived by stakeholders.....	119

5.4.2 Comparison of ecosystem disservices as perceived by the stakeholders	121
5.4.3 Difference in stakeholders' perceptions	121
5.4.4 Themes derived from open questions.....	123
5.5. Conclusion.....	125
 CHAPTER 6 – BEST PRACTICE HEALTH CLINIC GARDENS.....	 128
6.1 Introduction	128
6.2 Methods... ..	129
6.2.1 Physiognomic and floristic diversity	129
6.2.2 Physical and social resources diversity.....	130
6.2.3 Perceptions of ecosystem services and disservices	130
6.2.4 Consolidation of data.....	131
6.3 Results..... ..	131
6.3.1 Rustenburg Local Municipality	131
6.3.2 Moses Kotane Local Municipality.....	132
6.3.3 Madibeng Local Municipality.....	133
6.3.4 Moretele Local Municipality	134
6.3.5 Bojanala District Municipality	135
6.4 Discussion	136
6.4.1 Rustenburg Local Municipality	136
6.4.2 Moses Kotane Local Municipality.....	137
6.4.3 Madibeng Local Municipality.....	138
6.4.4 Moretele Local Municipality	138
6.4.5 Bojanala District Municipality	139

6.5 Conclusion.....	139
CHAPTER 7 – CONCLUSION	144
7.1 Introduction	144
7.2 Contributing aspects of health clinic gardens to resilience-building strategies	145
7.3 Implementation of the information from this dissertation	146
7.4 Future studies.....	147
BIBLIOGRAPHY	149
ANNEXURES.....	171

LIST OF TABLES

Table 3-1: Best represented plant families of health clinic gardens in Bojanala District Municipality	55
Table 3-2: Best represented plant genera of health clinic gardens in Bojanala District Municipality	55
Table 3-3: The most frequent occurring plant species of health clinic gardens in Bojanala District Municipality.	56
Table 3-4: The most frequent occurring endemic plant species of health clinic gardens in Bojanala District Municipality.....	57
Table 3-5: Endangered and protected species found in health clinic gardens in Bojanala District Municipality	59
Table 3-6: The most frequent occurring invasive plant species in health clinic gardens in Bojanala District Municipality.....	60
Table 3-7: Most frequent occurring edible plant species in health clinic gardens of Bojanala District Municipality.....	64
Table 3-8: Most frequent occurring medicinal plants in health clinic gardens of Bojanala District Municipality	64
Table 4-1: Potential stakeholders (social resources) that can be involved at health clinic gardens and the roles they play (adapted from Cilliers <i>et al.</i> , in press).....	81
Table 4-2: Potential physical resources at health clinic gardens in the Bojanala District Municipality.	82
Table 4-3: Scores of physical resources at health clinic gardens in the Bojanala District Municipality.	83
Table 4-4: Scores for time spent on gardening and gardening knowledge at health clinic gardens in the Bojanala District Municipality.	84
Table 4-5: Largest health clinic gardens surveyed in the Bojanala District Municipality.	85
Table 4-6: Health clinic gardens in the Bojanala District Municipality with highest scores regarding total physical resources.....	87

Table 4-7: Resilience-building categories (adapted from Camps-Calvet <i>et al.</i> , (2015)) and its application for health clinic gardens in the Bojanala District Municipality.	102
Table 5-1: Example of questions asked in the interview of different stakeholders at health clinic gardens of the Bojanala District Municipality.	111
Table 5-2: Example of how the Likert scale was used in the questionnaire.....	112
Table 5-3: Ecosystem services at health clinic gardens as perceived by the stakeholders	114
Table 5-4: Ecosystem disservices as perceived by the stakeholders involved in health clinic gardens of the Bojanala District Municipality	116
Table 5-5: The manner in which communities of practice are fostered in home gardens versus health clinic gardens (adapted from Taylor & Lovell, (2014))	126
Table 6-1: Health clinic gardens with the highest ranking in Rustenburg Local municipality ..	132
Table 6-2: Health clinic gardens with the highest ranking in Moses Kotane Local Municipality	133
Table 6-3: Health clinic gardens with the highest ranking in Madibeng Local Municipality	134
Table 6-4: Health clinic gardens with the highest ranking in Moretele Local Municipality	135
Table 6-5: Health clinic gardens with the highest ranking in Bojanala District Municipality.....	136
Table 6-6: Summary of results on top scored health clinic gardens	139
Table 7-1: Resilience-building strategies and contributing aspects at health clinic gardens in the Bojanala District Municipality.	146
Table 8-1: Questionnaire used for the survey at health clinic gardens in the Bojanala District Municipality, North-West Province, South Africa.....	171
Table 8-2: Questionnaire used to determine stakeholders' perceptions on ecosystem services and disservices at health clinic gardens	173
Table 8-3: List of total physical resources at each clinic garden	176
Table 8-4: Post hoc test (ANOVA) of water supply at the different local municipalities	177
Table 8-5: Post hoc test (ANOVA) of equipment at the different local municipalities.....	177

Table 8-6: Post hoc test (ANOVA) of fertilising used at the different local municipalities.....	177
Table 8-7: Pearson correlation of resources and distance to local municipality offices	177
Table 8-8: Post hoc test (ANOVA) of gardening knowledge over the different local municipalities	178
Table 8-9: Correlation between distance to local municipality office as well as species richness in the garden and gardening knowledge of the groundsmen	178
Table 8-10: Post hoc test (ANOVA) of time spent in the gardens over the different local municipalities	178

LIST OF FIGURES

Figure 1-1: Study Area: Local municipalities of the Bojanala District Municipality, North West Province (NW), South Africa.	30
Figure 1-2: Vegetation types of Bojanala District Municipality, North West Province (NW), South Africa, compiled from (Mucina & Rutherford, 2006).	31
Figure 3-1: Geographical origin of alien species in health clinic gardens in Bojanala District Municipality	61
Figure 3-2: Representation of growth forms in health clinic gardens of Bojanala District Municipality	62
Figure 3-3: Representation of Raunkiaer's life-forms in health clinic gardens of Bojanala District Municipality	62
Figure 3-4: Number of plant species with potential uses found in health clinic gardens of Bojanala District Municipality.....	63
Figure 3-5: Non-metric Multidimensional Scaling (NMDS) of plant species composition and cover abundance in health clinic gardens to show the difference between the Local Municipalities of Bojanala District Municipality	65
Figure 3-6: Differences in the number of species in each micro-garden of health clinic gardens in Bojanala District Municipality.	66
Figure 3-7: Comparison of exotic (naturalised), exotic (cultivated), native and indigenous species of the different micro-gardens in health clinic gardens in the Bojanala District Municipality.....	67
Figure 3-8: Percentage species of each growth form found in the micro-gardens of health clinic gardens in the Bojanala District Municipality.....	67
Figure 3-9: Distribution of Raunkiaer's life-forms in each micro-garden of health clinic gardens in the Bojanala District Municipality	68
Figure 4-1 (A) Comparison of total area and (B) available area of health clinic gardens over the different local municipalities in the Bojanala District Municipality (different symbols show statistical significant differences).	85
Figure 4-2: Distribution of total physical resources over the Bojanala District Municipality	86

Figure 4-3: Deviation from average of total physical resources (10.07) at each health clinic garden in the Bojanala District Municipality.	87
Figure 4-4: NMDS of total resource composition at each health clinic garden comparing the different local municipalities in the Bojanala District Municipality.	88
Figure 4-5: Comparison of water supply (A), irrigation methods (B), gardening equipment (C) and fertilising (D) in the different local municipalities of Bojanala District Municipality (different symbols indicate statistical significant differences)	89
Figure 4-6: Deviation from average water and irrigation supply at each health clinic garden in the Bojanala District Municipality.	89
Figure 4-7: Stakeholder diversity of health clinic gardens in the Bojanala District Municipality (green areas indicate high diversity and red areas, low diversity)	90
Figure 4-8: Stakeholder abundance at health clinic gardens in the Bojanala District Municipality	91
Figure 4-9: Percentage of health clinic gardens in the different local municipalities where stakeholders are involved.....	92
Figure 4-10: Gardening knowledge scores compared over the different local municipalities of Bojanala District Municipality.....	93
Figure 4-11: Deviation from average gardening knowledge scores at health clinic gardens in the different local municipalities of Bojanala District Municipality	93
Figure 4-12: Gardening knowledge vs number of species with potential uses in different local municipalities	94
Figure 4-13: Time spent in health clinic gardens (days per month) compared over the different local municipalities in the Bojanala District Municipality	95
Figure 4-14: Motivations for starting a garden at the clinics in the different local municipalities	95
Figure 4-15: Rating of social (S) and physical (P) resources at each local municipality of the Bojanala District Municipality regarding the traffic light concept: green = good; yellow = medium; red = bad	101

Figure 5-1: Potential stakeholders at health clinic gardens in the Bojanala District Municipality indicating their current involvement.....	107
Figure 5-2: Percentage of stakeholders that perceived the ecosystem service at health clinic gardens in the Bojanala District Municipality, as valuable (that gave a score of 4/5 out of 5 to the service) and a comparison between the scores given by the stakeholders at the different local municipalities.	115
Figure 5-3: A) Differences between the high scores (4/5 or 5/5) given by the stakeholders to the ecosystem services at health clinic gardens in the Bojanala District Municipality and B) the difference between local municipalities according to the percentage of stakeholders that gave a high score (4/5 or 5/5) for cultural services.	115
Figure 5-4: Comparison of rated disservices at the different local municipalities in the Bojanala District Municipality.....	116
Figure 5-5: Comparison of perceptions of facility managers, caregivers and groundsmen on ecosystem services at health clinic gardens in the Bojanala District Municipality. Red and orange areas indicate a low score and negative perception, while green areas indicate high scores and positive perceptions.	117
Figure 5-6: Difference in perceptions of groundsmen and facility managers on ecosystem services at health clinic gardens in the Bojanala District Municipality.	118
Figure 5-7: Themes obtained from the open questions asked in the interviews at health clinic gardens in the Bojanala District Municipality.....	119
Figure 5-8: The roles of the stakeholders involved at health clinic gardens in the Bojanala District Municipality. NGO's and THP's are abbreviations for Non-governmental Organisations and Traditional Health Practitioners respectively.	123
Figure 6-1: Health clinic gardens with the highest ranking in Rustenburg Local Municipality .	132
Figure 6-2: Health clinic gardens with the highest ranking in Moses Kotane Local Municipality	133
Figure 6-3: Health clinic gardens with the highest ranking in Madibeng Local Municipality	134
Figure 6-4: Health clinic gardens with the highest ranking in Moretele Local Municipality	135

Figure 6-5: Health clinic gardens with the highest ranking in the Bojanala District

Municipality	136
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Chapter 1 - Introduction

“Differences are not intended to separate, to alienate. We are different precisely in order to realize our need of one another.”

— Archbishop Desmond Tutu



CHAPTER 1 - INTRODUCTION

1.1 Problem statement and research rationale

Fifty-four percent of the world's population are presently living in cities (Elmqvist *et al.*, 2013; McPearson *et al.*, 2016; United Nations (UN), 2014). This percentage is expected to increase in the future (Elmqvist *et al.*, 2013; McPearson *et al.*, 2016; United Nations (UN), 2014). The fastest growth rates (up to 5 %) will occur in urban areas of Africa and Asia (Elmqvist *et al.*, 2013; McPearson *et al.*, 2016; United Nations (UN), 2014). Urbanisation can be described as the multifaceted expansion of urban areas and rapid invasion of natural land cover (Elmqvist *et al.*, 2013; Enqvist *et al.*, 2014; McPhearson *et al.*, 2016). Since urban areas will continue to expand, it is impossible to study aspects of ecological systems, while ignoring the impacts of social systems (Redman *et al.*, 2004).

Resilience thinking is one of the approaches used to study and examine changes in social-ecological systems (Cote & Nightingale, 2012). Resilience can be defined as the ability of a system to maintain its functions when a disturbance occurs (Gunderson & Holling, 2001). A social-ecological system consists of the continuous interaction between biophysical and social factors in a resilient and sustainable manner (Redman *et al.*, 2004; Rogers *et al.*, 2013). To maintain resilience, diversity of biophysical (Elmqvist *et al.*, 2003), and social factors (Tëngo *et al.*, 2014) plays an important role. Each aspect (ecological/social) has different attributes and functions within the system and a wide variety of aspects therefore increase the system's ability to adapt to different situations or disturbances (Elmqvist *et al.*, 2003; Colding & Barthel, 2013). Some of the natural processes occurring in ecosystems can provide benefits for humans also known as ecosystem services (Gómez-Baggethun & Barton 2013; Millennium Ecosystem Assessment (MEA), 2005; TEEB, 2011). Ecosystem disservices, however, are natural processes which have a negative influence on social systems (Lyytimäki *et al.*, 2008; Dörhen & Haase, 2015). Since interactions in social-ecological systems are not necessarily linear, a complexity frame of mind is needed to make sense of the heterogeneity of the structure, relationships and properties materialising from these processes (Rogers *et al.*, 2013).

The interface of social and ecological systems presents complex problems or “wicked” problems which are difficult to formulate because of too many determining and interacting factors and of which the solution is complicated and sometimes confusing (McPhearson *et al.*, 2016; Xiang, 2013).

South Africa is currently struggling with many wicked problems of which food and nutrition security, poverty and biodiversity loss are on the list of top priorities (Faber *et al.*, 2011; McHale *et al.*, 2013; UNDP, 2014). Where enough food is available for the greater parts of the

population of South Africa, nutrition deficiency continues to be a problem (Vorster *et al.*, 2011). The nutrient content of the food consumed by most South Africans is not sufficient and can be described as a “hidden hunger” (Tsegay & Rusare, 2014). This “hidden hunger” persists in 33% of children under five years of age where vitamin A is the major deficient nutrient (UNICEF, 2008). As development and urbanisation invade rural areas in many African countries, traditional food (such as African Leafy Vegetables (ALV’s)) is increasingly replaced by a westernised diet densely packed with unsaturated fats, sugar and oils (Van Jaarsveld *et al.*, 2014; Vorster *et al.*, 2011). Both over- and undernutrition cause diseases decreasing the health of the major part of the society (Vorster *et al.*, 2011).

To improve the primary health care in South Africa, 4277 health clinics were established across the country of which 1600 were upgraded and newly built since 1994 (Pillay & Barron, 2011). Some communities in South Africa are situated in deep rural areas where access to proper health care is minimal and health clinics help to alleviate this problem (Pillay & Barron, 2011). There are two types of primary health care facilities namely, local health clinics and community health centres (Cullinan, 2006). Local health clinics normally operate only for 8 hours a day and provide a range of primary health care services provided by nurses (Cullinan, 2006). Some of the staff is required to sleep at or near the clinic in case an emergency occurs (Cullinan, 2006). Community Health Centres also provide 24-hour maternity and accident/emergency services additionally to primary health care (Cullinan, 2006). There are approximately 30 beds for patients which can be occupied for 48 hours observation (Cullinan, 2006). Four main goals were identified by the Minister of Health South Africa to ensure “A long and healthy life for all South Africans” which is part of the purpose of establishing health clinics (Pillay & Barron, 2011):

- To increase the average life expectancy
- To reduce child and maternal mortality
- To decrease the prevalence of HIV and AIDS as well as the accompanying occurrence of Tuberculosis
- To improve the efficiency of the Health System of South Africa

As the development of the health facilities took place, gardens were also established around the buildings which not only improved the aesthetical aspects at the clinics but also provide green spaces which can be cultivated to provide fresh fruit and vegetables, ensuring a healthier diet for the surrounding community and patients at the clinic.

A unique combination of natural (plant species composition, floristic and functional diversity), physical (gardening equipment, boreholes, water tanks, fertiliser and available space) and social resources (different stakeholders involved in the garden) are present at health clinic gardens which have the potential to be integrated to provide a sustainable food supply. Certain

aspects of the health clinic gardens will be investigated that can have an influence on the resilience of the system. These aspects include the plant species composition, floristic and functional diversity, the availability of resources (natural, physical and social) as well as the stakeholders' perceptions of the ecosystem services and disservices.

Within this study, health clinic gardens in the Bojanala District (consisting of 5 local municipalities) of the North West Province, South Africa, are investigated to provide some insight on the socio-ecological system of health clinic gardens and to offer recommendations, based on best practices, to improve the potential of the clinic gardens. The major ethnic group in the North-West Province is the Tswana People.

1.2 Background: The Tswana People

The Tswana currently live in the eastern and north-western parts of South Africa and were formerly part of the Sotho Group who migrated from northern Africa in several separated unknown time periods (Schapera, 1953; Van Warmelo, 1974). The history of the Tswana People is quite unclear and little is known of the exact time they settled in South Africa (Schapera, 1953). Being people with mostly herding stock, they stayed in areas where grazing was in abundance. The area probably was the Kalahari and north-west South Africa (Schapera, 1953; Van Warmelo, 1974). The tribes living within the margins of this study are called the Bafokeng, Bakgatla-ba-kgafela, Bapo-ba-Mogale and the Bakubung-ba-Ratheo (Mnwana, 2015) which are also governing authorities of the communal lands (inhabitants of these areas must submit to the laws and customs of the tribe (South Africa, 2004)).

1.2.1 Social and economic aspects of the Tswana People

Traditionally, the homes of the Tswana were circular and shaped like a beehive. It consisted of a mixture of grass and mud (Walton, 1956). As protection against wild mammals, reptiles and insects, doors and windows were small and circular and a clean open space was kept around the hut (Molebatsi *et al.*, 2010; Walton, 1956). Along with cattle and goats, the Tswana economy originally consisted of vegetable gardens and cultivated land where crops such as sorghum, maize and sweet cane were planted. Vegetables included pumpkin, melon and different kinds of peas and beans. It was the women's responsibility to care for the gardens and each wife usually had her own garden or gardens (Schapera, 1934).

A certain lay-out is used in the gardens of the Tswana people. Molebatsi *et al.*, (2010) determined that each garden is divided into eight different sections or "micro-gardens":

- Lebala - bare ground around the home to keep snakes and other wild animals at a distance (sometimes the area around the building is paved).

- Naga - natural vegetation where indigenous species are sometimes harvested and used as food or medicine – at clinic gardens, this type of micro-garden can be extensively big, called natural woodland.
- Lawn – this is part of colonial influences and was mostly seen in urban gardens (Davoren *et al.*, 2015).
- Vegetable garden – many indigenous species which form part of African Leafy Vegetables are commonly used (Faber *et al.*, 2010; Janse van Rensburg *et al.*, 2007; Van Jaarsveld *et al.*, 2014).
- Medicinal garden – which can also be cared for by Traditional Health Practitioners (THP's) (Mosina *et al.*, 2014; Ndawonde *et al.*, 2007).
- Ornamental garden – also part of colonial influences (Davoren *et al.*, 2015)
- Hedge – some indigenous species such as *Dononaea viscosa* var. *angustifolia* is shaped to form a hedge around the yard.
- Orchard – fruit trees with medicinal value can also be found such as *Citrus x limon*.

This layout is called the Tswana tshimo layout (Molebatsi *et al.*, 2010) which is also investigated at health clinics gardens in this study.

1.3 Research aims and objectives

This study consists of three major parts namely, natural resource diversity, physical resource diversity and social resource diversity which form part of the social-ecological system at health clinic gardens. The main aim of this study was therefore to determine the natural, physical and social diversity at health clinic gardens in the Bojanala District, North West Province, South Africa so that recommendations, based on best practices, can be made to improve the potential of the gardens. Specific aims and objectives were:

- To determine the plant species composition, floristic and functional diversity at each health clinic garden.
 - To compare the plant species composition and cover abundance over the different local municipalities
 - To compare the micro-gardens of health clinic gardens according to floristics and physiognomic characteristics
- To determine the resource diversity (social and physical) at health clinic gardens
 - To compare the different local municipalities with the aim to organise thoughts toward recommendations for the management of health clinic gardens in each local municipality.
- To determine the perceptions of the different stakeholders on ecosystem services and disservices at health clinic gardens

- To determine the involvement of each stakeholder at the clinic garden
- To identify a subset of best practice clinics which have the potential to increase resilience.
 - To create a scoring system that can be used to score the plant species composition, floristic and physiognomic diversity, physical and social resource diversity as well as the perceptions on ecosystem services.
- To contribute towards developing a management framework to ensure a more resilient system of health clinic gardens that can be applied in other provinces in South Africa and other countries in Sub-Saharan Africa.

1.4 Layout and chapter division

This dissertation consists of 7 chapters. The first chapter (introduction) contains the problem statement and research rationale as well as the aims and objectives of this study. It also provides some background on the Tswana People and the social and economic aspects of their culture. Overall materials and methods including background information on the study area are discussed in this chapter. Chapter 2 (Literature Review) elaborates on recent research on urbanisation, social-ecological systems and the concept of resilience as well as how it applies to social-ecological systems in an urban environment. Research on urban gardens and ecosystem services are also provided. The first results chapter (Chapter 3) depicts the natural resource diversity (plant species composition, floristic and functional diversity) at each health clinic garden compared across the local municipalities. The fourth chapter contains the resource diversity (physical and social) at health clinic gardens also compared across the different local municipalities. The last results chapter (Chapter 5) considers health clinic gardens as communities of practice and the perceptions of the different stakeholders on ecosystem services and disservices. Chapter 6 provide a scoring/ rating system to identify clinics with the most potential to improve resilience (which will also serve as recommendations for the Department of Health of the North-West Province). Chapter 7 contains the conclusion of this study.

1.5 Materials and methods

Since the three result chapters were written in the form of scientific papers, some duplication of information might occur. A broad description of the study area and sampling methods will be given that will be further refined in each results chapter.

1.5.1 Study Area

This study is part of a more comprehensive research project on all health clinic gardens in the North-West Province, South Africa. This province consists of 4 district municipalities namely

Bojanala Platinum District Municipality (Rustenburg region), Dr Kenneth Kaunda District Municipality (Klerksdorp region), Dr Ruth Segomotsi Mompati District Municipality (Vryburg region) and Ngaka Modiri Molema District Municipality (Mafikeng region). These districts are further divided into local municipalities. The extent of this study's surveys is the Bojanala District Municipality (Figure 1-1). Bojanala District covers approximately 18 333 km² and consists of 5 local municipalities. In each local municipality a certain amount of clinics were surveyed: Moses Kotane = 42; Madibeng = 21; Kgetlengrivier = 3; Moretele = 22; Rustenburg = 17 (Figure 1-1). Since Kgetlengrivier Municipality only had three clinics of which two could not be surveyed because of renovations, the data of the remaining clinic was merged with Rustenburg Local Municipality for the purpose of this study to prevent problems in statistical analysis. Rustenburg Local Municipality was chosen, since it is located nearest to Kgetlengrivier Municipality and has the second least number of health clinics.

According to Coetzee & Du Toit (2011), service delivery such as municipal services (especially water supply), basic governmental services (applications and approval for social grants, IDs and passports and registration of births and deaths) and emergency services (response time and condition of ambulances, the fire brigade and police vehicles) are gravely neglected in many communities of South Africa. Citizens also have complaints on the availability of jobs, proper education and resources for training (Coetzee & Du Toit, 2011). In contrast with these negative aspects, Bojanala District Municipality is very rich in minerals and wildlife and contains some of the largest mining industries (80% of the world's known PGM (Platinum Group Metals) reserves), manufacturing development and recreation assets such as the Sun City Hotel and several nature reserves (Pilanesberg National Park, Borakalalo National Park and Madikwe Game Reserve) (Coetzee & Du Toit, 2011; Mnwana, 2015). These platinum reserves occur within the borders of several communal lands (land areas where inhabitants must submit to the laws and customs of the ruling community (South Africa, 2004)) and some are still governed by 'tribal' authorities who belong to the following tribes: Bafokeng, Bakgatla-ba-Kgafela, Bapo-ba-Mogale and Bakubung-ba-Ratheo (Claasens, 2014; Mnwana, 2015). One of the largest communal areas (Moses Kotane Local Municipality) is governed by the Bakgatla-ba-Kgafela tribe and because of their shares in the platinum reserves, they are considered as one of the richest tribes in South-Africa (Mnwana, 2015). The richest tribe in Africa, however, is considered to be the Bafokeng tribe, also living in Bojanala District (Rustenburg Local Municipality) (Manson & Mbenga, 2003). In the middle of the 19th century the capitals of the Bafokeng tribe were situated at Phokeng and Luka which is close to Rustenburg's current location (Manson & Mbenga, 2003) (Figure 1-1).

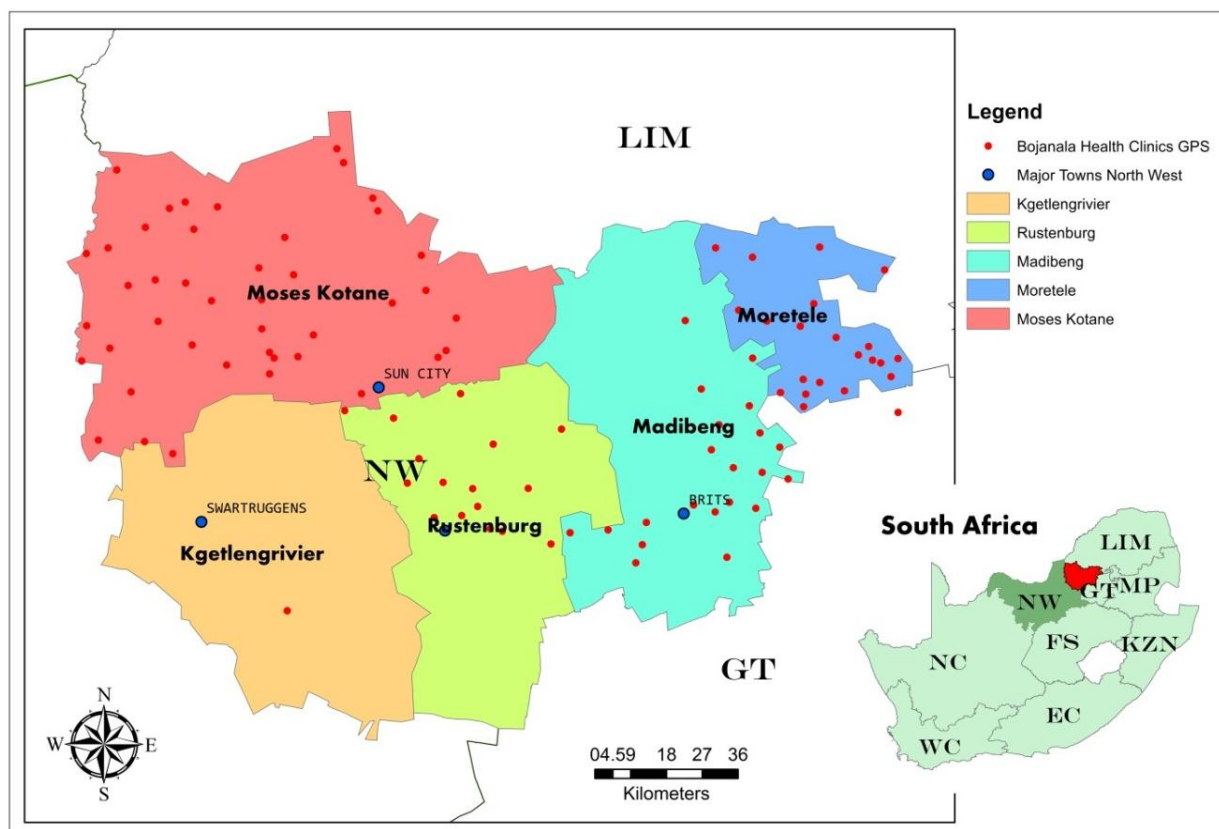


Figure 1-1: Study Area: Local municipalities of the Bojanala District Municipality, North West Province (NW), South Africa.

The study area is situated in the Savanna Biome where Central Bushveld vegetation is dominant and includes 22 vegetation units of which Zeerust Thornveld, Springbokvlakte Thornveld, Pilanesberg Mountain Bushveld, Dwarsberg-Swartruggens Mountain Bushveld, Marikana Thornveld, Moot Plains Bushveld, Rand Highveld Grassland and Central Sandy Bushveld cover the largest areas (Figure 1-2) (Mucina & Rutherford, 2006). The altitude of the study area is between 1000 and 1500 m above sea level and is situated in summer rainfall region of approximately 550-650 mm per year ranging to 700 mm at the eastern side of the area (Mucina & Rutherford, 2006). Frost is frequent in winter and is determinative of the vegetation surviving and growing in this area (Mucina & Rutherford, 2006). The herbaceous layer is dominated by grass species (most abundant) and the tree and shrub layers are mostly dense or open thorny woodland where *Acacia* species are dominant (Mucina & Rutherford, 2006). The geology of this area consists largely of the Pretoria Group (Transvaal Supergroup) in the Zeerust Thornveld, Moot Plains Bushveld, Dwarsberg-Swartruggens Mountain Bushveld, Rand Highveld Grassland and the Dwaalboom Thornveld (Mucina & Rutherford, 2006). The Springbokvlakte Thornveld contains the Karoo Supergroup and the Lebowa Granite Suite and the Rashoop Granophyre Suite occur in the Central Sandy Bushveld (Mucina & Rutherford, 2006). The Pilanesberg Mountain Bushveld contains one of the few largest alkaline ring complexes in the world (Mucina & Rutherford, 2006). The Rustenburg Layered Suite also

occurs in both Marikana Thornveld and the Dwaalboom Thornveld (Mucina & Rutherford, 2006). The mean monthly maximum temperature for the study area is 36.7 °C, while the mean monthly minimum temperature is -0.4°C for summer and winter respectively (Mucina & Rutherford, 2006).

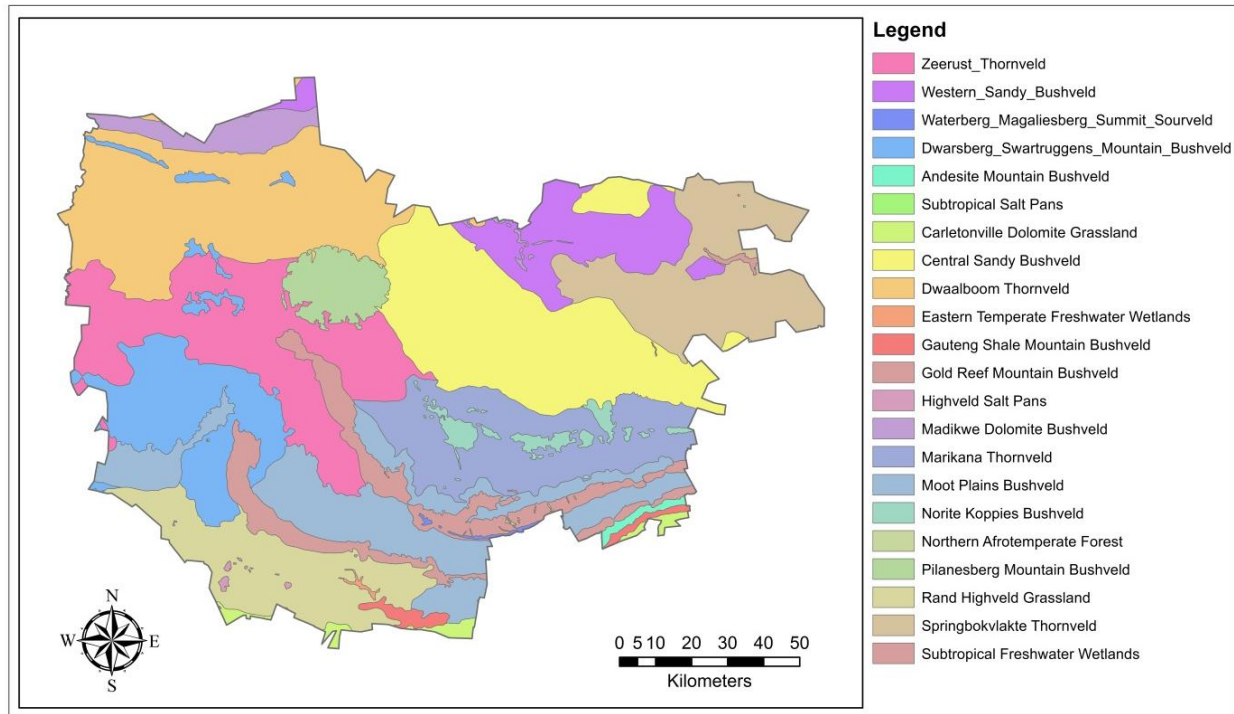


Figure 1-2: Vegetation units of Bojanala District Municipality, North West Province (NW), South Africa, compiled from (Mucina & Rutherford, 2006).

1.5.2 Overall sampling methods and data analysis

Although 114 health clinics exist in Bojanala District, only 103 clinics were suited for surveys because of renovations, lack of space for gardening and non-permanent building sites.

The plant species composition, floristic and physiognomic diversity of each clinic garden was determined (Table 8-1 in the appendix) and compared with similar studies on urban and peri-urban domestic gardens and rural home gardens in the North-West Province (Lubbe *et al.*, 2011; Molebatsi *et al.*, 2013). Although the vegetation units surrounding the gardens differ, home and domestic gardens are similar to health clinic gardens in the sense that they are man-made habitats. Plant species were also classified according to status (exotic naturalised, exotic cultivated, indigenous and native species (Lubbe *et al.*, 2011)), endemic species (including endangered and protected species), invader species, Raunkiaers' life-forms (phanerophytes, chamaephytes, hemicryptophytes, therophytes, geophytes and hydrophytes (Kent, 2012)), growth forms (herbs, herb: graminoids, herb: succulents, shrubs, shrub: succulents, trees, tree: succulents, climbers and parasites), potential usefulness (ornamental, food, shade, hedge,

medicinal uses and other - wooden handles for tools, brooms, hats, string, toothbrushes and perfume, dye for leather or wood, thatch grass and spiritual uses (Lubbe *et al.*, 2011; Molebatsi *et al.*, 2013)) and poisonous plants (causes skin allergies or contact dermatitis, poisonous, very poisonous, deadly (Van Wyk *et al.*, 2002)).

The plant species composition of each clinic garden was also compared across the different local municipalities. The different micro-gardens of health clinic gardens were also compared according to floristic and physiognomic data.

As part of the physical resources, the area covered by each micro-garden was determined as well as the total garden size. Social and other physical resources were recorded using a questionnaire (Table 8-1 in the appendix). Detailed information was collected on the stakeholders involved, time spent on garden activity, gardening knowledge, motivation for gardening and maintenance of the garden. Physical resources such as gardening tools and water sources, irrigation methods and fertiliser/compost use were recorded. Questions were asked on the vegetable uses as well as the origin of seeds and other propagation material.

Data on the perceptions of stakeholders on the provision of ecosystem services and disservices were gathered using questionnaires (Table 8-2 in the appendix). By using the Likert Scale (Gliem & Gliem, 2003), the extent to which services are perceived to be delivered, were recorded. The Likert scale has been successfully used in several other urban garden studies (Calvet-Mir *et al.*, 2012; Goddard *et al.*, 2013; Van Heezik *et al.*, 2012) and to ensure the credibility of the data, the method was applied by only one person throughout the study. Provisioning services evaluated include nutritious food, sources of energy, medicinal plants, construction material and fodder/green manure (Millennium Ecosystem Assessment (MEA), 2005; TEEB, 2011). Regulating services were determined regarding biological control/pollination, soil quality and local climate (Millennium Ecosystem Assessment (MEA), 2005; TEEB, 2011). The provision of habitat for species and the maintenance of genetic diversity regarding supporting services were also determined (Millennium Ecosystem Assessment (MEA), 2005; TEEB, 2011). Cultural services investigated include recreational/mental/physical health, spiritual/sense of place, aesthetical appreciation, social networking and education and science (Millennium Ecosystem Assessment (MEA), 2005; TEEB, 2011). Ecosystem disservices determined in this study include allergies/decline in health, accidents, financial costs, environmental costs, crime (fear and stress), damage to infrastructure and blockage of view (Millennium Ecosystem Assessment (MEA), 2005; TEEB, 2011).

The physical and social resource diversity as well as the perceptions of the stakeholders on ecosystem services and disservices of each health clinic garden was compared over the different local municipalities. A subset of “best practice” clinics which have the most potential to

increase resilience were identified by creating a scoring system to score each health clinic garden regarding these aspects.

1.5.3 Data analysis

The data was analysed by using PRIMER version 6 (2006) and STATISTICA version 12 (2013) (Clarke & Gorley, 2006; StatSoft, Inc. 2013). Basic statistics and correlations such as ANOVA's (Field, 2007) and ordinations (Kent, 2012) was applied to compare the different groups and detect significant differences in plant species composition, resource diversity and the perceptions of the stakeholders on ecosystem service and disservice provision. Several techniques in ArcMAP (GIS) were used to interpolate differences between local municipalities and to give the data a spatial dimension.

Chapter 2 – Literature review



CHAPTER 2 - LITERATURE REVIEW

2.1 Introduction

Through urbanisation, human and natural environments on earth are becoming more integrated - increasing the need for knowledge on the complex interactions between these environments. This chapter provides a review of urbanisation and global trends of urban environments. Research on social-ecological systems are also discussed which give insight on the interactions between social and ecological systems in urban environments and the frameworks in which these systems can be studied. There is a lack of information on urban social-ecology in developing countries which contain unique interactions between social and ecological environments and complex problems including food security. Urban agriculture and urban gardens have been explored in previous research as a possible approach to address food security in urban areas of developing countries. Expansive research has been done on urban gardening globally including developing countries in Africa where the focus has been on the plant species composition and biodiversity of gardens. Information on plant species diversity can give an indication of the ability of a system to adapt, since a variety of functional traits could improve response diversity and in turn maintain the resilience of the system. A diversity of social and physical resources can have the same effect on the adaptability of a system. The benefits humans derive from processes in the natural environment (ecosystem services) can also be affected by the adaptability of the system. A review is also given on disservices caused by ecosystems and the effect it can have on the valuation of ecosystem services.

2.2 Urbanisation

Urbanisation can be defined as the multi-dimensional expanding of urban areas while rapidly changing land cover and human populations (Elmqvist *et al.*, 2013; Enqvist *et al.*, 2014; McPhearson *et al.*, 2016). Globally, natural systems and interactions are changing and urbanisation is one of the key forces behind it (Elmqvist *et al.*, 2013). Current trends in urban areas can be summarized into 5 general directions as suggested by Elmqvist *et al.*, (2013). The first trend is that urban areas are growing faster than the human population and the fastest growth rates are expected to be in Africa and Asia (up to 5 %) (Elmqvist *et al.*, 2013; United Nations (UN), 2015). More than half of the world's population (54% of 7349 million) are currently living in cities (McPhearson *et al.*, 2016; United Nations (UN), 2015). Human population growth in Africa have been 2,55 % annually from 2010-2015 and are expected to increase with 493 million over the next 15 years (United Nations (UN), 2015). The second trend suggests that local and regional climate are changed by the expansion of urban areas since changing surface areas and pollution have a long term effect on weather patterns (Elmqvist *et al.*, 2013;

McPhearson *et al.*, 2016). The third trend refers to the demands on natural resources which are greatly intensified and increased by urbanisation because of materials needed for infrastructure and maintaining the urban economy (Gómez-Baggethun & Barton 2012; Elmqvist *et al.*, 2013). The fourth trend describes that most urbanisation are occurring in or near biodiversity hotspots which is the primary threat to endangered species (Elmqvist *et al.*, 2013; Miller & Hobbs 2002). The last trend claims that “Green Economy” is influenced by urbanisation (Elmqvist *et al.*, 2013). As human systems become increasingly connected to natural systems through urbanisation, the need to define natural capital regarding economic value become progressively important (de Jong *et al.*, 2014; McPhearson *et al.*, 2016).

2.3 Social-ecological systems

When considering the above trends, it is impossible to ignore the impacts of social systems while studying ecological systems in the modern world (Redman *et al.*, 2004). According to Redman *et al.*, (2004) researchers in the past often neglected the relationship between ecological and social systems and tried to solve problems from the perspective of one or the other. Social-ecological systems can therefore be described as coherent systems where biophysical factors regularly interact with social factors in a manner that is resilient and sustainable (Redman *et al.*, 2004; Rogers *et al.*, 2013). Knowledge about the areas where social and environmental dynamics intersect are crucial to create perspective and understanding on how power and competing value systems are integral to the development and effectiveness of a social-ecological system (Cote & Nightingale 2012; Rogers *et al.*, 2013). Complex (“wicked”) problems often occur at the interface of social and ecological systems, since the many interacting factors cause difficulty in identifying the source of problems and also increase the struggle to find sufficient solutions (McPhearson *et al.*, 2016; Xiang, 2013).

2.3.1 Social-ecological frameworks

Binder *et al.*, (2013) suggested that there are three main criteria in which social-ecological frameworks can be classified namely: whether the relationship between the social and ecological system is uni-/ or bidirectional; whether the framework illustrates an anthropocentric or eco-centric perspective and whether the framework is action-oriented or analysis-oriented. One of the most effective frameworks identified by Binder *et al.*, (2013) is the Social-Ecological Systems Framework (SESF), because it addresses social and ecological systems in equal depth and also provides for different degrees of specificity at various levels. This framework aims to create a common vocabulary for researchers of diverse disciplinary backgrounds to develop and discover alternative theories and models which organise the influential variables on the analysing procedure and indicate processes that have an effect on the results of each different study (Binder *et al.*, 2013; McGinnis & Ostrom 2014). An important factor of this

framework is the presumption that humans can make conscious decisions (individually or as a group member) which has the potential to significantly change the outcome (McGinnis & Ostrom 2014). According to Schewenius *et al.*, (2014) the future of urban environments are dependent on an integrated social-ecological systems approach to ensure resilience and sustainability. It is also true that no single framework can be sufficient in accommodating all research issues in a social-ecological system (Binder *et al.*, 2013). Choosing the right framework is dependent on the research question and the conceptualization of both the environmental and social system (Binder *et al.*, 2013).

2.3.2 Social-ecology in urban environments

Research on social-ecology in urban environments has mostly been concentrated in the more developed countries of the Northern Hemisphere, while the fastest rates of urbanisation is occurring in developing countries in the Southern Hemisphere (Lubbe *et al.*, 2010; McConnachie & Shackleton, 2010; McHale *et al.*, 2013). Developing countries, such as South Africa, experience unique social-ecological conditions in which there are a steeper socio-economic gradient from urban to rural than in developed countries (McHale *et al.*, 2013). This socio-economic gradient also influences the management and condition of environmental aspects in the richer and poorer areas which will serve as an indication of this unique pattern (McConnachie & Shackleton, 2010). There is therefore a need to expand the current paradigm of urban social-ecology to encompass the developing world (McHale *et al.*, 2013). Unique conditions and interactions between social and ecological aspects in developing countries also produce complex (“wicked”) problems such as a lack of food security, poverty and biodiversity loss which should be considered from a social-ecological systems perspective in order to find solutions (McHale *et al.*, 2013; Xiang, 2013).

2.4 Food security

Amongst other aspects, mechanisation of commercial farms promotes the movement towards cities and poverty becomes a growing reality in all human settlements (cities, towns and villages). While most urbanites are dependent on commercially grown crops, local food distribution systems become neglected and undermined by economic and political changes (Brown & Jameton, 2000). The fast growing world population cause food security to be one of the major challenges in maintaining sustainability and delaying of the rate of biodiversity loss in food production landscapes (Barthel *et al.*, 2013; Zezza & Tascioti, 2010). According to FAO (2008) food security can be described as: “...the situation when people have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs.” Food security in cities can be threatened by several factors such as low biodiversity, climate change, uninformed management practices, lack of space and finances, inefficient supply of clean water

and a lack of knowledge (Schewenius *et al.*, 2014; Bharwani *et al.*, 2005; Crumley, *et al.* 2013; Barthel & Isendahl 2012; Koyenikan 2007; Reuther & Dewar, 2006a). To ensure global food security, it is not only the biological components of ecosystems that should be considered, but also the knowledge of management practices that relate to these conditions (Barthel *et al.*, 2013; Reuther & Dewar, 2006).

2.5 Urban agriculture and urban gardens

For urbanites, food security has always been one of the most important factors threatening resilience within the cities (Barthel & Isendahl, 2012). By considering ancient civilization, one discovers that urban gardens, urban farming, efficient water management and acknowledgement of social-ecological memories to ensure endurance of these practices, can serve as a key factors in urban support systems and food security over long periods of time (Barthel & Isendahl, 2012; Drechsel & Dongus, 2010). Urban agriculture (using open space within urban areas to plant crops and to produce livestock goods (Drechsel & Dongus, 2010; Zezza & Tasciotti, 2010)) can not only serve as an extra source of income, but also improve social interaction, alleviate boredom and stress and enhance community engagement (Reuther & Dewar 2006; Zezza & Tasciotti 2010; Adekunle *et al.*, 2014). There is, however, some debate between scientists on the economic viability of urban agriculture (Reuther & Dewar 2006) and its capacity to successfully alleviate poverty in developing countries (Ellis & Sumberg, 1998). An incredibly large amount of food is consumed within cities which enlarge the debt when considering the small share they can produce (Gómez-Baggethun & Barton, 2013). In some areas, however, urban agriculture can serve as an essential source of food for urbanites (Barthel & Isendahl 2012; Dixon *et al.* 2009; Gómez-Baggethun & Barton 2012; Zezza & Tasciotti 2010). Urban agriculture has in the past served as a solution for localised food shortages, the degradation of urban communities and urban poverty in both developed and developing countries for a long time (Dixon *et al.*, 2009; Prain & Lee-smith, 2010). Considering the fact that more than half of the global population live in cities, urban agriculture should be the main focus in approaching the future of food and nutrition security (Barthel & Isendahl, 2012; Dixon *et al.*, 2009; Zezza & Tasciotti, 2010). There are numerous social, ecological and health benefits associated with urban agriculture which includes physical health, psychological well-being, environmental education, increase of biodiversity and ecological interactions within cities (Dixon *et al.*, 2009; Zezza & Tasciotti, 2010; Prain & Lee-smith, 2010). Urban agriculture can therefore serve as a holistic approach to food and nutrition security which is more directly connected to the economic, environmental and social factors affecting diet and health than commercialised food production (Dixon *et al.*, 2009; Drechsel & Dongus 2010).

Research on home gardens as sources of food production indicated that these gardens have the potential to significantly increase food and nutrition security in cities as well as have a

positive effect on human health and well-being (Reyes-García *et al.*, 2012; Koyenikan, 2007; Musotsi *et al.*, 2008; Maroyi, 2009; Adekunle *et al.*, 2014). Urban gardens are especially crucial in some developing countries where an economic crisis might drive poor citizens to depend on cheaper food with low nutritional value instead of food with a richer set of micronutrients (Zezza & Tasciotti, 2010). According to Webb (2000) nutrition and health should be key factors in future research addressing urban food gardens and urban agriculture.

2.5.1 Global urban gardening

In Europe and the USA there were several cases of community and domestic gardens that showed potential to improve food provisioning in urban areas as well as encouraging the community to take responsibility for the condition of the immediate environment (Bendt *et al.*, 2013; Chan *et al.*, 2015; Krasny & Tidball, 2009; Okvat & Zautra, 2011). Gardens in urban areas have a unique ability to improve interaction between people and communities and in this way also stimulate environmental learning such as in the case of community gardens in Berlin and New York City (Bendt *et al.*, 2013; Chan *et al.*, 2015). This does not benefit individuals, but also the entire community (Okvat & Zautra, 2011; Siewell *et al.*, 2015). For the individual, community gardens positively influences the psychological condition, physical recovery as well as cognitive abilities, but these effects can also extent to stimulate social networking (especially across cultures) and establish a more peaceful atmosphere which may reduce violence in the area (Bendt *et al.*, 2013; Okvat & Zautra 2011; Siewell *et al.*, 2015). Apart from the social benefits derived from urban gardens, studies in both developed and developing countries revealed that green infrastructure (a network of ecological systems in an urban environment which can perform several functions (Tzoulas *et al.*, 2007)) is maintained by urban gardens such as localized air-cooling, green corridors and flood control (Cameron *et al.*, 2012; Galluzzi *et al.*, 2010; Taylor *et al.*, 2016). Urban gardens are also important in combatting climate change through carbon sequestration, causing decrease in harmful gas emissions and promoting a healthy urban lifestyle such as encouraging people to rather walk to work than to use a vehicle (Okvat & Zautra, 2011). Urban gardens are also a major contributor to urban biodiversity which establish a more diverse habitat improving the wildlife in urban areas (Galluzzi *et al.*, 2010). Since humans are intimately linked to their gardens, these gardens can make a unique contribution to green infrastructure and will also directly affect human health and well-being (Cameron *et al.*, 2012).

2.5.2 Urban gardening in Africa

Although being a very diverse continent, Africa produces unique challenges when it comes to urban gardening such as a lack of space, equipment and access to resources (Koyenikan, 2007; Reuther & Dewar, 2006b). Poverty, corruption and violent political rants leave urban

gardens in Africa vulnerable to climatic conditions and enhance the effect that the condition of the environment has on social health. The social and psychological benefits derived from urban gardens (amendment of self-worth, reduction of stress levels, stimulation of networking as well as improvement of skills and environmental knowledge) however, still cause an increase of community gardens in urban areas across Africa (Koyenikan, 2007; Okvat & Zautra, 2011; Reuther & Dewar, 2006b). Some of the proven benefits of home gardens in South Africa include enhancing food security, health and social interrelationships and also combat boredom and stress (Adekunle *et al.*, 2014). Traditional knowledge and gardening techniques (such as the use of African Leafy Vegetables and the Tswana tshimo layout) has a prominent influence on home gardening in South Africa and also play an important role in the integration of traditional and modern agricultural knowledge (Faber *et al.*, 2002; Galluzzi *et al.*, 2010; Molebatsi *et al.*, 2010; Adekunle *et al.*, 2014). Socio-economic status also has an influence on the type and diversity of plant species occurring in domestic gardens in South Africa which might be a result of preference, culture or limitations regarding resources (Lubbe *et al.*, 2010).

2.5.3 Plant species composition in urban gardens

Previous studies found that most urban gardens host a high diversity of plant species of which many are alien (Das & Das, 2005; Davoren *et al.*, 2015; Jansen van Rensburg *et al.*, 2015; Lubbe *et al.*, 2010; Molebatsi *et al.*, 2010; Smith *et al.*, 2006; Zerbe *et al.*, 2003). Species richness in domestic gardens, even though many species might be alien, can be important to connect the surrounding wildlife with the urban areas and to link fragmented habitats (Goddard *et al.*, 2010; Smith *et al.*, 2006). Cultural and political history often has a great influence on species diversity and richness in urban gardens (Barthel *et al.*, 2010; Davoren *et al.*, 2015; Lubbe *et al.*, 2010; Jansen van Rensburg *et al.*, 2007; Jansen van Rensburg *et al.*, 2015b; Maroyi, 2009; Molebatsi *et al.*, 2013; Zerbe *et al.*, 2003). Davoren *et al.*, (2015) and Lubbe *et al.*, (2010) discovered that species composition in gardens are clearly linked to socio-economic status as well as culture. Tswana tshimo gardens owned by people of lower socio-economic status contain more native and useful (medicinal or food) species while the colonial gardens of people with higher socio-economic status contain less native and useful species and more ornamental species (Davoren *et al.*, 2015). Maroyi, (2009) found similar results where food production was the primary function of rural home gardens - tubers, vegetables and fruit trees were most commonly used. Jansen van Rensburg *et al.*, (2015; 2007) found that gardening in South Africa were often linked to women and traditional livelihoods of the past and were seen as an important occupation. African leafy vegetables (ALV's) were some of the indigenous species used in these gardens of which amaranth, spider plant, jute and nightshade were the most common (Jansen van Rensburg *et al.*, 2015b; Jansen van Rensburg *et al.*, 2007).

ALV's are plant species which are consumed in Africa (not necessarily native to Africa) as leafy vegetables, especially in the rural and traditional communities (Jansen van Rensburg *et al.*, 2015b; Jansen van Rensburg *et al.*, 2007; Van Jaarsveld *et al.*, 2014). These plants are also called morogo or *imifino* in the native languages in South Africa. ALV's occur in both natural and cultivated fields (Faber *et al.*, 2010). Because of urbanisation and the loss of indigenous knowledge, the use of ALV's in Africa is in a decline (Faber *et al.*, 2010; Jansen van Rensburg *et al.*, 2015a). Eight main groups of plant species are typically used in South Africa as African Leafy Vegetables namely: amaranth (*Amaranthus sp.*), spider flower (*Cleome gynandra*), rape or Chinese cabbage (*Brassica rapa* subsp. *chinensis*), nightshade (*Solanum retroflexum* with some other species of the *S. nigrum* complex), Jew's mallow (*Corchorus olitorius* and *C. tridens*), cowpeas (*Vigna inguiculata*) and pumpkins (*Cucurbita pepo*, *C. maxima* and *C. moschata*), melons (*Citrullus lanatus* and *Cucumis melo*) as well as other indigenous cucurbits, such as balsam pear (*Momordica balsamina*) (Jansen van Rensburg *et al.*, 2007; Faber *et al.*, 2010). Traditionally, these leafy vegetables will either be served individually or mixed with other leaves, after being cooked or fried (Faber *et al.*, 2010). Before the winter season, some of these leaves are also dried and stored and will be eaten when food is scarce (Faber *et al.*, 2010). ALV's can play an essential role in mitigating the nutrient deficiency/ imbalance in vulnerable communities of developing countries such as South Africa (Faber *et al.*, 2010; Faber *et al.*, 2002; Van Jaarsveld *et al.*, 2014). Some of the more urbanised communities, however, consider these vegetables as food for poor people and will therefore avoid using it to maintain good prestige (Faber *et al.*, 2010). There are, however, still many benefits in using ALV's. These plants are nutritious food growing for free in the wild (in most of the rural houses' back yard), which can be easily accessed and continually harvested (Faber *et al.*, 2010). In urban communities, ALV's are also sold at informal markets, serving as an economic asset (Faber *et al.*, 2010). According to Van Jaarsveld *et al.*, (2014), ALV's are not a good source of zinc, but can significantly contribute to the RDA of Vitamin A and iron as well as some other essential nutrients which are mostly deficient in developing countries. Pigweed and cowpeas can contribute more than 75% of children's RDA for Vitamin A, while pumpkin leaves can provide 50-75% of the RDA for iron (Van Jaarsveld *et al.*, 2014). The nutrient content of ALV's are diverse and these plant species should therefore be considered as a solution to the nutrient imbalance in many countries in Africa (Van Jaarsveld *et al.*, 2014).

2.6 Complex adaptive systems and resilience

According to Walker & Salt (2006), all natural systems go through a cycle of events. This cycle is adaptive, since the natural system sometimes has the ability to reorganise itself and react to changes in the environment around it (Gunderson & Holling, 2001). This adaptive cycle can also be identified in social systems and are therefore a useful approach in studying the changes in

social-ecological systems (Walker & Salt, 2006). These adaptive systems are also complex, because of the complex interactions between the components (ecological and social) of the system, causing the system to be heterogeneous in structure (Rogers *et al.*, 2013). There are four stages within this cycle namely the rapid growth stage, conservation stage, release stage and reorganization stage. In the rapid growth stage new opportunities and resources are used by social and ecological elements to build up connections and inhabit new niches (Gunderson & Holling, 2001; Walker & Salt, 2006). In the conservation stage energy and materials begin to accumulate and species or people become established and compete for available resources (Gunderson & Holling, 2001; Walker & Salt, 2006). Connections between actors and components within the system become stronger and more complicated (Gunderson & Holling, 2001; Walker & Salt, 2006). When a problem or disturbance occurs, the system may collapse and the components which were interconnected in the system will be released (release stage) (Gunderson & Holling, 2001; Walker & Salt, 2006). Components and actors (species and people) within the system will then reorganise itself (reorganization stage) by introducing new resources and stakeholders, which will enhance innovation and restructuring to prepare the system for the next phase of exploitation (Gunderson & Holling, 2001; Walker & Salt, 2006). The system's response to changes in each of the stages depends on the strength of the connections between the internal components of the system also known as the system's flexibility or resilience (Walker & Salt, 2006). Resilience enhances the system's ability to maintain its functions in the midst of changing conditions (Gunderson & Holling, 2001).

2.6.1 Diversity of plant species

Diversity is one of the key aspects of maintaining resilience within a complex adaptive system since it has the ability to spread risks, to create buffers and provides a greater variety of possibilities to manage a system when uncertainties are high (Colding *et al.*, 2003). Each of the plant species in a garden has certain functional traits which contribute to the functional diversity of the garden. When there are many species in each functional group (functional redundancy), there will always be some species to maintain the functions within the system if some are lost in the case of a disturbance (Elmqvist *et al.*, 2003). Functional diversity therefore enhances resilience within a system by reducing the risk that a specific ecosystem function becomes lost in damaged systems (Colding & Barthel, 2013). This will also enhance response diversity which means that each of the species in the functional group reacts different to a disturbance and will therefore create various levels of absorbance (Colding *et al.*, 2003; Colding & Barthel, 2013).

2.6.2 Resource diversity

A diversity of resources (physical and social) can also contribute to improve the resilience of systems. Department for International Development (DfID, 2000) determined that resources or

capital can be divided into five categories namely, natural, social, human, physical and financial capital. According to Fabricius & Collins (2007) and Goddard *et al.*, (2010), lack of some of these capital can cause failure in natural resource management. Human, financial and physical capital, also called “hard” capital, are often scarce in supply in rural areas with low socio-economic status which are situated in remote areas (Fabricius & Collins, 2007). Different kinds of capital are therefore unequally distributed over a certain area influencing the demands on social, physical and natural levels (Buchmann, 2009; Fabricius & Collins, 2007)

Human capital, which can be described as skills, education, labour, health and knowledge (DfID, 2000), has the potential to improve the resilience of a social-ecological system as long as it occurs in great diversity. When knowledge of diverse backgrounds are linked and combined, new information is created which can change the perspective on current situations or problems (Tengö *et al.*, 2014). Co-production of knowledge, cross-fertilization of knowledge and integration of knowledge are results of the enriched picture formed by combining different sets of knowledge (Tengö *et al.*, 2014). This is part of a more extensive approach (Multiple Evidence Based) where indigenous, local, technical and scientific related knowledge systems interact to ensure deeper insight and cooperative assessment (Tengö *et al.*, 2014).

Social capital (social networks, norms, support groups and relationships of trust) play an important role at urban gardens to ensure adaptive capacity, a high diversity of species and gardening strategies (Buchmann, 2009; Glover, 2004). Natural, physical and financial capital is also greatly influenced and dependent on the diversity of social capital at urban gardens (Buchmann, 2009; Goddard *et al.*, 2010). Although the benefits of social capital are extensive, evidence of these benefits will only show after a long period of time (Kingsley & Townsend 2006).

Natural capital sustain the provision of ecosystem services which are benefits for humans derived from nature and are therefore intricately linked to social and human capital in urban environments (Tibesigwa *et al.*, 2016). Plant species composition, for instance, influences the vulnerability of home gardens to sudden environmental changes and also affects food security (Buchmann, 2009; Das & Das, 2005).

Physical and financial capital are also closely interrelated as well as linked to human and social capital, since the implementation of basic infrastructure requires regular inflows of money. Gardening methods will be a great determinant of the diversity and amount of physical (gardening tools, transport, open space etc.) and financial capital needed (Reyes-García *et al.*, 2012). Financial capital sometimes influence long-term strategies of gardening (the gardener can only plant when he/she can afford seed or he/she will only plant species from which a larger profit is gained) (Bharwani *et al.*, 2005).

It is also evident in several cases that access to resources is crucial in maintaining sustainability and to improve the resilience of the system (Abramson *et al.*, 2015; Glover, 2004; Tibesigwa *et al.*, 2016). The accessibility to diverse resources (natural, social, human, financial and physical capital) also influences the benefits humans can derive from it (Hancock, 2010).

2.7 Ecosystem services and disservices

Benefits that humans receive from natural processes in ecosystems can be described as ecosystem services (Gómez-Baggethun & Barton, 2013; Millennium Ecosystem Assessment (MEA), 2005; TEEB, 2011). Millennium Ecosystem Assessment (MEA) (2005) suggested that ecosystem services can be grouped into four categories namely provisioning services, regulating services, supporting services and cultural services. Some of the processes occurring in ecosystems, however, can have an adverse effect on humans such as pests, diseases, allergies, poisonous animals and geophysical disturbances (floods or earthquakes) (Lyytimäki *et al.*, 2008; Von Döhren & Haase, 2015). Since ecosystem services and disservices convey aspects of the relationship between humans and natural processes, most of the research on ecosystem services and disservices focus on urban areas where concepts such as governance and valuation of ecosystem services are explored (Ahern *et al.*, 2014; Andersson *et al.*, 2014; Barthel *et al.*, 2010; Bennett *et al.*, 2009; Costanza *et al.*, 2014; Gómez-Baggethun & Barton, 2013; Schultz *et al.*, 2015; TEEB, 2011; Wamsler *et al.*, 2014). Through ecosystem services sociological and ecological systems are both included and interact in a specific manner which were also researched in cities (Andersson *et al.*, 2007; Cook *et al.*, 2012; Hamann *et al.*, 2015; Mastrangelo *et al.*, 2015; Redman *et al.*, 2004; Schewenius *et al.*, 2014).

Ecosystem services provided by urban gardens was also researched (Barthel *et al.*, 2010; Beumer & Martens, 2014; Calvet-Mir *et al.*, 2012; Cameron *et al.*, 2012; Mohri *et al.*, 2013; Reyes-García *et al.*, 2012; Taylor & Lovell, 2015; Van Heezik *et al.*, 2012). The contribution of home gardens in food provisioning, (Reyes-García *et al.*, 2012; Taylor & Lovell, 2014) as well as the adverse effects that home gardens can have on human health and well-being (Cameron *et al.*, 2012; Victoria Reyes-García *et al.*, 2012; Taylor & Lovell, 2014) were previously researched. The important role of culture in urban gardens and the cultural services provided by urban gardens have also been explored (Calvet-Mir *et al.*, 2012). Expression of culture and practice of tradition are often one of the most important functions of urban gardens (Barthel *et al.*, 2010; Mohri *et al.*, 2013; Taylor & Lovell, 2014). Rural home gardens usually contain a large diversity of plant species and can be seen as better hosts of biodiversity than urban gardens but with better focused governance, urban gardens also have potential to provide this service (Mohri *et al.*, 2013; Van Heezik *et al.*, 2012). Studies on allotment gardens in Sweden revealed that knowledge about services provided by gardens can be transferred from one generation to the next, preserving this information for a long time (Barthel *et al.*, 2010).

Fewer research exist on ecosystem disservices in urban areas especially in the Southern Hemisphere (Beumer & Martens, 2014; Cilliers *et al.*, 2013; Cook *et al.*, 2012; Elmqvist *et al.*, 2013; Gómez-Baggethun & Barton, 2013; Lyytimäki *et al.*, 2008; Szücs *et al.*, 2015; Taylor & Lovell, 2014; Von Döhren & Haase, 2015). The focus of many of the ecosystem disservices studies was on Western Europe and North-America (Von Döhren & Haase, 2015). The effect of ecosystem disservices on the value of ecosystem services was also explored in previous literature (Gómez-Baggethun & Barton, 2012).

2.8 Summary

Although extensive research on urbanisation and social-ecology in urban areas have already been conducted, there is still need for more information on the subjects of the response of social-ecological systems to changes in the condition of the environment and the complexity of how wicked problems should be addressed – especially in developing countries. The mixed successes and failures of urban agriculture, have led to the conclusion that no singular framework can serve as a solution, but that more attention should be given to various diverse sets of solutions. The key could therefore be in integrating the diversity of natural, physical and social resources which will improve the resilience of the complex adaptive system.

Chapter 3 – Plant species composition contributing to the natural resource diversity of health clinic gardens in the Bojanala District Municipality



CHAPTER 3 - PLANT SPECIES COMPOSITION CONTRIBUTING TO THE NATURAL RESOURCE DIVERSITY OF HEALTH CLINIC GARDENS IN THE BOJANALA DISTRICT MUNICIPALITY

3.1. Introduction

“Gardens” is a loaded concept, which can include a massive variety of different aspects, depending on the people visiting it, the situation in which it is used and the plants it contain. When researching gardens, there is a constant battle between social and ecological aspects, sometimes mixing and interacting or challenging each other for more attention. Addressing this issue, Redman *et al.*, (2004) concluded that both ecosystems and human systems should be equally studied forming a perspective of a single complex social-ecological system. The composition of plant species in a garden can therefore give an indication of the social benefits derived from the garden such as providing food and nutrition security (plant species with nutritional value), improving physical recovery (plant species with medicinal value) and stimulating social cohesion (Koyenikan, 2007; Okvat & Zautra, 2011; Reuther & Dewar, 2006). Natural capital (natural resources which can provide ecosystem services and good for humans (DfID, 2000)) in a garden includes the plant species which provide food, medicine, wood and shelter from the sun or wind. Social capital (the structure of social networks and relationships (DfID, 2000)) often influence the management of natural resources (Bodin *et al.*, 2009) which can either increase or decrease the availability and condition of natural capital at gardens.

Gardens at health clinics in South Africa are investigated in this study to determine whether social benefits can be derived from these ecosystems. Health clinics were established across South Africa (in urban and rural areas) to provide better health care for those living in areas too far from the nearest hospital (Cilliers *et al.*, in press; Cullinan, 2006; Pillay & Barron, 2011). Gardens around these facilities were primarily started to provide fresh fruit and vegetables for patients struggling to keep a healthy immune system.

Both plant species composition and social benefits associated with gardens in urban areas have been researched in many parts of USA and Europe (Andersson *et al.*, 2007; Barthel *et al.*, 2010; Beumer & Martens, 2014; Cameron *et al.*, 2012; Calvet-Mir *et al.*, 2012; Galluzzi *et al.*, 2010; Gaston *et al.*, 2005; Goddard *et al.*, 2010; Goddard *et al.*, 2013; Kendal *et al.*, 2012; Kendal *et al.*, 2012; Okvat & Zautra, 2011). The interplay of social aspects with biophysical factors is reflected by research on urban gardens throughout the world. Research on community and domestic gardens in Europe and USA indicated that these gardens not only have the potential to assist in food production, but can also enhance environmental stewardship and civic engagement (Krasny & Tidball, 2009; Okvat & Zautra, 2011). According to Bendt *et al.*, (2013),

gardens which are open to the public can significantly broaden the environmental learning and social interaction associated with urban gardens. In the USA, Okvat & Zautra (2011) found that community gardening not only benefits the individual, but also the whole community and improves environmental resilience within cities. Individual benefits include better cognitive abilities, faster physical recovery and better psychological condition. Community gardening enhance social networking, encourage multicultural relations and reduce crime which benefits the community (Okvat & Zautra, 2011). Studies on domestic gardens in Spain revealed that the purpose for keeping a garden mostly relates to tradition, hobbies or financial benefits (Reyes-García *et al.*, 2012).

Internationally, home gardens not only contribute to urban green infrastructure by enhancing localized cooling of air and mitigating the influences of floods, but also contribute to biodiversity in the city which means that both agro-biodiversity and cultural diversity are higher and provision of habitat for urban wildlife is also improved (Cameron *et al.*, 2012; Galluzzi *et al.*, 2010). Some of the previous studies found that rural home gardens played a stronger role in harbouring biodiversity than urban home gardens, but with good management, maintenance of biodiversity can also occur in urban gardens (Mohri *et al.*, 2013; Van Heezik *et al.*, 2012). Urban gardens play an important role in mitigating the effects of climate change by reducing the emission of harmful gasses and by encouraging a change in urban lifestyles which are more environmental friendly (Okvat & Zautra, 2011). The contribution of domestic gardens to urban green infrastructure is unique and because of its close connection to humans, has the greatest influence on human health and well-being (Cameron *et al.*, 2012). This contribution can be both positive (localized air cooling, mitigation of floods, haven for wildlife, restoration of degraded ecosystems and maintenance of biodiversity) and negative (misuse of fertilisers and pesticides and increase of alien species) (Cameron *et al.*, 2012; Gaston *et al.*, 2005; Mohri *et al.*, 2013; Reyes-García *et al.*, 2012).

In Africa, the situation of urban gardening is slightly different and problems mostly occur in the form of a lack of space, equipment and access to resources (Koyenikan, 2007; Reuther & Dewar, 2006). Being much more vulnerable to climatic conditions because of poverty, corruption and instable political situations, social aspects are more severely affected by the condition of the ecological factors and vice versa. In spite of these problems, it was found that the social and psychological benefits (amendment of self-worth, reduction of stress levels, stimulation of networking as well as improvement of skills and environmental knowledge) conquers and community gardens keep on multiplying (Koyenikan., 2007; Okvat & Zautra, 2011; Reuther & Dewar, 2005). According to Adekunle *et al.*, (2014), home gardens in South Africa improve food security, health and social interrelationships as well as play an important role in the alleviation of boredom and stress. Home gardening is closely associated with traditional knowledge and

practices (such as the use of African Leafy Vegetables) and often plays a role in the aggregation of traditional and modern agricultural knowledge (Faber *et al.*, 2002; Galluzzi *et al.*, 2010; Molebatsi *et al.*, 2010; Adekunle *et al.*, 2014). The study of Lubbe *et al.*, (2010) in South Africa revealed that the plant species composition of domestic gardens change along the socio-economic gradient. Domestic and home gardens studied in South Africa also provide certain ecological benefits such as increasing biodiversity and providing a refuge for endangered and endemic species (Lubbe *et al.*, 2011; Molebatsi *et al.*, 2013)

In South Africa, food supply is often sufficient, but no consideration is given to nutritional value. Social problems such as nutrient deficiencies play a very dominant role in the community and could be explained by the “hidden hunger” concept, which means that enough food is available, but the body still hunger because of a deficiency of certain nutrients (Vorster *et al.*, 2011; UNICEF and the Micronutrient Initiative, 2004). Lack of nutrients have an immensely negative effect on people’s health (especially children) such as causing brain damage and blindness, inducing stillbirths and abortions, causing fatigue, lethargy and the lack of concentration as well as aggravate diarrhoea and cause child deaths (UNICEF and the Micronutrient Initiative, 2004). Aside from the physical deterioration, “hidden hunger” in developing countries generates tremendous economic costs (UNICEF and the Micronutrient Initiative, 2004). A great number (40%) of children under the age of 5 years are suffering from malnourishment with mainly vitamin A deficiency (UNICEF, 2008). These children’s immune systems become compromised and in developing countries this leads to the death of approximately 1 million children each year (UNICEF and the Micronutrient Initiative, 2004). Compared with the rest of the world, Africa has the highest proportion (2.55 million) of children under the age of 6 which experience night blindness as a result of vitamin A deficiency (WHO, 2009). The saddest part of the problem is that the most vulnerable child, who is at greatest risk, will probably not receive vitamin supplements because of a lack of access to goods and services (UNICEF and the Micronutrient Initiative, 2004).

Nutrient deficiency in South Africa can partly be attributed to the concept of “nutrition transition” suggested by Vorster *et al.*, (2011). This concept explains that in African countries, an African diet (e.g. African Leafy Vegetables (ALV’s)) is gradually replaced by a Westernised diet, which is energy-dense and contains more sugar, fats and oils. Other health-related diseases associated with overnutrition such as obesity and diabetes also become now evident and put a double burden on the society (Popkin, 2004; Vorster *et al.*, 2011).

African Leafy Vegetables (ALV’s) is a collective term used to describe plant species used in Africa (not necessarily indigenous to Africa) that serve as leafy vegetables in many rural households (Jansen van Rensburg *et al.*, 2007). The rural communities in South Africa often refer to these plants as *morogo* or *imifino*. ALV’s mostly grow naturally in the wild, but can also

be obtained from some cultivated fields. Because of urbanisation and the loss of indigenous knowledge, the use of ALV's in Africa is in a decline (Jansen van Rensburg *et al.*, 2007). ALV's can play an essential role in mitigating the nutrient deficiency/ imbalance in vulnerable communities of developing countries such as South Africa (Faber *et al.*, 2002; Faber *et al.*, 2010; Van Jaarsveld *et al.*, 2014).

Gardens provide an opportunity to greatly improve the link between environmental and health care education which will enhance the intake of Vitamin A rich foods and other essential micro-nutrients especially needed for children in developing countries (Faber *et al.*, 2002). It also improves maternal knowledge which means that the mother can make an informed decision about her children's health (Faber *et al.*, 2002).

Two of the studies done in the North-West Province, South Africa, were on domestic gardens in urban to rural areas. Molebatsi *et al.*, (2010) found that domestic gardens in the North-West Province are characterised by a certain layout. The garden consists of several micro-gardens: Lebala (open ground or bare soil around the home to keep snakes and other wild animals out), Naga (natural vegetation used to harvest indigenous species which serve as food or medicine), lawn, vegetable garden, medicinal garden, ornamental garden, hedge and the orchard. This is called the Tswana tshimo layout and is mostly an attribute of Tswana home gardens in rural areas (Molebatsi *et al.*, 2010). The second study was done by Lubbe *et al.*, (2011), who were the first to determine the floristics of domestic gardens in Tlokwe Municipality in the North-West Province. The aim of the study was to improve our knowledge of the biodiversity in domestic gardens in a developing country.

In this study, the aim is to determine the plant species composition, floristic and physiognomic diversity of health clinic gardens in the Bojanala District Municipality. The objectives were to compare the plant species composition and cover abundance over the different local municipalities and to compare the floristics and physiognomic characteristics of the different micro-gardens in health clinic gardens.

3.2. Materials and methods

3.2.1 Sampling and data analysis

A total of 103 clinics were surveyed in the Bojanala District Municipality. The survey was based on the Tswana tshimo layout, since this layout was previously identified in Tswana home gardens in the North-West Province (Molebatsi *et al.*, 2010) and the major ethnic group in the Bojanala District Municipality is the Tswana People (Schapera, 1953; Van Warmelo, 1974). The plant species in each micro-garden was identified and an average cover of each species as a percentage of the total garden size (excluding the cover of the clinic building) was determined.

Since tree species (orchard and shade trees) can occur over several micro-gardens at a time, they were identified separately in each clinic garden. Identification of species was done up to species level using of the AP Goossen Herbarium at the North-West University, Potchefstroom Campus, expert knowledge and several books and field guides (Brickell, 1994; Pienaar, 1984; Pienaar, 1994; Retief & Herman, 1997; Steward, 1994; Van Oudtshoorn, 2012; Van wyk & Van wyk, 2013; Van Wyk & Malan, 1988).

Species were classified according to status (exotic naturalised, exotic cultivated, indigenous and native), species endemic to South Africa, endangered and protected species, invasive species, physiognomic characteristics (Raunkiaers' life-forms and growth forms of species), origin of naturalised and cultivated alien species and potential uses of species. Information on each plant species were obtained by using a variety of sources namely: Flora Zambesiaca (2015), SANBI – Red List of South African Plants (2015), Brickell, 1994; Pienaar, 1984; Pienaar, 1994; Retief & Herman, 1997; Steward, 1994; Van Oudtshoorn, 2012; Van Wyk & Van Wyk, 2013 and Van Wyk & Malan, 1988.

The status classification of species was done by using the following definitions (Lubbe *et al.*, 2011):

- Exotic naturalised (including invaders & weeds) – species which are not indigenous to South Africa, but are adapted to the conditions in the North-West Province so that it can sustain self-replacing populations naturally.
- Exotic cultivated – species not indigenous to South-Africa, but are cultivated in gardens. This includes garden hybrids.
- Indigenous species - species which do not naturally occur within the North-West province, but are indigenous to South Africa. These species are usually cultivated in gardens.
- Native – species occurring naturally in the North-West Province.

The conservation status of each species and endemic species was identified according to the IUCN Red List Categories and Criteria (IUCN, 2012) which includes: extinct (EX), extinct in the wild (EW), regionally extinct (RE), critically endangered, possibly extinct (CR PE), critically endangered (CR), endangered (EN), vulnerable (VU), near threatened (NT), declining, least concern (LC), data deficient – insufficient information (DDD), data deficient – taxonomically problematic (DDT) and not evaluated (NE).

Invasive species were also identified using South Africa's National List of Invasive Species (South Africa, 2014b). Four different categories were used to classify the invasive species. Category 1a (C1a) include species that should be removed and with which no trading is allowed

(South Africa, 2014a). Species in Category 1b (C1b) must be managed and closely monitored and also eradicated if possible (South Africa, 2014a). Trading with these species is also prohibited (South Africa, 2014a). Category 2 (C2) include species which are usually important for commerce (such as pine trees), but have the potential to become invasive (South Africa, 2014a). A permit is compulsory when these plant species are used for any prohibited activity. Category 3 (C3) invasive species can be kept in specific monitored areas (such as urban areas where Jacaranda trees are allowed) or provinces, but no propagation or trade with these species is allowed (South Africa, 2014a).

Raunkiaers' life-forms (phanerophytes, chamaephytes, hemicryptophytes, geophytes, hydrophytes, therophytes) and the species' growth forms (herb, herb: graminoid, herb: succulent, shrub, shrub: succulent, tree, tree: succulent, climber and parasite) were determined with the help of expert knowledge, previous studies (Van der Walt, 2013; Davoren, 2009) done in the North-West Province as well as using photos taken during the field work. Physiognomic data, which include species' life-forms, growth forms, stratification and size, can be useful in determining the measure of disturbance in an area (Kent, 2012). Morphological (such as life-form and growth form) characteristics of a plant species cause the species to function in a certain way (functional traits) and can increase the functional diversity of an ecosystem (Kent, 2012). A diversity of functional traits in an ecosystem, improve the functional redundancy (several species with the same set of functional traits can improve a system's ability to maintain its functions when some species are lost as a result of a disturbance) (Elmqvist *et al.*, 2003). A great number of life-forms and growth forms can, therefore, be an indication of a disturbance in an area (Kent, 2012).

Potential uses of species were classified according to usefulness based on previous studies (Lubbe *et al.*, 2011; Molebatsi *et al.*, 2013) into the following categories: Ornamental, Food (including African leafy vegetables, edible fruit, tubers or rhizomes, grain, fruit trees, leafy vegetables, spice or herbs, vegetables and roots used for coffee or as yeast), shade, hedge, medicinal uses and other (including uses in producing wooden handles for tools, brooms, hats, string, toothbrushes and perfume, dye for leather or wood, thatch grass and spiritual uses) (Van Wyk & Gericke, 2000; Van Wyk & Wink, 2004; Van Wyk *et al.*, 2000). Poisonous plants were also noted and include plants in the following categories which apply to humans: Causes skin allergies or contact dermatitis, poisonous, very poisonous and deadly to humans (Van Wyk *et al.*, 2002). Plants falling under categories "not really poisonous" and "poisonous to animals" were not included (Van Wyk *et al.*, 2002).

The frequency of occurrence of each species (also according to family and genus, endemic, endangered and invasive species) was determined by counting the number of clinic gardens where the species was recorded by using Microsoft Excel (Excel 2013). The plant species

composition of each clinic garden was compared over the different local municipalities by using non-metric multidimensional scaling (NMDS) in PRIMER version 6 (2006) (Clarke & Gorley, 2006). Basic correlations (ANOVA's) were also applied to test for significant differences between the local municipalities by using STATISTICA version 12 (2013) (StatSoft, Inc. 2013). The percentage of species in each micro-garden of each category (status, growth form and life-form) was determined in Microsoft Excel (Excel 2013).

3.3 Results

3.3.1 All health clinic gardens

3.3.1.1 Dominant families

In the Bojanala District Municipality, there were 116 plant families and 645 species recorded in the health clinic gardens. The three most frequently recorded families were Asteraceae, Poaceae and Fabaceae and these families also represented the highest number of plant species (29% of the total species recorded) (Table 3-1). Frequency of occurrence was determined by counting the number of times represented species of the family occurred in all clinics. The 20 families which are best represented in the clinic gardens contains 62% of the total number of species surveyed (645 species). Although the Asteraceae family contained the highest number of species found in clinic gardens (10.4% of the total species recorded), species from the Poaceae family occurred more frequently in the clinic gardens. A total of 44 (38%) families were represented by only one plant species and 17 (15%) families by only two plant species. More than half of the species belonging to the Asteraceae family were exotic. The Fabaceae and Poaceae families consisted mostly of native and indigenous species (Table 3-1).

3.3.1.2 Plant genera representation

A total of 404 genera were recorded of which *Acacia* (12 species), *Eragrostis* (12 species) and *Euphorbia* (11 species) were the best represented (Table 3-2). The top 20 genera represent 16% of the total number of species recorded from health clinic gardens in the Bojanala District. Most genera were represented by only one species. The genera *Acacia* and *Eragrostis* consisted mostly of indigenous species which are also native to the North-West Province, while the majority of species representing genera *Euphorbia* and *Solanum* were exotic (Table 3-2).

Table 3-1: Best represented plant families of health clinic gardens in Bojanala District Municipality

Position	Family	Frequency of occurrence: clinic gardens	Number of species (number of exotic species)	Percentage (%) of total number of species
1	Asteraceae	626	67 (40)	10.4
2	Poaceae	761	61 (12)	9.4
3	Fabaceae	408	60 (17)	9.3
4	Malvaceae	166	29 (14)	4.5
5	Euphorbiaceae	129	22 (14)	3.4
6	Solanaceae	114	17 (13)	2.6
7	Lamiaceae	46	15 (5)	2.3
8	Apocynaceae	84	15 (9)	2.3
9	Convolvulaceae	71	14 (6)	2.2
10	Crassulaceae	69	14 (6)	2.2
11	Anacardiaceae	140	11 (3)	1.7
12	Amaryllidaceae	44	11 (5)	1.7
13	Amaranthaceae	161	11 (9)	1.7
14	Asphodelaceae	52	9 (1)	1.4
15	Acanthaceae	15	8 (1)	1.2
16	Brassicaceae	35	8 (7)	1.2
17	Verbenaceae	71	8 (7)	1.2
18	Rutaceae	50	7 (6)	1.1
19	Agavaceae	28	7 (7)	1.1
20	Chenopodiaceae	70	7 (7)	1.1

Table 3-2: Best represented plant genera of health clinic gardens in Bojanala District Municipality

Position	Genera	Family	Number of species (number of exotic species)	Percentage (%) of total number of species
1	<i>Acacia</i>	Fabaceae	12 (1)	1.9
2	<i>Eragrostis</i>	Poaceae	12 (2)	1.9
3	<i>Euphorbia</i>	Euphorbiaceae	11 (9)	1.7
4	<i>Solanum</i>	Solanaceae	8 (5)	1.2
5	<i>Hibiscus</i>	Malvaceae	8 (5)	1.2
6	<i>Ipomoea</i>	Convolvulaceae	7 (3)	1.1
7	<i>Aloe</i>	Asphodelaceae	5 (1)	0.8
8	<i>Lactuca</i>	Asteraceae	5 (3)	0.8
9	<i>Citrus</i>	Rutaceae	4 (4)	0.6
10	<i>Agave</i>	Agavaceae	4 (4)	0.6
11	<i>Searsia</i>	Anacardiaceae	4 (0)	0.6
12	<i>Kalanchoe</i>	Crassulaceae	4 (1)	0.6
13	<i>Plumeria</i>	Apocynaceae	3 (3)	0.5
14	<i>Alternanthera</i>	Amaranthaceae	3 (3)	0.5
15	<i>Verbena</i>	Verbenaceae	3 (3)	0.5
16	<i>Plectranthus</i>	Lamiaceae	2 (0)	0.3

Table 3-2 continues

Position	Genera	Family	Number of species (number of exotic species)	Percentage (%) of total number of species
17	<i>Blepharis</i>	Acanthaceae	2 (0)	0.3
18	<i>Zephyranthus</i>	Amaryllidaceae	2 (2)	0.3
19	<i>Brassica</i>	Brassicaceae	2 (2)	0.3
20	<i>Chenopodium</i>	Chenopodiaceae	2 (2)	0.3

3.3.1.3 Plant species representation

The most frequent species recorded for health clinic gardens in the Bojanala District was *Cynodon dactylon* (96 times out of 103 clinic gardens) and the second most frequent species was *Urochloa mosambicensis* (83 times out of 103 clinic gardens) (Table 3-3). These species are both native to the North-West Province. The top 20 most frequently recorded species were represented by nine indigenous species of which eight are native to the North-West Province, nine exotic naturalised and two exotic cultivated species. These species are mostly herbs and a few trees (Table 3-3).

Table 3-3: The most frequent occurring plant species of health clinic gardens in Bojanala District Municipality.

Position	Plant Species	Family	Status	Growth form	Frequency of occurrence in clinic gardens
1	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	Native (LC)	Herb: Graminoid	96
2	<i>Urochloa mosambicensis</i> (Hack.) Dandy	Poaceae	Native (LC)	Herb: Graminoid	83
3	<i>Acacia tortilis</i> (Forssk.) Hayne subsp. <i>heteracantha</i> (Burch.) Brenan	Fabaceae	Native (LC)	Tree	63
4	<i>Schkuhria pinnata</i> (Lam.) Cabrera*	Asteraceae	Exotic (naturalized)	Herb	61
5	<i>Prunus persica</i> (L.) Batsch. var. <i>persica</i> *	Rosaceae	Exotic (cultivated)	Tree	48
6	<i>Conyza bonariensis</i> (L.) Cronquist*	Asteraceae	Exotic (naturalized - weed)	Herb	45
7	<i>Eragrostis lehmanniana</i> Nees var. <i>chaunantha</i> (Pilg.) De Winter	Poaceae	Native (LC)	Herb: Graminoid	42
8	<i>Boerhavia erecta</i> L.*	Nyctaginaceae	Exotic (naturalized - weed)	Herb	41
9	<i>Melinis repens</i> (Willd.) Zizka subsp. <i>repens</i>	Poaceae	Native (LC)	Herb: Graminoid	41
10	<i>Agapanthus</i> sp.	Agapanthaceae	Indigenous (cultivated)	Herb	40
11	<i>Bidens pilosa</i> L.*	Asteraceae	Exotic (naturalized - weed)	Herb	39
12	<i>Morus alba</i> L. var. <i>alba</i> *	Moraceae	Exotic (naturalized - C3 invader, except sterile)	Tree	39
13	<i>Spinacia oleracea</i> L.*	Chenopodiaceae	Exotic (cultivated)	Herb	39

Table 3-3 continues

Position	Plant Species	Family	Status	Growth form	Frequency of occurrence in clinic
14	<i>Malvastrum coromandelianum</i> (L.) Garcke*	Malvaceae	Exotic (naturalized - C1b invader)	Herb	38
15	<i>Melia azedarach</i> L.*	Meliaceae	Exotic (naturalized - C3 invader)	Tree	38
16	<i>Aristida canescens</i> Henrard subsp. <i>canescens</i>	Poaceae	Native (LC)	Herb: Graminoid	37
17	<i>Enneapogon cenchroides</i> (Licht. ex Roem. & Schult.) C.E.Hubb.	Poaceae	Native (LC)	Herb: Graminoid	37
18	<i>Euphorbia hirta</i> L.*	Euphorbiaceae	Exotic (naturalized)	Herb	37
19	<i>Gomphrena celosioides</i> Mart.*	Amarathaceae	Exotic (naturalized)	Herb	37
20	<i>Searsia lancea</i> L.f.	Anacardiaceae	Native (LC)	Tree	37

3.3.1.4 Endemic species

Twenty eight species endemic to South Africa were found in this study of which five are native to the North-West Province (Table 3-4). The most frequently occurring species was *Pelargonium zonale*. Two endemic species are assessed as vulnerable (VU) (*Kalanchoe longiflora* and *Podranea ricasoliana*) and one species, *Haworthia fasciata*, is near threatened (NT). Two species, *Elephantorrhiza obliqua* and *Lampranthus roseus* were not evaluated because of a lack of data (DDT). Only one tree (*Podocarpus henkelii*) and one climber (*Podranea ricasoliana*) endemic species were found in the survey. From a total of 28 endemic species, nine species (32.1 %) were succulents.

Table 3-4: The most frequent occurring endemic plant species of health clinic gardens in Bojanala District Municipality

Position	Plant Species	Status	Growth form	Drought tolerancy	Frequency of occurrence in clinic gardens
1	<i>Pelargonium zonale</i> (L.) L'Hér.	Indigenous (cultivated) (LC - Endemic to SA)	Shrub	non-succulent	27
2	<i>Tulbaghia simmleri</i> P.Beauv.	Indigenous (LC - Endemic to SA)	Herb	non-succulent	27
3	<i>Sida spinosa</i> L. var. <i>spinosa</i>	Native (LC - Endemic to SA)	Herb	non-succulent	26
4	<i>Dimorphotheca fruticosa</i> (L.) Less.	Indigenous (LC - Endemic to SA)	Herb	non-succulent	23
5	<i>Aptenia cordifolia</i> (L.f.) Schwantes	Indigenous (LC - Endemic to SA)	Herb: succulent	succulent	21
6	<i>Gazania rigens</i> (L.) Gaertn. var. <i>leucolaena</i> (DC.) Roessler	Indigenous (LC - Endemic to SA)	Herb	non-succulent	19
7	<i>Carpobrotus edulis</i> (L.) L.Bolus subsp. <i>edulis</i>	Indigenous (LC - Endemic to SA)	Herb: succulent	succulent	15
8	<i>Portulaca grandiflora</i> Hook.	Native (LC - Endemic to SA)	Herb: succulent	succulent	6

Table 3-4 continues

9	<i>Senecio scaposus</i> DC. var. <i>scaposus</i>	Indigenous (LC - Endemic to SA)	Herb: succulent	succulent	5
10	<i>Strelitzia reginae</i> Aiton	Indigenous (LC - Endemic to SA)	Herb	non-succulent	5
11	<i>Kalanchoe longiflora</i> Schltr. ex J.M.Wood	Indigenous (VU - Endemic to SA)	Herb: succulent	succulent	4
12	<i>Aloe striata</i> Haw.	Indigenous (LC - Endemic to SA)	Herb: succulent	succulent	3
13	<i>Crassula capitella</i> Thunb. subsp. <i>capitella</i>	Indigenous (LC - Endemic to SA)	Herb: succulent	succulent	3
14	<i>Strelitzia alba</i> (L.f.) Skeels	Indigenous (LC - Endemic to SA)	Tree	non-succulent	3
15	<i>Aristida diffusa</i> Trin. subsp. <i>burkei</i> (Stapf) Melderis	Native (LC - Endemic to SA)	Herb: Graminoid	non-succulent	3
16	<i>Lampranthus roseus</i> (Willd.) Schwantes	Indigenous (DDT - Endemic to SA)	Herb: succulent	succulent	2
17	<i>Kniphofia praecox</i> Baker	Indigenous (LC - Endemic to SA)	Herb	non-succulent	2
18	<i>Euryops chrysanthemoides</i> (DC.) B.Nord.	Indigenous (LC - Endemic to SA)	Shrub	non-succulent	2
19	<i>Haworthia fasciata</i> (Willd.) Haw.	Indigenous (NT - Endemic to SA)	Herb: succulent	succulent	2
20	<i>Elephantorrhiza obliqua</i> Burt Davy var. <i>obliqua</i>	Indigenous (DDT - Endemic to SA)	Shrub	non-succulent	1
21	<i>Amaryllis belladonna</i> L.	Indigenous (LC - Endemic to SA)	Herb	non-succulent	1
22	<i>Chlorophytum capense</i> (L.) Voss	Indigenous (LC - Endemic to SA)	Herb	non-succulent	1
23	<i>Dietes grandiflora</i> N.E.Br	Indigenous (LC - Endemic to SA)	Herb	non-succulent	1
24	<i>Isoglossa woodii</i> C.B.Clarke	Indigenous (LC - Endemic to SA)	Shrub	non-succulent	1
25	<i>Podocarpus henkelii</i> Stapf ex Dallim. & Jacks.	Indigenous (LC - Endemic to SA)	Tree	non-succulent	1
26	<i>Podranea ricasoliana</i> (Tanf.) Sprague	Indigenous (VU - Endemic to SA)	Climber	non-succulent	1
27	<i>Crabbea angustifolia</i> Nees	Native (LC - Endemic to SA)	Herb	non-succulent	1
28	<i>Triumfetta sonderi</i> Ficalho & Hiern	Native (LC - Endemic to SA)	Shrub	non-succulent	1

3.3.1.5 Endangered and protected species

From a total of 645 plant species surveyed in health clinic gardens in Bojanala District Municipality, 321 species were indigenous to South Africa of which 210 plant species were native to the North-West Province. A total of nine species were identified as important according to the RED Data List of South African Plants. Two species, *Kalanchoe longiflora* and *Podranea ricasoliana* are Vulnerable (VU) which indicates that these species are at high risk of extinction (IUCN, 2012). *Kalanchoe longiflora* was recorded in four clinic gardens and *Podranea ricasoliana* was found only once (Table 3-5). *Elaeodendron transvaalense* and *Haworthia fasciata* are near threatened (NT) and has therefore the potential to become at risk of extinction in the near future (IUCN, 2012) (Table 3-5). Five species, namely *Hypoxis hemerocallidea*,

Boophone disticha, *Crinum bulbispermum*, *Eucomis autumnalis* and *Crinum macowanii*, were evaluated as Declining. This means that these species cannot be classified under the five IUCN criteria and also do not qualify for being Critically Endangered, Endangered, Vulnerable or Near Threatened, but are continually declining because of threatening processes (such as overharvesting for the medicinal market) (Table 3-5). All of these endangered species are perennial and only two are succulents. Five out of the nine species can potentially be used for medicinal purposes.

Table 3-5: Endangered and protected species found in health clinic gardens in Bojanala District Municipality

Position	Plant Species	Status	Drought tolerancy	Potential use	Frequency of occurrence in clinic gardens
1	<i>Kalanchoe longiflora</i> Schltr. ex J.M.Wood	Indigenous (Vulnerable - Endemic to SA)	succulent	Ornamental	4
2	<i>Boophone disticha</i> (L.f.) Herb	Native (Declining)	non-succulent	Medicinal	3
3	<i>Hypoxis hemerocallidea</i> Fisch., C.A.Mey. & Ave-Lall.	Native (Declining)	non-succulent	Medicinal	3
4	<i>Haworthia fasciata</i> (Willd.) Haw.	Indigenous (Near Threatened - Endemic to SA)	succulent	Ornamental	2
5	<i>Crinum bulbispermum</i> (Burm.f.) Milne-Redh. & Schweik	Native (Declining)	non-succulent	Ornamental	2
6	<i>Eucomis autumnalis</i> (Mill.) Chitt.	Native (Declining)	non-succulent	Medicinal	2
7	<i>Podranea ricasoliana</i> (Tanf.) Sprague	Indigenous (Vulnerable - Endemic to SA)	non-succulent	Ornamental	1
8	<i>Crinum macowanii</i> Baker	Native (Declining)	non-succulent	Medicinal	1
9	<i>Elaeodendron transvaalense</i> (Burt Davy) R.H.Archer	Native (Near Threatened)	non-succulent	Medicinal	1

3.3.1.6 Invasive species

In total, 14 declared invasive species were found in clinic gardens (South Africa, 2014b) (Table 3-6). Frequently found invasive species were *Morus alba* (39 clinic gardens), *Malvastrum coromandelianum* (38 clinic gardens) and *Melia azedarach* (38 clinic gardens) (Table 3-6). The origin of these species is central Asia to China (*Morus alba*), North America (*Malvastrum coromandelianum*) and India and Sri-Lanka (*Melia azedarach*). The other invasive species originated from a wide range of countries in North and South America, Europe, Madagascar and Asia (Table 3-6). Only one species (*Coreopsis lanceolata*) is evaluated as a Category 1a invader which means that this species should be removed if encountered. Nine species are Category 1b invaders, which should also be closely monitored and removed if possible. Only one species, *Casuarina cunninghamiana*, is a Category 2 invader which has the potential to

become invasive because of its importance in commerce. Three Category 3 invaders were found: *Morus alba*, *Melia azedarach* and *Duranta erecta*. These species may only be cultivated in certain restricted areas (such as urban areas). *Morus alba* can potentially be used for its edible fruit, *Melia azedarach* has medicinal uses and *Duranta erecta* is usually planted for ornamental purposes (Table 3-6). From a total of 14 invasive species, 6 are poisonous to humans of which 5 have medicinal uses.

Table 3-6: The most frequent occurring invasive plant species in health clinic gardens in Bojanala District Municipality

Plant Species	Origin	Status	Potential use	Poisonous	Frequency of occurrence
<i>Morus alba</i> L. var. <i>alba</i> *	central Asia to China	Exotic (naturalized - C3 invader except sterile cultivars or hybrids)	Food: fruit tree	No	39
<i>Malvastrum coromandelianum</i> (L.) Garcke*	North America	Exotic (naturalized - C1b invader)	n/a	No	38
<i>Melia azedarach</i> L.*	India and Sri-Lanka	Exotic (naturalized - C3 invader in urban areas)	Medicinal	Yes	38
<i>Tecoma stans</i> (L.) Kunth*	Florida to Argentina	Exotic (naturalized - C1b invader)	Hedge	No	25
<i>Jacaranda mimosifolia</i> D.Don.*	Bolivia and Argentina	Exotic (naturalized - C1b invader except in urban areas)	Shade	No	24
<i>Catharanthus roseus</i> (L.) G.Don.*	Madagascar	Exotic (naturalized - C1b invader except sterile cultivars or hybrids)	Medicinal	Yes	21
<i>Duranta erecta</i> L.*	Florida to Brazil	Exotic (naturalized - C3 invader except sterile cultivars or hybrids)	Ornamental	Yes	17
<i>Argemone ochroleuca</i> Sweet subsp. <i>ochroleuca</i>	Mexico	Exotic (naturalized - C1b invader)	Medicinal	Yes	13
<i>Datura stramonium</i> L.*	North America	Exotic (naturalized - C1b invader)	Medicinal	Yes	13
<i>Casuarina cunninghamiana</i> Miq	eastern Australia	Exotic (naturalized - C2 invader)	Shade	No	13
<i>Mirabilis jalapa</i> L.*	central America	Exotic (naturalized - C1b invader)	Ornamental	No	12
<i>Verbena bonariensis</i> L.*	Brazil to Argentina	Exotic (naturalized - C1b invader)	n/a	No	12
<i>Coreopsis lanceolata</i> L.*	North America	Exotic (cultivated - C1a invader except sterile cultivars or hybrids)	Ornamental	No	11
<i>Nerium oleander</i> L.*	Morocco to China	Exotic (naturalized - C1b invader except sterile cultivars of hybrids)	Medicinal	Yes	10

3.3.1.7 Origin of naturalised and cultivated alien species

Figure 3-1 shows that most alien species in clinic gardens originated from South America, Tropical America, Garden Origin and Europe. Only 1 plant species come from the Mediterranean and the Canary Islands (Figure 3-1).

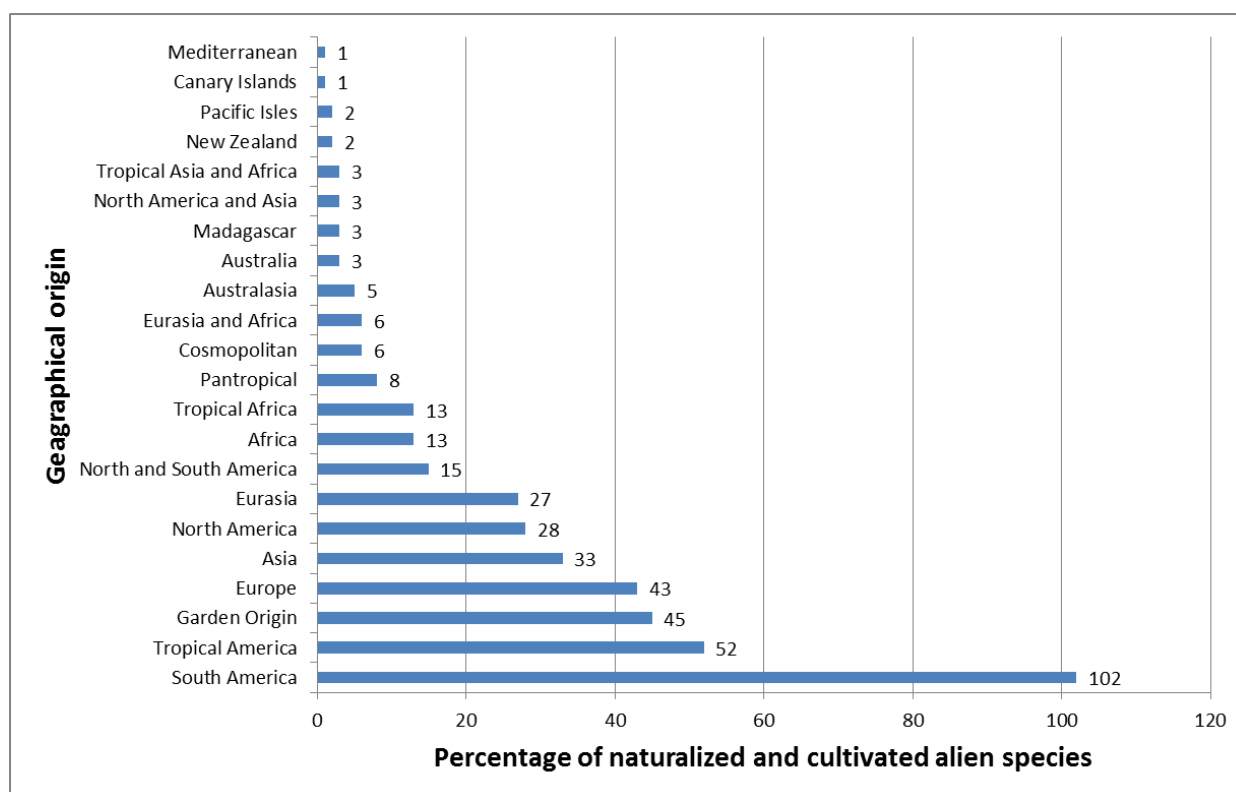


Figure 3-1: Geographical origin of alien species in health clinic gardens in Bojanala District Municipality

3.3.1.8 Representation of growth forms and Raunkiaer's life-forms

Herbaceous plants species were dominant in health clinic gardens followed by trees and shrubs (Figure 3-2). *Schkuria pinnata* (found in 61 (59%) clinic gardens) and *Conyza bonariensis* (found in 45 (43.7%) clinic gardens) were the most frequently occurring herbaceous plant species in health clinic gardens (Table 3-3). Tree species such as *Acacia tortilis* (occurred in 63 (61.2 %) clinic gardens) and *Prunus persica* (occurred in 48 (46.6%) clinic gardens) were also frequently recorded (Table 3-3) as well as the shrub species, *Dichrostachys cinerea* (occurred in 30 (29%) of the clinic gardens).

The most abundant life-form recorded in health clinic gardens was phanerophytes (mostly represented by species such as *Acacia tortilis*, *Prunus persica* and *Dichrostachys cinerea*) (Figure 3-3). Phanerophytes include all perennial plants which have aerial shoot apices and can include shrubs and trees (Kent, 2012). Therophytes, such as *Acalypha indica*, were also dominant in health clinic gardens (Figure 3-3). These species are annual herbs or ephemeral plants adapted to complete their life cycle when preferable conditions prevails (Kent, 2012).

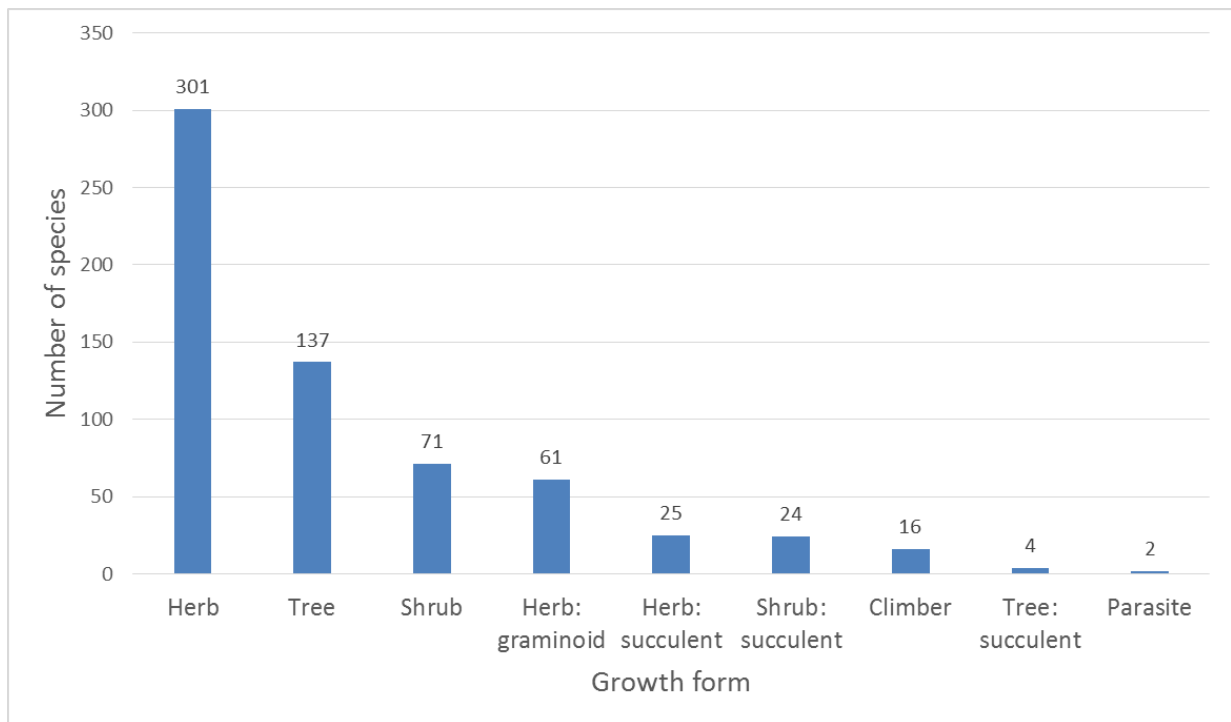


Figure 3-2: Representation of growth forms in health clinic gardens of Bojanala District Municipality

Chamaephytes (perennial plants with shoot apices a small distance from the ground such as *Dahlia pinnata*), hemicryptophytes (perennial plants with shooting buds that are level with the ground such as *Convolvulus saggitatus*) and geophytes (perennial plants with a storage organ under the ground such as *Agapanthus* spp.) were less dominant in health clinic gardens (Figure 3-3) (Kent, 2012). Only one hydrophyte (aquatic plant), *Typha capensis*, was recorded (Figure 3-3) (Kent, 2012).

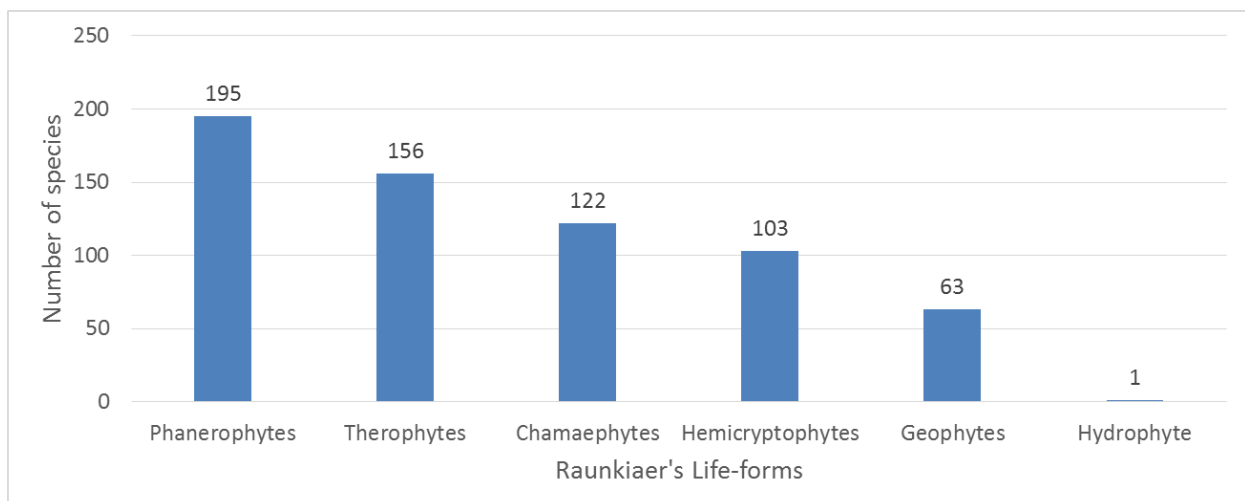


Figure 3-3: Representation of Raunkiaer's life-forms in health clinic gardens of Bojanala District Municipality

3.3.1.9 Species with potential uses

According to Figure 3-4 most species found in clinic gardens can be used for ornamental purposes (186 plant species). The number of plant species with potential medicinal value was also high (145 plant species). Ninety five edible species were found. Species used as hedges were only four. There were also species with many other uses such as: dye for leather or wool, wood for tools, thatch grass, spiritual uses, fibre for string or weaving hats, uses for perfume or as a toothbrush or to make brooms. Since medicinal and edible plant species can be associated with human health, the most frequent occurring species of both of these categories were also determined.

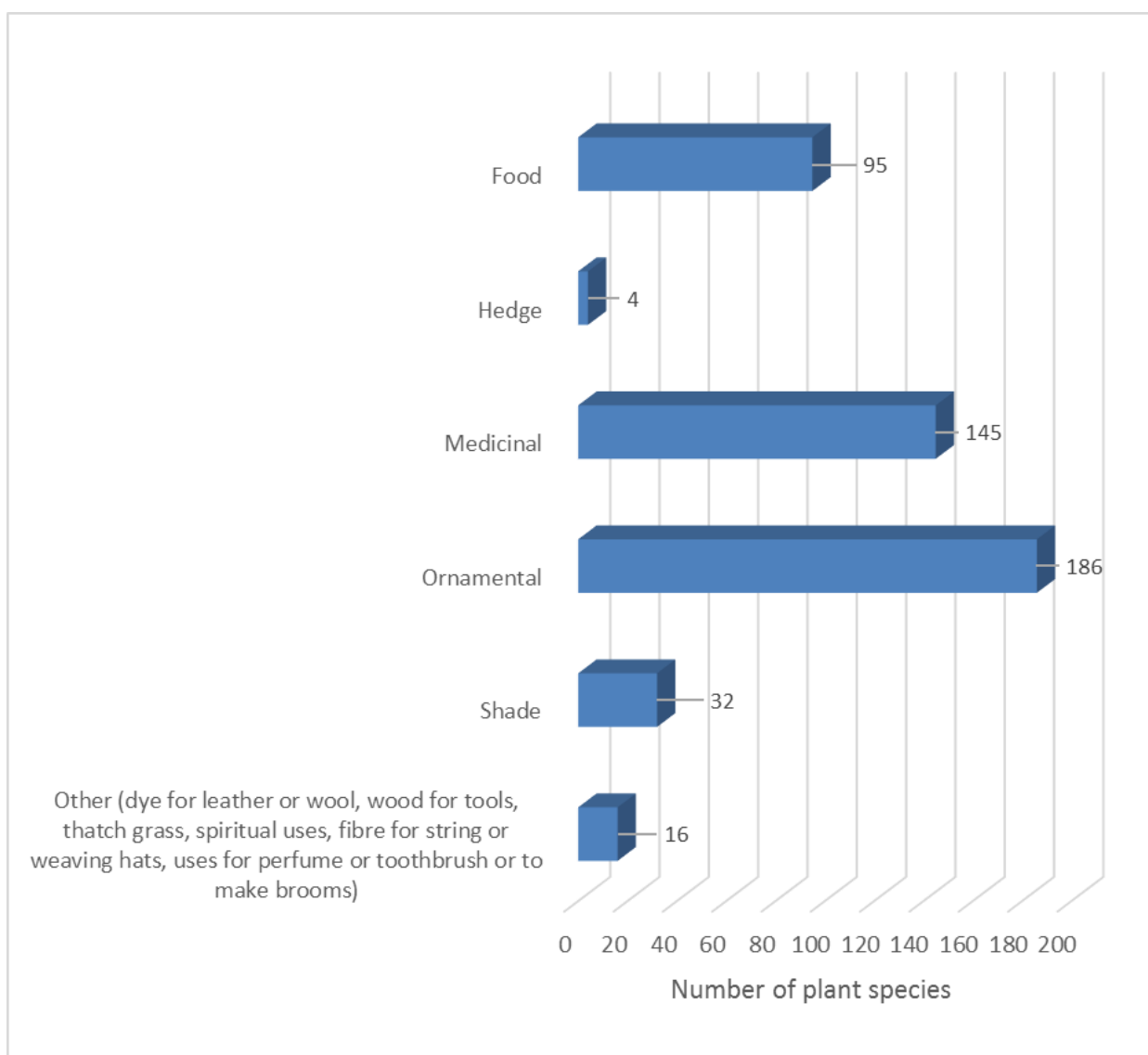


Figure 3-4: Number of plant species with potential uses found in health clinic gardens of Bojanala District Municipality

The most frequently occurring edible plant species (83 clinic gardens) was *Urochloa mosambicensis* (Table 3-7). This is a native species which can be used as grain. From the top

10 most frequent edible plant species, six species were ALV's and seven species were exotic of which one was a category 3 invader (*Morus alba*) (Table 3-7).

Table 3-7: Most frequent occurring edible plant species in health clinic gardens of Bojanala District Municipality

Position	Plant Species	Potential use	Status	Frequency of occurrence in clinic gardens
1	<i>Urochloa mosambicensis</i> (Hack.) Dandy	Food: grain	Native (LC)	83
2	<i>Prunus persica</i> (L.) Batsch. var. <i>persica</i> *	Food: fruit tree	Exotic (cultivated)	48
3	<i>Boerhavia erecta</i> L.*	Food: african leafy vegetable, medicine	Exotic (naturalized - weed)	41
4	<i>Bidens pilosa</i> L.*	Food: african leafy vegetable, medicine	Exotic (naturalized - weed)	39
5	<i>Morus alba</i> L. var. <i>alba</i> *	Food: fruit tree	Exotic (naturalized - C3 invader, except sterile cultivars or hybrids)	39
6	<i>Spinacia oleracea</i> L.*	Food: leafy vegetable	Exotic (cultivated)	39
7	<i>Searsia lancea</i> L.f.	Food: fruit tree	Native (LC)	37
8	<i>Bidens bipinnata</i> L.	Food: african leafy vegetable	Exotic (naturalized - weed)	35
9	<i>Amaranthus hybridus</i> L.*	Food: african leafy vegetable	Exotic (naturalized - weed)	33
10	<i>Pentarrhinum inspidum</i> E.Mey.	Food: african leafy vegetable	Native (LC)	25

The most frequently occurring medicinal plant species is *Agapanthus spp* which occurred in 40 clinic gardens (Table 3-8). *Melia azedarach*, a Category 3 invader in urban areas, occurred in 38 clinic gardens. From the top 10 most frequent medicinal plant species, 4 are poisonous to humans. One species, *Tulbaghia simmleri*, is endemic to South Africa.

Table 3-8: Most frequent occurring medicinal plants in health clinic gardens of Bojanala District Municipality

Position	Plant species	Status	Poisonous	Frequency of occurrence in clinic gardens
1	<i>Agapanthus</i> sp	Indigenous	Yes	40
2	<i>Melia azedarach</i> L.*	Exotic (naturalized - C3 invader in urban areas)	Yes	38
3	<i>Tagetes minuta</i> L.*	Exotic (naturalized)	no	34
4	<i>Schinus molle</i> L.*	Exotic (naturalized)	Yes	33
5	<i>Combretum erythrophyllum</i> (Burch.) Sond.	Native (LC)	No	32
6	<i>Ziziphus mucronata</i> Willd. subsp. <i>mucronata</i>	Native (LC)	No	32
7	<i>Dichrostachys cinerea</i> (L.) Wight & Arn. subsp. <i>africana</i> Brenan & Brummitt var. <i>pubescens</i> Brenan & Brummitt	Native (LC)	No	30
8	<i>Schkuhria pinnata</i> (Lam.) Cabrera*	Exotic (naturalized)	No	30
9	<i>Tulbaghia simmleri</i> P.Beauv.	Indigenous (LC - Endemic to SA)	No	27
10	<i>Euphorbia helioscopia</i> L.	Exotic (naturalized)	Yes	26

3.3.2 Comparison of local municipalities:

Two-dimensional non-metric multi-dimensional scaling (NMDS) based upon Bray Curtis similarity between clinic gardens revealed that the species composition is not distinctly different

when comparing the local municipalities (Figure 3-5). Although the sampled clinic gardens did not separate into distinctive groups in ordinal space, Rustenburg Local Municipality appears to be concentrated more to the bottom and Moses Kotane Local Municipality is more dominant to the top-right of the graph. Similar patterns were observed for native and cultivated exotic species, but not for indigenous and naturalised exotic species. The species composition of Madibeng and Moretele local municipalities cannot be distinguished from the other local municipalities (Figure 3-5).

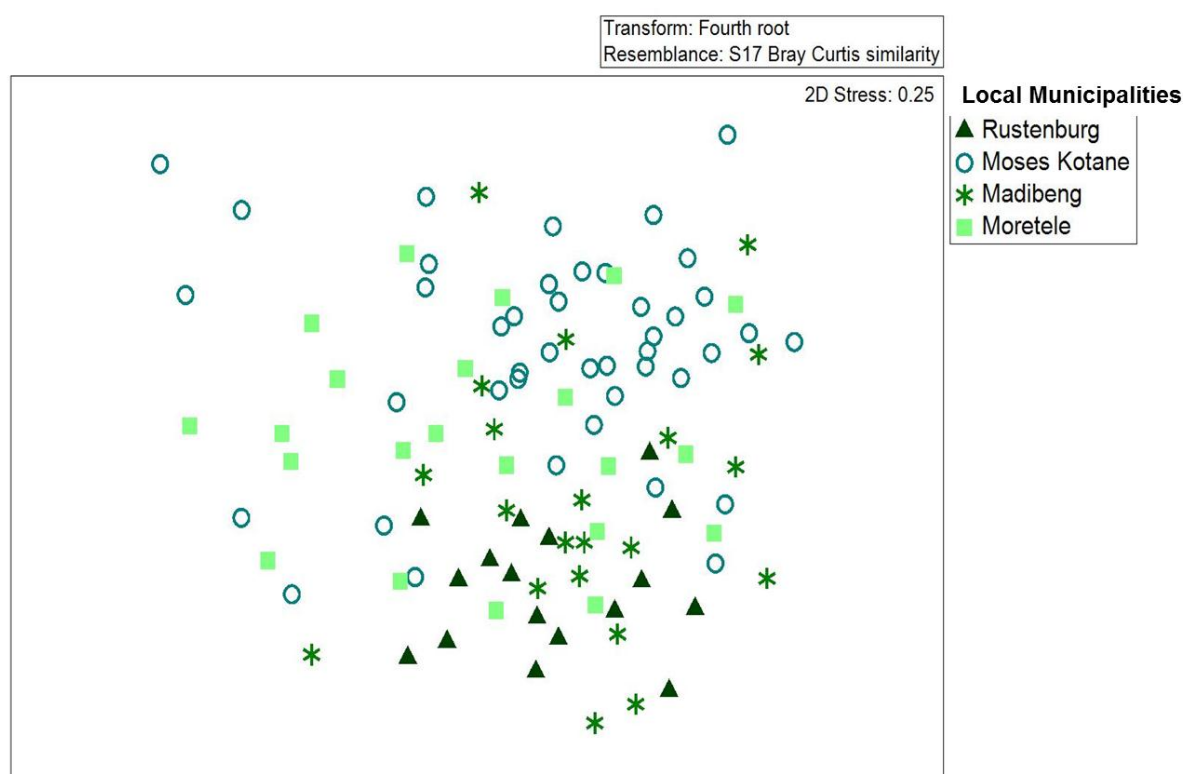


Figure 3-5: Non-metric Multidimensional Scaling (NMDS) of plant species composition and cover abundance in health clinic gardens to show the difference between the Local Municipalities of Bojanala District Municipality

The Analysis of Variance (ANOVA) between the number of species of clinic gardens in the different local municipalities showed no statistical variance ($p=0.13$). Differences between all combinations of species assemblages of the local municipalities were also tested with an Unequal N HSD (Honestly Significantly Different) and the results also showed no significant variance between any of the local municipalities.

Plant species with potential uses were also compared between the local municipalities and the results showed only small differences. In all the local municipalities, food, ornamental and medicinal uses were the dominant potential uses of plant species occurring in health clinic gardens.

3.3.3 Comparison of micro-gardens

Significant differences ($p < 0.05$) were found between the numbers of species occurring in the micro-gardens. The naga micro-garden differed significantly from all other micro-gardens regarding number of species except with the medicinal micro-garden (Figure 3-6). The few species used as hedge were significantly less than the number of species in the naga micro-garden. The ornamental, lawn, medicinal and vegetable micro-gardens did not differ significantly from each other.

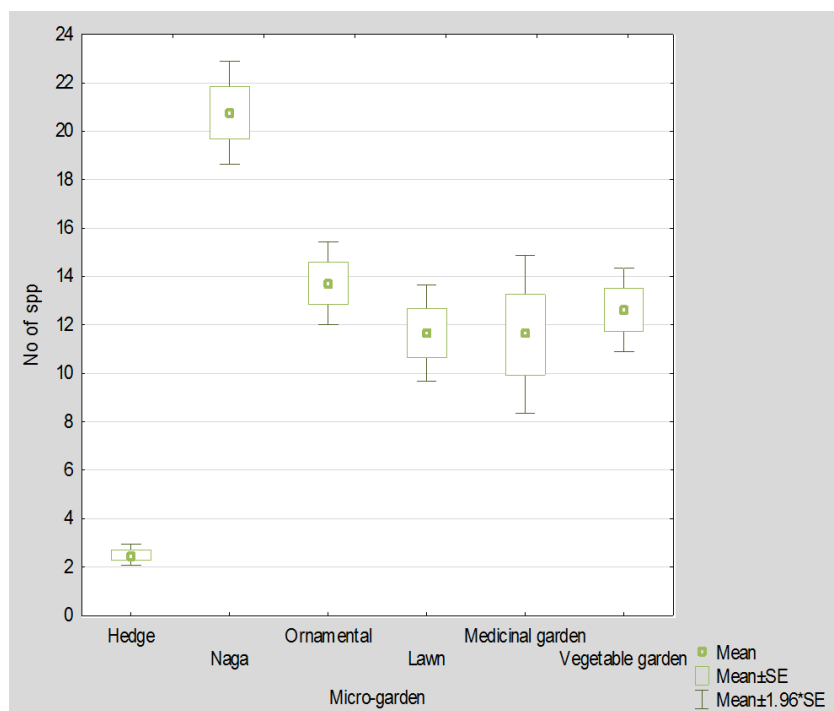


Figure 3-6: Differences in the number of species in each micro-garden of health clinic gardens in Bojanala District Municipality.

The species composition regarding native, indigenous and exotic species varied across the different micro-gardens (Figure 3-7). Native species were dominant. The most native species occurred in the naga micro-garden and the least were recorded in the ornamental micro-garden (Figure 3-7). Sixty percent of the species used for ornamental purposes were exotic. There were no exotic (cultivated) species used as hedge (Figure 3-7).

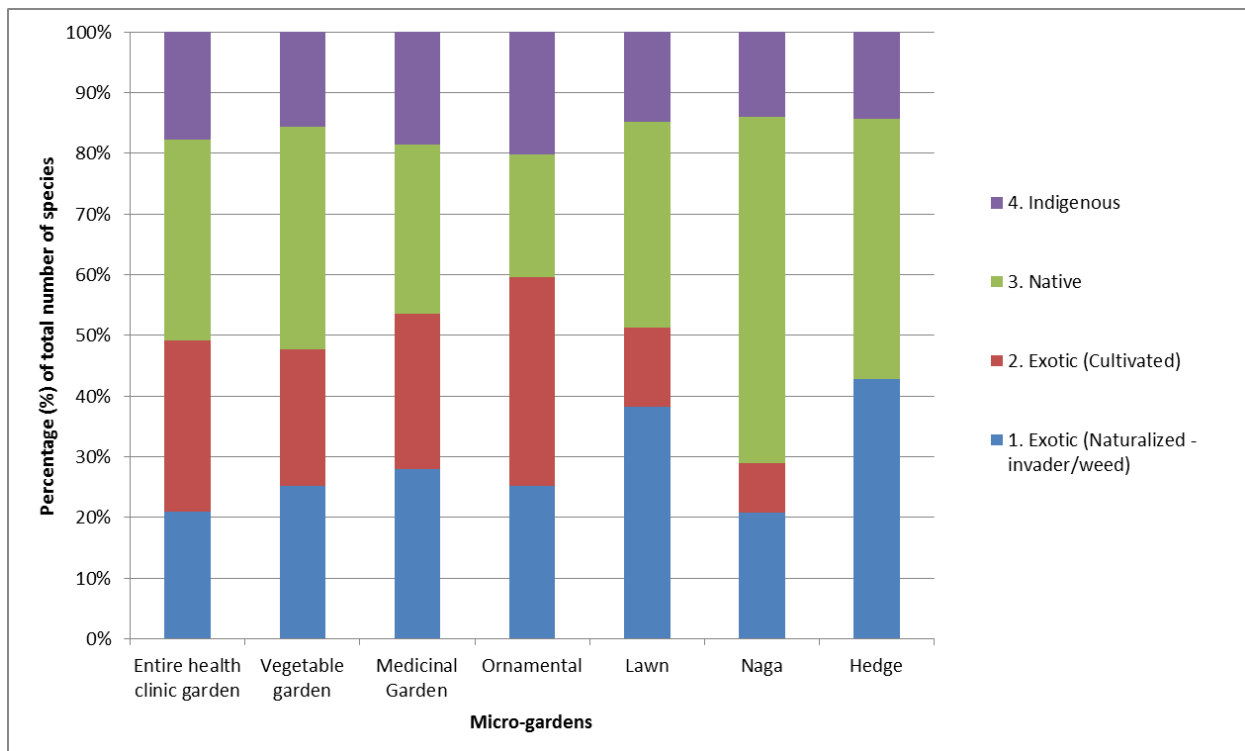


Figure 3-7: Comparison of exotic (naturalised), exotic (cultivated), native and indigenous species of the different micro-gardens in health clinic gardens in the Bojanala District Municipality.

Figure 3-8 indicates that the naga contains the highest number of different growth forms (herb: graminoids, herbs, herb: succulents, shrub: succulents, shrubs, and climbers and a parasite). The hedge and medicinal garden have the lowest number of growth forms. Herbaceous plants are dominant in all micro-gardens. The percentage distribution of growth forms shows that hedge is the most evenly divided (40% herbs, 40% shrubs and 20% climbers)

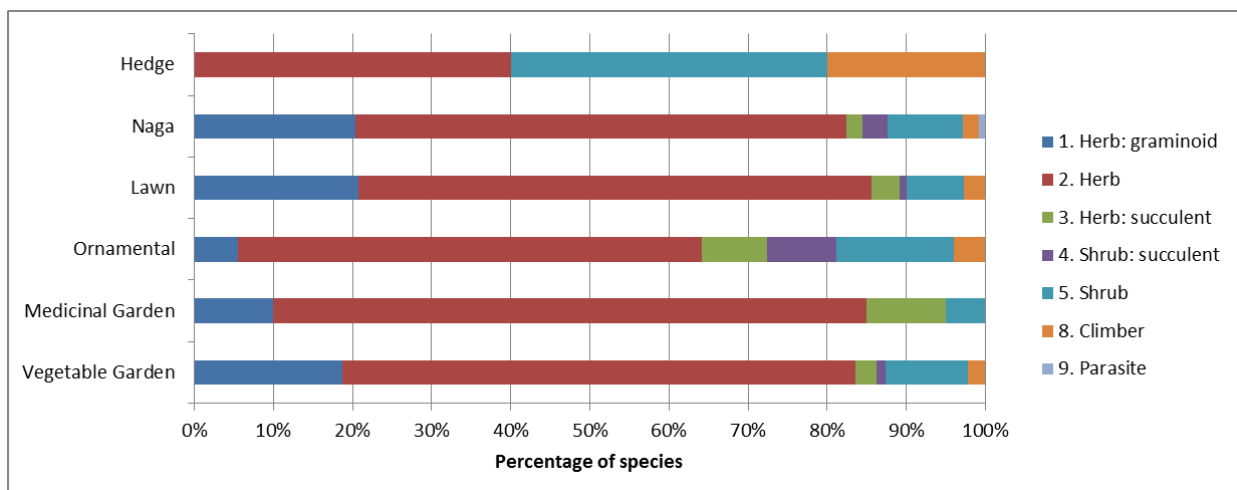


Figure 3-8: Percentage species of each growth form found in the micro-gardens of health clinic gardens in the Bojanala District Municipality

There is overall an even distribution of life-forms in all micro-gardens (Figure 3-9). Therophytes is the most dominant life-form, especially in vegetable gardens. These species complete their life-cycle in one year (annual) and survive from seed to seed in summer months (Kent, 2012). Only one hydrophyte (plant species which buds grow under water (Kent, 2012)) was found in the Naga (Figure 3-9). A higher percentage of geophytes were found in the medicinal garden (Figure 3-9). Geophytes are perennial plants with bulbs, rhizomes and tubers growing under the ground and from which new plants will develop in each growing season (Kent, 2012).

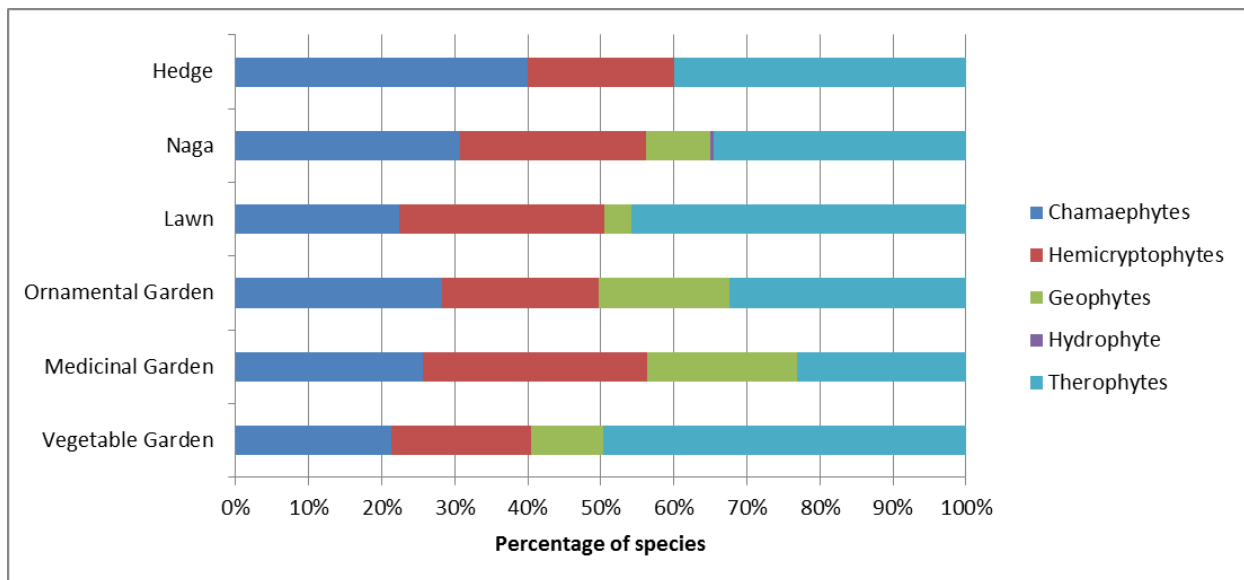


Figure 3-9: Distribution of Raunkiaer's life-forms in each micro-garden of health clinic gardens in the Bojanala District Municipality

3.4. Discussion

3.4.1 Dominant families

Some of the most species rich families in South Africa were also found in clinic gardens (Asteraceae, Poaceae and Fabaceae) (Germishuizen *et al.*, 2006). This similarity might be explained by the natural vegetation area (naga microgarden) occurring in clinic gardens which increase the number of native species (Molebatsi *et al.*, 2010; Mucina & Rutherford, 2006). Asteraceae is a plant family with a cosmopolitan distribution and contains many species adapted to almost every climate in the world (Pienaar, 1984). It is also a popular family cultivated in domestic gardens in many parts of the world (Smith *et al.*, 2006; Lubbe *et al.*, 2011; Molebatsi *et al.*, 2013). Species of the Fabaceae family are commonly used as ornamental plants in gardens. These species are fast growing and occur naturally in temperate regions (Pienaar, 1984). Plant species of the Fabaceae family can also fix nitrogen which improves the nitrogen content of the soil in the garden (Duncan *et al.*, 2011).

Family representation in clinic gardens showed some similarities with other domestic and home garden studies in urban and peri-urban areas (Lubbe *et al.*, 2011) and deep rural areas (Molebatsi *et al.*, 2013) in the North-West Province. The dominant families in this study (Asteraceae, Fabaceae and Poaceae) were also dominant in the deep rural areas (Molebatsi *et al.*, 2013). In domestic gardens in urban and peri-urban areas, however, families such as Lamiaceae and Iridaceae also featured in the top 20 families (Lubbe *et al.*, 2011). A larger number of families are often found in urban domestic gardens for ornamental purposes although most of these families are represented by only one species (Smith *et al.* 2006). Domestic gardens are therefore aesthetically orientated which means that most of the plants will be present for ornamental purposes (Davoren *et al.*, 2015). Clinic gardens are dependent on resources provided by governmental institutions (Pillay & Barron, 2011), and therefore do not have access to a wide range of ornamental plant species.

3.4.2 Dominant genera and plant species representation

The total number of genera in clinic gardens (404 genera) is also considerably less than the total genera recorded in domestic and home gardens (501 genera) proving the previously mentioned notion that domestic gardens have more diverse ornamental plants than clinic gardens which are focused on food and nutrition provision (Lubbe *et al.*, 2011; Molebatsi *et al.*, 2013). The two most dominant genera recorded in clinic gardens (*Acacia* and *Eragrostis*) consisted mostly of native species adapted to the climate of that region. The genus *Acacia* consists of perennial tree species adapted to dry conditions with bipinnately compound leaves and stipular leaves modified into thorns. Grass species from the genus *Eragrostis* surveyed in this study commonly grow in disturbed areas and are often beneficial to combat erosion.

Except for *Indigofera*, *Amaranthus*, *Aristida* and *Asparagus*, the top 10 genera in clinic gardens are also similar to that of rural domestic gardens (Molebatsi *et al.*, 2013) in the North-West Province. In urban/peri-urban areas, the majority (15 out of the top 20 species) of the most frequent species were alien (Lubbe *et al.*, 2011). There were less exotic species (11 out of the top 20 species) dominant in clinic gardens.

Cynodon dactylon, *Conyza bonariensis*, *Eragrostis lehmanniana* and *Euphorbia hirta* were under the top 20 most frequently recorded species in both clinic gardens and domestic gardens in urban/peri-urban areas (Lubbe *et al.*, 2011). The two species, *Cynodon dactylon* and *Eragrostis lehmanniana*, were frequent in both rural home and clinic gardens (Molebatsi *et al.*, 2013). *Cynodon dactylon* and *Eragrostis lehmanniana* are native grass species which naturally occurs throughout the North-West Province. These species are therefore well adapted to the climate of this region. According to Lubbe *et al.*, (2011), preference is given to plant species with high tolerance to climatic conditions for cultivation in domestic gardens in the North-West

Province. One category 1b invader, *Malvastrum coromandelianum*, and two category 3 invaders, *Melia azedarach* and *Morus alba*, was also among the top 20 most frequently recorded species at clinic gardens, which did not occur as frequent in domestic gardens (Lubbe *et al.*, 2011).

3.4.3 Endemic species

Several of the endemic species found in clinic gardens was consistent with the endemic species found in domestic and home gardens of which the most frequent are: *Tulbaghia simmleri*, *Sida spinosa*, *Aptenia cordifolia*, *Carpobrotus edulis* and *Portulaca grandiflora* (Lubbe *et al.*, 2011; Molebatsi *et al.*, 2013). The presence of two vulnerable and one near threatened species proves the fact that clinic gardens, similar to domestic and home gardens, can play an important role in the conservation of endemic species (Lubbe *et al.*, 2011; Molebatsi *et al.*, 2013). The cultivation of these species should therefore be promoted to enhance the protection thereof (Davoren, 2009; Lubbe *et al.*, 2011).

3.4.4 Endangered and protected species

Several endangered species were found in home and domestic gardens in the North-West Province which also occur in clinic gardens namely, *Hypoxis hemerocallidea*, *Crinum bulbispermum*, *Eucomis autumnalis* and *Crinum macowanii* (Lubbe *et al.*, 2011; Molebatsi *et al.*, 2013). The number of endangered and protected species found in clinic gardens (9) was much less than in domestic gardens of urban and peri-urban areas (18) (Lubbe *et al.*, 2011), but was very similar to home gardens in rural areas of the North-West Province (8) (Molebatsi *et al.*, 2013). Health clinic gardens can still be an important tool to protect and stimulate the propagation of threatened species, since it is central to communities and an ideal place for sharing information (Chapter 4). Several previous studies found that gardens in human settlement areas can maintain biodiversity and provide essential habitat for threatened fauna and flora (Landman & du Plessis, 2002; Oliveira *et al.*, 2011; Reyes-García *et al.*, 2012; Zerbe *et al.*, 2003; Gaston *et al.*, 2005). Some of these species, however, are not cultivated for their value to biodiversity, but more for their potential uses (Das & Das, 2005). The usefulness of a species can be very dependent on the knowledge or perception of the gardener and this cause some species to lose their importance in gardens (Molebatsi *et al.*, 2013). Consistency in management for long periods of time can therefore contribute to conservation of species in human settlement areas (Zerbe *et al.*, 2003). Lower intensity of management and the use of native plant species' seed material for gardens can improve the city's contribution to maintenance of habitat and biodiversity (Zerbe *et al.*, 2003).

3.4.5 Invasive species

Similar to domestic and home gardens in the North-West Province, several invasive species were found in clinic gardens (*Durantha erecta*, *Morus alba*, *Melia azedarach*, *Casuarina cunninghamiana* and *Mirabilis jalapa*). Although the frequency of occurrence is low, invasive species in clinic gardens can play a major role in the propagation of exotic species, contributing to the creation of naturalised exotic populations (Cubino *et al.*, 2015; Molebatsi *et al.*, 2013). Detailed information and education on invasive species and the impact thereof on native and endemic species might be a tool to discourage the cultivation of alien plant species (part of human capital discussed in Chapter 4) (Cubino *et al.*, 2015).

3.4.6 Origin of naturalised and cultivated alien species

According to Molebatsi *et al.*, (2013), alien garden flora usually originates from areas with similar climate than the region where the garden is situated. These species are more desirable in some cases since they do not have natural enemies in this region and tend to look more healthy and colourful than indigenous species (Molebatsi *et al.*, 2013). It seems that species which originated in gardens were mostly found in the lawn and ornamental micro-garden which indicates its aesthetical role in clinic gardens. Species from Asia and South America are also popular (such as *Cycas revoluta* and *Duranta erecta*) because of their high aesthetical value. Eurasia also contains very popular medicinal plant species such as garden mint (*Mentha sachalinensis*), ginger (*Zingiber officinale*) and fennel (*Foeniculum vulgare*). Important vegetable species cultivated in clinic gardens such as spinach (*Spinacia oleracea*) and carrots (*Daucus carota*) also have Asian and European origin.

3.4.7 Representation of growth forms and Raunkiaer's life-forms

Similar to domestic gardens of urban and peri-urban areas as well as home gardens in rural areas of the North-West Province, herbs were the most dominant growth form of plant species recorded in health clinic gardens. Trees and shrubs were also in the top 3 most dominant growth forms in domestic (urban and peri-urban) (Lubbe *et al.*, 2011) and home gardens (rural areas) (Molebatsi *et al.*, 2013), although the shrubs were more than the trees, which differs from health clinic gardens (trees were second most dominant). *Prunus persica* was in rural home gardens (Molebatsi *et al.*, 2013), urban and peri-urban domestic gardens (Lubbe *et al.*, 2011), as well as in health clinic gardens one of the dominant tree species recorded in the North-West Province.

Phanerophytes were the most dominant life-form recorded in health clinic gardens, since this life-form contains both shrubs and tree species. Most of the species in the vegetable gardens of health clinic gardens are annuals and crops are rotated every season. This might be the reason

for the high number therophytes (annuals (Kent, 2012)) recorded in health clinic gardens. Since the climate of Bojanala District Municipality is very dry with a summer rainfall of 550-650 mm per year and harsh winters (Mucina & Rutherford, 2006), it makes sense that only one hydrophyte was found.

3.4.8 Species with potential uses

Utilitarian plants cultivated in home and domestic gardens can play an important role in stimulating plant diversity as well as contribute to the livelihood of the community (Cilliers & Siebert, 2012; Lubbe *et al.*, 2010; Pandey *et al.*, 2007). In contrast with the main purpose of clinic gardens (to improve the health of the community), the highest number of species is ornamental – similar to that of domestic gardens in the North-West Province (Lubbe *et al.*, 2011). The high number of medicinal plant species, on the other hand, was more consistent with home gardens in the North-West Province, indicating that clinic gardens contain a mixed composition of westernised and traditional influences (Davoren *et al.*, 2015; Lubbe *et al.*, 2011; Molebatsi *et al.*, 2013).

Aggregation of traditional and modern knowledge can often be created in home gardens where traditional and western gardening practices are combined (Faber *et al.*, 2002; Galluzzi *et al.*, 2010; Molebatsi *et al.*, 2010; Adekunle *et al.*, 2014) (also mentioned in Chapter 4 – co-production of knowledge). Most of the frequently occurring edible species found in clinic gardens, were leafy vegetables. Leafy vegetables are important sources of food to the rural communities of South Africa (Jansen van Rensburg *et al.*, 2007). The five ALV's which was found in many clinic gardens are well adapted to the climate of the region (Jansen van Rensburg, 2015a). ALV's can be a great asset for clinic gardens since these plant species can survive with little water and need low maintenance. The nutrient content of these species are usually higher than alternative cultivated species and will therefore help to alleviate the nutrition deficiency of the surrounding community (Faber *et al.*, 2002; Faber *et al.*, 2010; Van Jaarsveld *et al.*, 2014). Since ALV's are easily available, these species should be used alongside cultivated species at health clinic gardens to create awareness of their existence and usefulness.

Trading with medicinal plants is still popular in many rural areas of South Africa and are therefore an economic asset which should not be neglected (Ndawonde *et al.*, 2007). Medicinal plants most frequently found in clinic gardens consisted of exotic, indigenous and native species. According to Molebatsi *et al.*, (2010) medicinal plant species were traditionally harvested from the surrounding natural vegetation, but due to urbanisation, more exotic species were also cultivated in home gardens in the North-West Province. These species are used for pain relief and fever as well as diarrhea (Molebatsi *et al.*, 2010)

3.4.9 Comparison of local municipalities

Differences in the native species composition of Rustenburg and Moses Kotane Local Municipalities could be due to different vegetation types. The vegetation types in the Rustenburg Local municipality area are Marikana Thornveld, Norite Koppies Bushveld, Moot Plains Bushveld and Gold Reef Mountain Bushveld and in the Moses Kotane Local municipality are Dwaalboom Thornveld, Madikwe Dolomite bushveld, Zeerust Thornveld and Dwarsberg-Swartruggens Mountain Bushveld) (Mucina & Rutherford, 2006). Differences in the exotic cultivated species between Rustenburg and Moses Kotane Local Municipalities could be due to the social environment which often influences the diversity of the selected garden flora (Das & Das, 2005; Zerbe *et al.*, 2003). The Bafokeng community of Rustenburg might prefer different plant species in their gardens than the Bakgatla-ba-Kgafela people of Moses Kotane and cause a difference in the overall composition of plant species in clinic gardens (Figure 3-5). According to Cook *et al.*, (2012) there are also many other factors to be considered that determine the species composition of urban gardens. Management decisions such as maintenance, fertiliser and pesticide inputs and water use or supply, legacy effects such as previous landscaping decisions as well as multi-scalar human drivers such as human values and cognition, social norms and government policies can change the selection of garden plant species (Cook *et al.*, 2012). Plant species composition of urban gardens can also change according to socio-economic status (Lubbe *et al.*, 2010) and with the presence of the Bafokeng tribe, which is the richest in Africa, one can assume that Rustenburg Local municipality maintain a higher socio-economic status overall than Moses Kotane.

3.4.10 Comparison of micro-gardens

European influences on the Batswana culture encouraged the use of ornamental plants in Batswana home gardens for aesthetical purposes and might be the reason for a greater diversity of ornamental plants in clinic gardens in the Bojanala District (Molebatsi *et al.*, 2010; Davoren, 2009; Davoren *et al.*, 2015). Similarly to home gardens in the North-West Province, there were also a large number of medicinal plants at clinic gardens (Molebatsi *et al.*, 2013). According to Cilliers & Siebert (2012) a very high demand for medicinal plants exists among communities living in the rural areas of South Africa and as these people migrate to cities, the demand will also grow in urban areas. This might also contribute to the high diversity of medicinal plants in clinic gardens.

The significant higher number of species in the naga micro-gardens indicates that natural areas can be important sources of useful native plants at clinic gardens (Molebatsi *et al.*, 2010; Davoren *et al.*, 2015). Some native medicinal species such as *Triumfetta sonderi* were found in health clinic gardens. The Batswana cultural background of the area can clearly be seen by the

typical Tswana tshimo garden design with the presence of a larger naga and lebala and a smaller diversity of species in ornamental and hedge micro-gardens (Davoren *et al.*, 2015) (Figure 3-6).

Since traditional useful native species grow naturally in the area, the Batswana people often keep a natural area with native species in their gardens for household purposes (Molebatsi *et al.*, 2010). This explains the presence of more native species in the naga micro-garden. Similar to home gardens in the North-West Province, ornamental plant species in clinic gardens are also mostly exotic (Davoren, 2009; Molebatsi *et al.*, 2010). With urbanisation and development, traditional gardening practices lose their importance and westernised influences cause people to use exotic species as ornamentals in their gardens (Davoren *et al.*, 2015).

Since the naga is part of the surrounding natural vegetation (Molebatsi *et al.*, 2013), it could be the reason for the high number of growth forms. Some growth forms (such as parasites) which occur in the naga, might not be planted in the other micro-gardens, since it has no aesthetical value. A lack of knowledge on the medicinal value of some of the native plant species (Van Wyk & Gericke, 2000) with different growth forms, can also be the cause of fewer growth forms found in the medicinal garden.

The dominance of therophytes in the vegetable garden can be explained by the fact that therophytes are annuals (Kent, 2012). Most of the plant species in the vegetable garden are only adapted to survive in the weather conditions of one season and will be exchanged with other plant species every season. The high percentage of geophyte species in the medicinal garden might be clarified by the fact that the bulbs and tubers of most geophytes have medicinal value, such as *Zingiber officinale* (Van Wyk & Gericke, 2000).

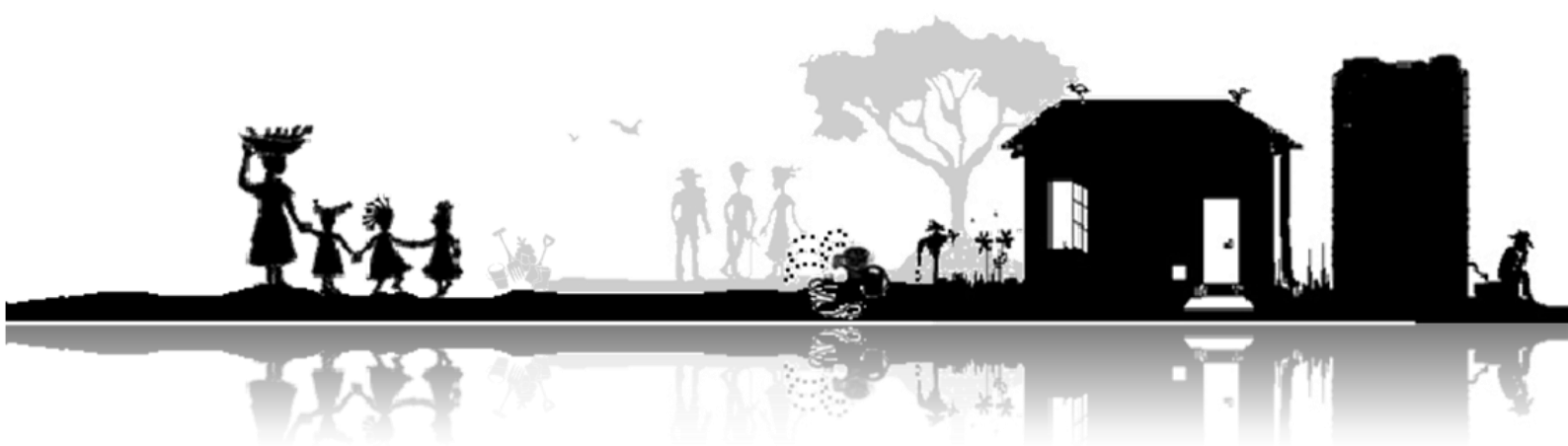
3.5. Conclusion

Health clinic gardens reflect most of the basic structure of home and domestic gardens in the North-West Province. There are only minor differences. Clinic gardens contain less ornamental species and families such as Iridaceae and Lamiaceae and the total genera contain much fewer exotic species. Although clinic gardens contain much less endangered and protected (red data) species than was found in domestic gardens in the North-West Province (Lubbe *et al.*, 2011), there is still potential for clinic gardens to serve as refuge areas of these species in urban areas. The Tswana tshimo layout is also very dominant in clinic gardens especially in the more rural areas (Davoren *et al.*, 2015). The lay-out of gardens in the North-West Province, whether it is a clinic garden or a domestic/home garden, portrays traditional Tswana culture influences, but the variety of species used for ornamental purposes are dependent on the available resources (such as financial or water resources or a nearby nursery) (further explored in Chapter 4). That

is part of the reason for the dominance of exotic species at home/ domestic gardens (Davoren *et al.*, 2015; Lubbe *et al.*, 2011; Molebatsi *et al.*, 2013).

Overall there was no substantial difference in species composition over the four local municipalities. Moses Kotane has a wider range of native species present in the clinic gardens which can be explained by the rural setting of this Local municipality. Local municipalities also did not differ according to the species with potential uses present. Food, medicinal and ornamental species were the main categories present throughout the Bojanala District Municipality. Several African Leafy Vegetables were found in the clinic gardens (*Amaranthus spp.*, *Cleome gynandra*, *Vigna unguiculata*, *Cucurbita maxima*, *Citrullus lanatus* etc.) which can assist in lightening the burden of nutrition deficiency in the area (Faber *et al.*, 2002; Faber *et al.*, 2010; Van Jaarsveld *et al.*, 2014). Needing low maintenance and being adaptable to dry climates, it is crucial to inspire the use of these plants at clinic gardens as well as spreading the knowledge to those who do not use them in their gardens.

Chapter 4 – Physical and social resource diversity at health clinic gardens in the Bojanala District Municipality, South Africa



CHAPTER 4 –PHYSICAL AND SOCIAL RESOURCE DIVERSITY AT HEALTH CLINIC GARDENS IN THE BOJANALA DISTRICT MUNICIPALITY, SOUTH AFRICA

4.1. Introduction

The constant conversion of natural landscapes to become part of urban infrastructure reduce the space for pure natural science and force scientists to take human activities and practices into consideration (Redman *et al.*, 2004). Complex or “wicked” problems often occur with the integration of natural and social environments which scientists struggle to comprehend because of innumerable determining and intermingling factors making it difficult to formulate a proper and clear solution (McPhearson *et al.*, 2016; Xiang, 2013).

Such “wicked” problems are also a current struggle in South Africa, of which food and nutrition security, poverty and biodiversity loss are the most dominant (Faber *et al.*, 2011; McHale *et al.*, 2013; UNDP, 2014). According to Redman *et al.*, (2004) researchers in the past often neglected the relationship between ecological and social systems and tried to solve problems from the perspective of either one or the other. To obtain an objective result, it is impossible to study the natural environment while disregarding the intricately integrated social systems (Lebel *et al.* 2006; Redman *et al.* 2004). A complex social-ecological system (SES) therefore describes the regular interaction of ecological factors with the social environment in a resilient and sustainable manner (Lebel *et al.*, 2006; Redman *et al.*, 2004). It is important to have insight and comprehension about the interaction point of social and ecological dynamics since the effectiveness and development of social-ecological systems are integrally dependent on these conflicting value systems (Cote & Nightingale, 2012).

As a governmental attempt to improve health care in South Africa, health clinics were distributed throughout the country in urban and rural areas. Gardens were also started at these health facilities, which can provide fresh fruit and vegetables to the most vulnerable patients – especially those who need to have a strong immune system such as TB and HIV/AIDS patients. At these clinic gardens, a wide range of resources, or the lack thereof, convey typical problems of a complex social-ecological system. An uneven distribution of resources at these gardens can have an influence on the needs occurring on social, physical and natural level (Buchmann, 2009; Fabricius & Collins, 2007). These resources can be seen as “hard” capital and in remote and poor rural areas one will find that this type of capital (human, financial and physical) are in short supply (Fabricius & Collins, 2007).

Capital is divided into five groups by the Department for International Development (DfID) which can be described as follows, according to DfID (2000), Fabricius & Collins (2007) and Lebel *et al.*, (2006):

- Human capital: the unique set of education, skills, knowledge and health condition which provides the ability to labour and enable people to pursue different occupations and achieve livelihood objectives.
- Social capital: the aspects of social organisation including social networks, norms, support groups and relationships of trust.
- Natural capital: natural resources, from which ecosystem goods and services are extracted, sustained by the workings of ecosystems and can be useful for the social environment.
- Physical capital: basic infrastructure and physical products which are essential to sustain livelihoods.
- Financial capital: financial resources used to obtain occupational goals including both available stocks and regular inflows of money which contributes both to the consumption and production.

By ensuring a diverse set of resources and improving the availability thereof, one can improve a system's ability to absorb disturbances (Buchmann, 2009). According to Chan *et al.*, (2015), urban gardens often facilitate the mobilisation of resources. The reason for this is because urban gardens create opportunity for social networking, trust and relational ties to develop which results in the sharing and trade of resources (Chan *et al.*, 2015).

Social capital is, therefore, the key to building diverse human capital at urban gardens. A diverse set of stakeholders with a wide range of perspectives, skills and knowledge is crucial to mobilize the available physical and financial resources in such a way that the system can self-reorganise and eventually enable the system to be more resilient (Lebel *et al.*, 2006; Buchmann, 2009; Chan *et al.*, 2015). Tengö *et al.*, (2014) explain that by connecting knowledge systems from diverse backgrounds, new insights and innovations can be obtained to form an enriched picture of the problem ("wicked" problem) at hand. There are several approaches in which these knowledge systems can be combined to form a synergy such as co-production of knowledge which focusses on both the processes and stages of knowledge generation and simultaneously consider the production of social order (Tengö *et al.*, 2014) These are all attributes of the Multiple Evidence Based approach which combines indigenous, local, technical and scientific knowledge systems to widen the scope and create enriched understanding, causes triangulation and joint assessment of knowledge as well as creating a place of departure for further knowledge generation (Tengö *et al.*, 2014)

Gardens also play a crucial role in transferring knowledge from one generation to the next (Barthel *et al.*, 2010). Knowledge obtained through years of gardening and constant interaction with indigenous and cultivated plant species can in this way be preserved and is called social-ecological memory (Barthel *et al.*, 2010). At home gardens, indigenous culture and communal practices are conveyed through the types of species planted as well as the design of the garden (Molebatsi *et al.*, 2010; Galhena *et al.*, 2013). Certain gardening skills and valuable knowledge about indigenous crops unique to a certain culture are therefore preserved in home gardens (Galhena *et al.*, 2013; Galluzzi *et al.*, 2010). An example of this is the Tswana tshimo lay-out described by Molebatsi *et al.*, (2010). Tswana domestic gardens in the North-West Province are characterised by this lay-out which consists of several micro-gardens namely, lebala (bare soil), naga (natural vegetation), lawn, vegetable garden, medicinal garden, ornamental garden, hedge and the orchard (described in more detail in Chapter 3). It was also found that European influences in colonial times cause some of the home gardens to lose their traditional lay-out and become more structured according to western culture (Davoren *et al.*, 2015).

Opportunities to gain scientific knowledge about the natural environment and stewardship of natural resources are especially higher in urban gardens (Chan *et al.* 2015). In developing countries, such as South Africa, stewardship of natural resources is essential, since traditional home farming and wild food gathering are highly dependent on these resources and can quickly become destructive and out of control (Faber *et al.* 2011; Faber *et al.* 2002). It was also found that when the distribution of basic resources such as food and water is poor, families tend to turn to their home gardens as main supplier of food and other physical resources (Galhena *et al.*, 2013). Physical capital is therefore essential at urban gardens to ensure basic infrastructure, to sustain gardening practices and in the end also household needs. Financial capital, on the other hand, is also needed to sustain a constant supply of basic physical resources (equipment, water supply infrastructure, fertiliser and seed) and to maintain basic infrastructure. All capital is therefore interlinked in various levels and phases and it is crucial that the management of all different groups of capital should occur on community level (Fabricius & Collins, 2007).

Gardening in an urban environment should not be neglected and seen as the antithesis of urban development, but can represent an integrated urban activity that contributes to the resilience of cities (Barthel & Isendahl, 2013). Health clinic gardens can especially be a representation of this concept. Health personnel, garden personnel, scientists, traditional health practitioners, caregivers, NGO's and the local community provide different sets of knowledge and can be combined to ensure that clinic gardens are managed in an efficient, sustainable way (Cilliers *et al.*, in press). Social diversity is addressed in this way, which will contribute to the ability of the system to reorganise and provide renewal processes when a disturbance or some sort of crisis (e.g. malnutrition) occurs (Colding & Barthel, 2013; Olsson *et al.*, 2004).

It is therefore essential to keep in mind that building resilience at clinic gardens will demand adaptive co-management. This requires community-based management of resources at various levels designed to fit a specific scenario by considering the place, situation, community, cultures and complex problems occurring in that area (Olsson *et al.*, 2004; Fabricius & Collins, 2007).

The aim of this study was to determine the resource diversity (social and physical) at health clinic gardens in the Bojanala District Municipality. The different local municipalities were compared so that recommendations can be made for the management of clinic gardens in the District. Finally, a subset of clinics with the most potential to improve resilience, will be identified which can be used as examples in management strategies.

4.2. Materials and methods

A total number of 103 clinic gardens in the Bojanala District Municipality were sampled. Due to renovation and lack of space for gardening, not all clinics were suitable for sampling. The survey was done according to the Tswana tshimo lay-out which consists of a range of up to 8 micro-gardens: lebala (bare soil), naga (natural vegetation), lawn, vegetable garden, medicinal garden, ornamental garden hedge and the orchard (Molebatsi *et al.*, 2010). The cover area of each micro-garden, as well as the total garden size, was measured. The social and physical resources were recorded using a questionnaire (Table 4-1 & Table 4-2).

Table 4-1: Potential stakeholders (social resources) that can be involved at health clinic gardens and the roles they play (adapted from Cilliers *et al.*, in press).

Potential stakeholders	Description of the stakeholder	Role of stakeholder at the clinic garden
Facility Manager	Professional nurse in charge of the clinic	Facilitation and managing
Groundsman	Paid gardener	Gardening
Caregivers	Initiated by Department of Health to create job opportunities and improving living conditions in community (gets stipend from government)	Community health care and gardening
Community Works Program (CWP)	Also initiated by Department of Works and receive stipend from government	Community health care and gardening
Non-Governmental Organisations (NGO's)	may include caregivers, Community Health Workers and retired nurses	Financial contribution
Charity Workers	People from the community including church members	Gardening
Re-engineering Team	Consists of retired nurses and Community Health Workers	Facilitation and gardening

Table 4-1 continues

Potential stakeholders	Description of the stakeholder	Role of stakeholder at the clinic garden
Community Health Workers	Stipend paid by Department of Health	Community health care and gardening
Traditional Health Practitioners (THP's)	Traditional doctors using indigenous plants for healing purposes – also receive stipend from government	Gardening and contribute to the care of patients
Experts	Include dieticians and trainers from Department of Agriculture	Facilitation
Private companies	Usually mine companies situated in the area	Financial contribution
Patients	Those who are healthy enough sometimes help to tend to the garden	Gardening

Table 4-2: Potential physical resources at health clinic gardens in the Bojanala District Municipality.

Resource	Description
Water supply infrastructure	Tap, bore hole, plastic/metal Tank
Irrigation methods	Hose pipe, fixed irrigation system, water bucket, flooding
Compost	Self-made, bought or donated
Manure	kraal manure: cattle, chicken, fish, sheep, pigs, goat, pigeons and donkey
Gardening equipment	Spade, fork, rake, axe/pick, wheel barrow, lawn mower, grass cutter, saw, pruning shears, shade netting
Origin of seeds	Bought by responsible persons, donations, own nursery, provided by local municipality management, Royal Bafokeng or mine companies (LONMIN)
Available space	Open space for expansion of the garden (especially vegetable garden) - also create potential to increase natural, physical and social diversity.

Physical resources recorded include water supply infrastructure, irrigation methods, fertiliser or compost availability, available space as well as gardening equipment (Table 4-2). Questions were asked on the distribution and uses of the vegetables as well as the origin of seeds and other propagation material. Since these resources are highly dependent on the accessibility and financial capital from the local municipality management, the distance to local municipality office of each clinic garden was determined.

Each of the physical resources was recorded and a score was allocated to each clinic garden according to the presence or absence of these resources (Table 4-3).

Table 4-3: Scores of physical resources at health clinic gardens in the Bojanala District Municipality.

Key	Water supply infrastructure: bore hole, JoJo or metal tank, tap	Key	Equipment: spade, fork, rake, axe/pick, wheel barrow
1	only one of these	1	only one
2	2 of these	2	two items
3	bore hole and yoyo tank and tap	3	three items
	Irrigation	4	four items
1	flooding	5	all five items
2	bucket/watering can		Origin of seeds: bought by responsible person, donations, own nursery, provided by sub-district, other
3	hose pipe	1	only one origin
4	fixed irrigation system	2	two origins
	Fertilizer (compost and manure)	3	three origins
0	no compost or manure	4	four origins
1	one of these	5	five origins
2	both manure and compost		

Available space was also determined in square meters which included the Lebala (bare soil) as well as the paved areas.

Detailed information was collected on the stakeholders involved, time spent on garden activity, gardening knowledge, motivation for starting the garden (include patients with HIV/Aids and TB, malnourished, registered patients, elderly people, other chronically ill, other (diabetics, underweight babies, hypertension, vulnerable children)) and maintenance of the garden. Stakeholder abundance was determined by counting the number of stakeholders that is involved at the clinic gardens and stakeholder diversity was determined by counting the number of different types of stakeholders involved (facility managers, paid gardeners (groundsmen), caregivers (stipend paid by Department of Health), Community Works Program (CWP – stipend paid by Department of Works), NGO's (may include caregivers, Community Health Workers and retired nurses), charity workers from the community (includes churches), Re-engineering team (retired nurses, and Community Health Workers - stipend paid by Department of Health) and other clinic personnel, Traditional Health Practitioners (THP's – Stipend paid by Department of

Health), experts (including dieticians and trainers from Department of Agriculture), private companies and some of the patients) (Cilliers *et al.*, in press).

The scores for time spent gardening as well as gardening knowledge was determined as follows:

Table 4-4: Scores for time spent on gardening and gardening knowledge at health clinic gardens in the Bojanala District Municipality.

Key	Time spent in garden	Key	Gardening knowledge
<1	Days/month	1	No experience
1	Once/week	2	Basic
2	Twice/week	3	Intermediate
3	3 times / week	4	Advanced
4	4 times / week		
5	Every day		

Ordinations (Kent, 2012) were applied to compare the resource diversity of the clinic gardens within different groups (local municipalities, distance categories) and ANOVA's (Field, 2007) were done to determine if differences were significant by using both PRIMER version 6 (2006) (Clarke & Gorley, 2006) and STATISTICA version 12 (StatSoft, Inc. 2013). The resources composition was compared across the different local municipalities as well as the distance to the local municipality office. Each of the local municipalities is managed differently, because of the perceptions and mind-set of the manager and will therefore influence the availability of resources. Interpolation was also done in ArcMap by using the Inverse Distance Weighted (IDW) technique. This technique assumes that the measured value decreases with distance from the measured location. This indicates that diversity of stakeholders, for instance, will decrease with increasing distance from the health clinic. The other analyses and Pearson's correlations were done by using Microsoft Excel (Excel 2013).

4.3. Results

4.3.1 Total cover area and available area

The total area covered by the clinic gardens (including all the different micro-gardens as well as the paved areas and excluding the area of the clinic building) were compared across the different local municipalities to determine if any significant differences in area cover could influence the accuracy of analysis of resources present at the gardens (Figure 4-1). Although there were a few outliers (Table 4-5), the ANOVA (unequal N HSD Tuckey test) showed no significant difference between the means of the clinic garden sizes in the local municipalities (Figure 4-1).

Table 4-5: Largest health clinic gardens surveyed in the Bojanala District Municipality.

Local municipality	Clinic name	Total area (m2)
Moses Kotane	Mabeskraal	110444
Madibeng	Bapong	54803
Madibeng	Letlhabile	44554
Rustenburg	Bafokeng	25441
Moses Kotane	Pella	18415
Moretele	Kutlwanong	11800,25
Moretele	Maubane	11435,5

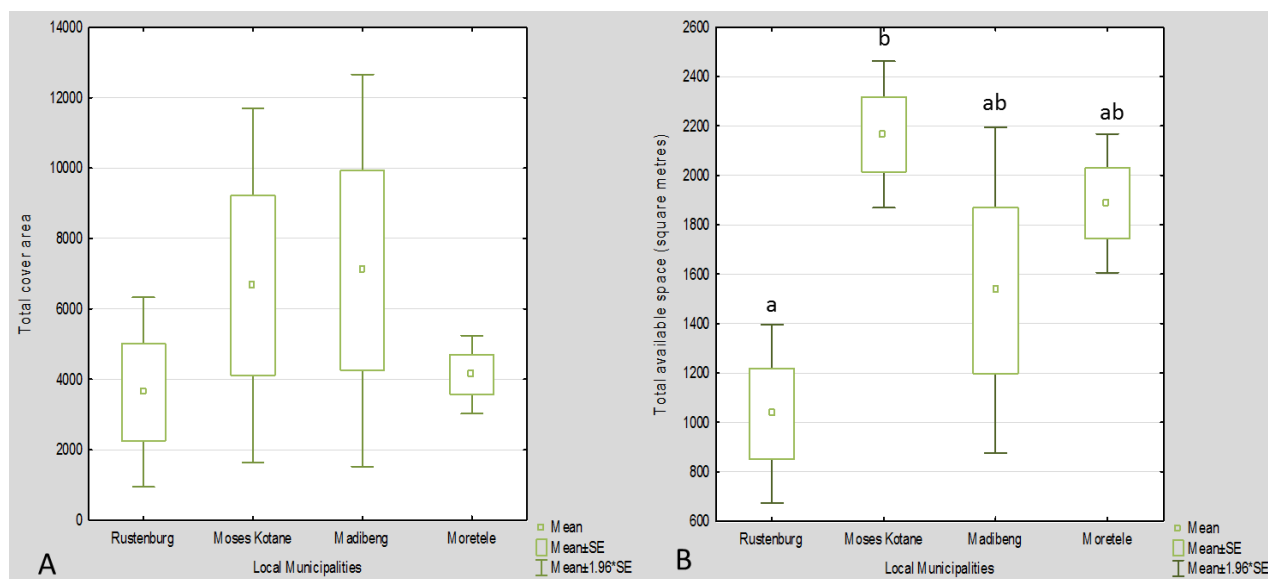


Figure 4-1 (A) Comparison of total area and (B) available area of health clinic gardens over the different local municipalities in the Bojanala District Municipality (different symbols show statistical significant differences).

Since no remarkable variance could be found in total area of the gardens (Figure 4-1a), the available area (lebalala and paved area) of the clinic gardens were also compared (Figure 4-1b). The available area can be seen as physical resources since it provides space for expansion of the garden (especially vegetable garden) which could create potential for increased natural, physical and social diversity. Rustenburg Local Municipality has significant less available space ($p = 0.002125$) than Moses Kotane Local Municipality for gardening (Figure 4-1b).

4.3.2 Total physical resources

When comparing the total physical resources present at the clinics (water supply and storage, available irrigation methods, compost/manure supply, gardening equipment and number of suppliers of seed), Rustenburg Local municipality has the most clinic gardens with the lowest scores for resources (red areas) (Figure 4-2). Three of the clinic gardens surveyed had no gardening equipment, irrigation or fertiliser. The southern part of Madibeng Local Municipality

also needs some attention (red and orange areas) (Figure 4-2). One of the clinic gardens lacks gardening equipment, irrigation and fertiliser and two other clinic gardens did not have gardening equipment or fertiliser.

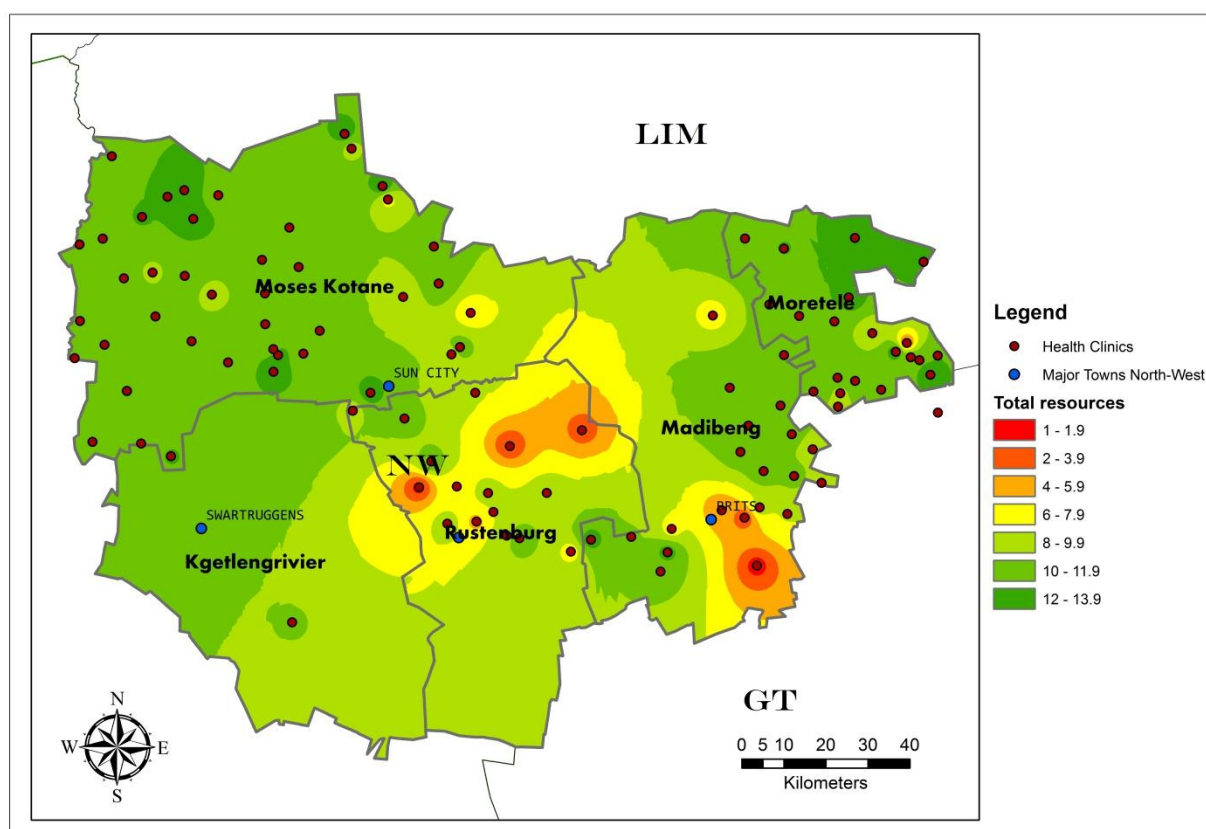


Figure 4-2: Distribution of total physical resources over the Bojanala District Municipality

Figure 4-3 conveys the scores of the different clinics for physical resources. The red circles indicate one clinic in Rustenburg Local Municipality and one clinic in Madibeng Local Municipality with lowest scores regarding total physical resources present. The clinics with highest scores are indicated with green circles (one clinic in Moses Kotane and 5 clinics in Moretele).

The maximum score a garden can get for physical resources is 19 (according to Table 4-3). None of the clinic gardens got the maximum score and the highest score was only 14. The clinics with highest scores regarding total resources are Kraalhoek Clinic (Mose Kotane) and Relebogile, Mathibestad, Kutlwanong, Kgomokgomo and Bossplass Clinics from Moretele Local Municipality (Table 4-6). A list of all clinic gardens and its scores of physical resources can be found in the Appendix (Table 8-3).

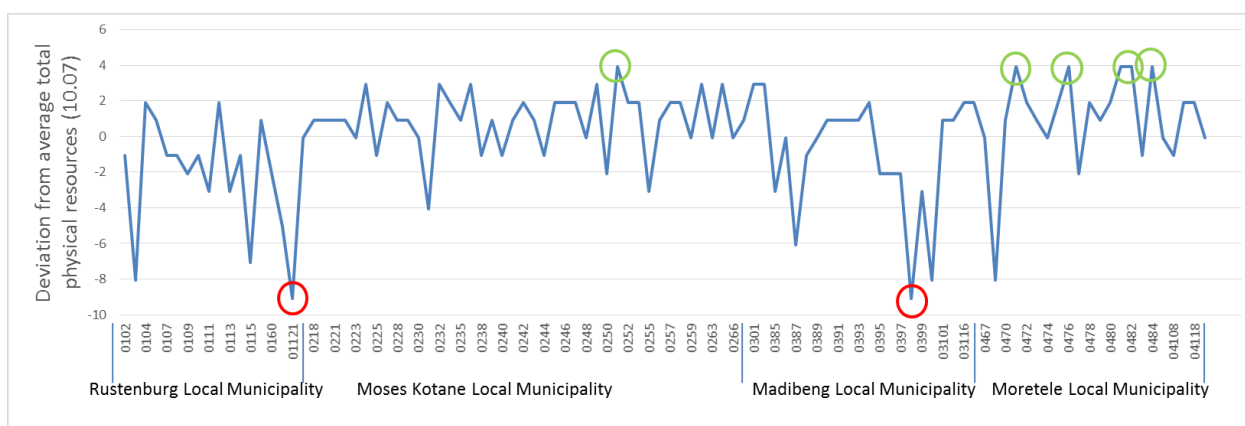


Figure 4-3: Deviation from average of total physical resources (10.07) at each health clinic garden in the Bojanala District Municipality.

Table 4-6: Health clinic gardens in the Bojanala District Municipality with highest scores regarding total physical resources

Local municipality	Clinic name	Total physical resource scores (maximum score = 19)
Moses Kotane	Kraalhoek	14
Moretele	Relebogile	14
Moretele	Mathibestad	14
Moretele	Kutlwanong	14
Moretele	Kgomokgomo	14
Moretele	Bosplass	14
Moses Kotane	Tweelaagte	13
Moses Kotane	Rampampaspoort	13
Moses Kotane	Obakeng	13
Moses Kotane	Linchwe	13
Moses Kotane	Bapong 2	13
Moses Kotane	Bakubung	13
Madibeng	Wonderkop	13
Madibeng	Bapong 1	13

According to Figure 4-4, there is no clear difference in the distribution of resources between local municipalities. Although this grouping is not very distinctive, clinics from Rustenburg Local Municipality are situated more to the left of the graph and Moretele clinics more to the right. This could indicate that clinics from Rustenburg contain a different combination of resources than clinics from Moretele Local Municipality.

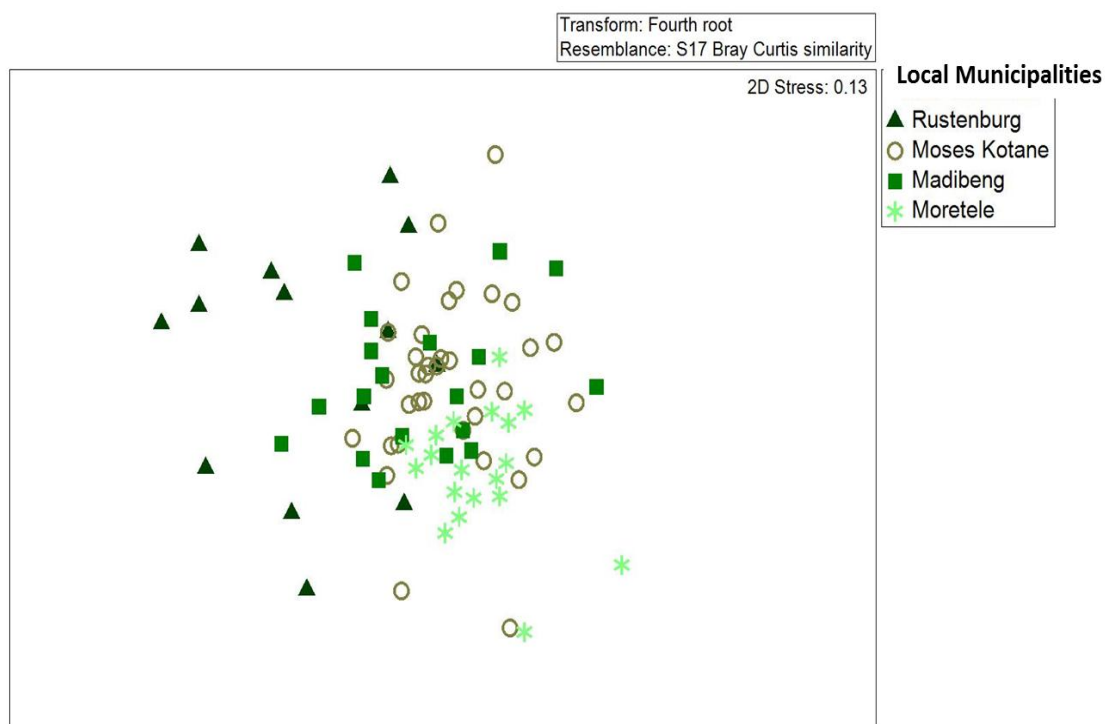


Figure 4-4: NMDS of total resource composition at each health clinic garden comparing the different local municipalities in the Bojanala District Municipality.

Significant differences can be seen in water supply, available gardening equipment and the use of fertiliser between the scores of the different local municipalities (Figure 4-5: A, C, D). No meaningful difference exists between the irrigation methods of the different local municipalities (Figure 4-5: B). Rustenburg has a significantly lower score than Moretele for water supply (Table 8-4 in appendix). Moretele has the best water supply and Moses Kotane has the highest score for irrigation, equipment and fertilising. Moses Kotane has significantly more equipment than Rustenburg Local municipality (Table 8-5 in appendix) ($p = 0.010472$) and significantly more fertiliser than Madibeng Local Municipality ($p = 0.011418$) (Table 8-6 in appendix).

Figure 4-6 conveys the deviation from average water & irrigation supply combined at each clinic. It is clear that Rustenburg has quite a few clinics with scores below the average although there are also some in Moses Kotane, Madibeng and Moretele. Even though Moretele Local Municipality was rated highest overall regarding water supply, it contains the clinic with the lowest score (clinic 468 – Thulwe (red circle on graph)). This clinic has no tap, borehole or tank and also has no watering bucket or hose pipe with which plants can be irrigated. No garden has therefore ever been made at this clinic before. The average score for water and irrigation was 4.78.

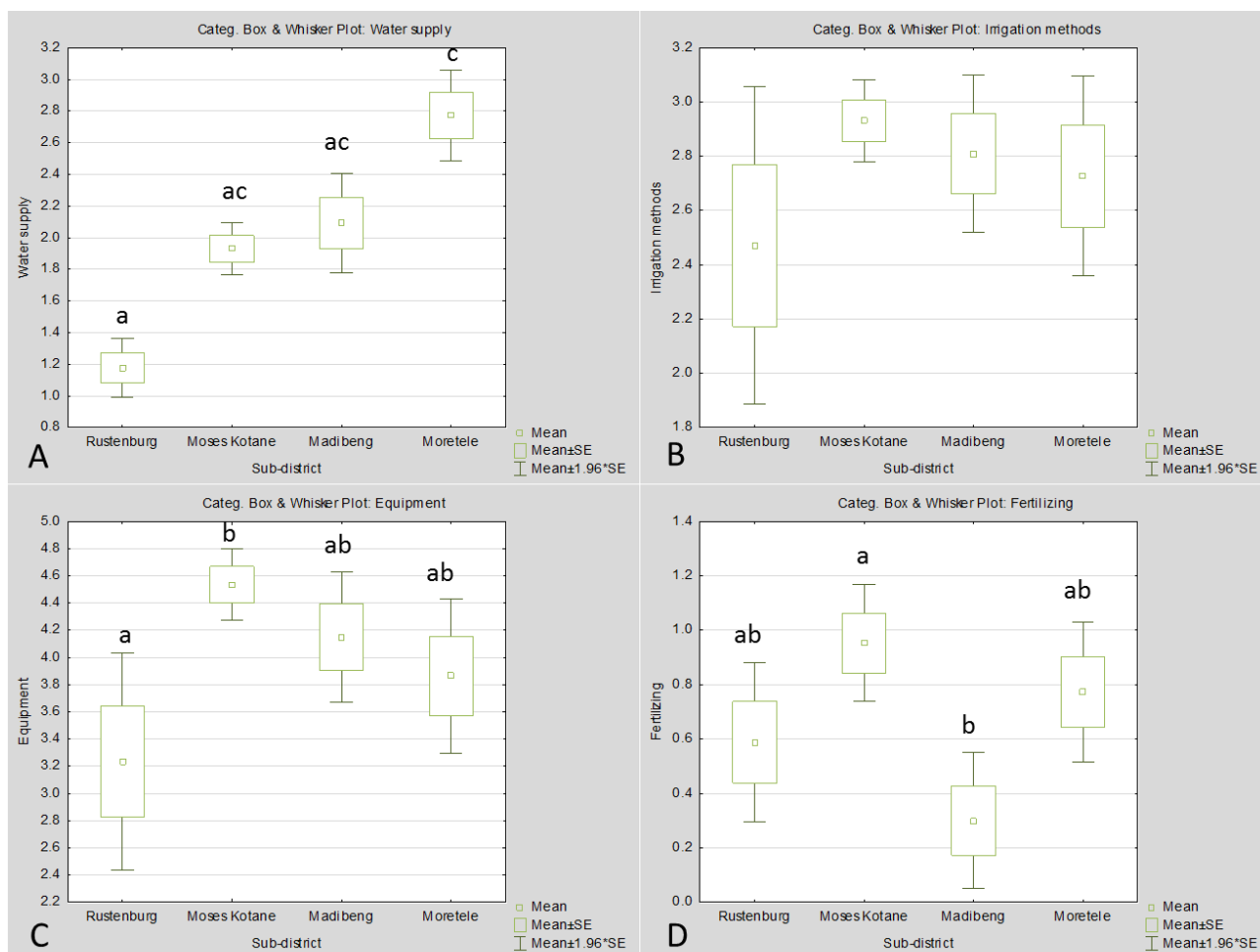


Figure 4-5: Comparison of water supply (A), irrigation methods (B), gardening equipment (C) and fertilising (D) in the different local municipalities of Bojanala District Municipality (different symbols indicate statistically significant differences)

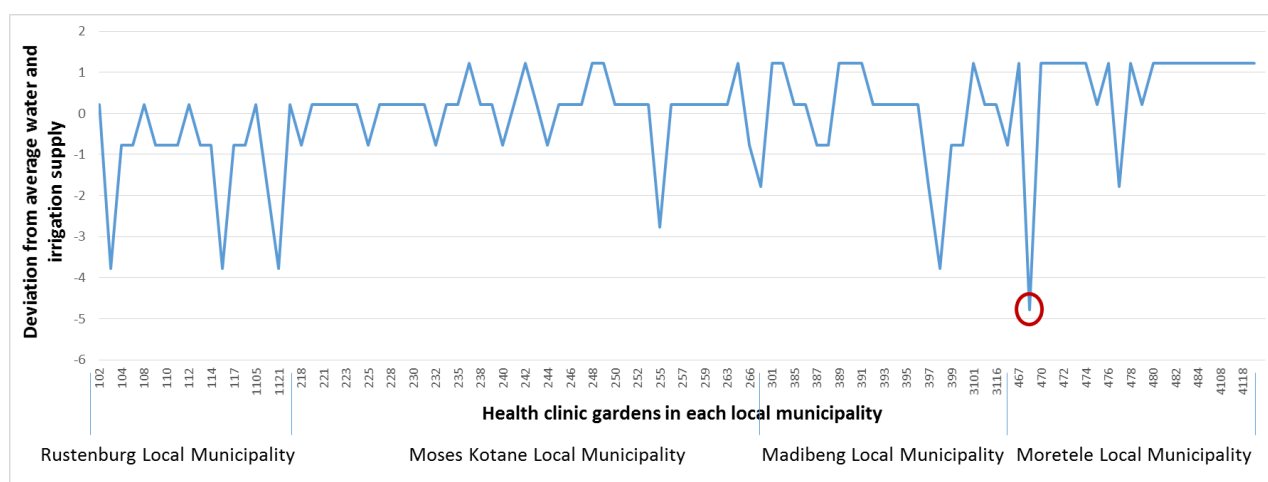


Figure 4-6: Deviation from average water and irrigation supply at each health clinic garden in the Bojanala District Municipality.

No strong correlation between distance to local municipality office and the resources at the clinics could be found (Table 8-7 in appendix).

4.3.3 Stakeholder diversity

Compared to the possible number of stakeholders which could be involved at each clinic garden (Cilliers *et al.*, in press), stakeholder diversity in Bojanala District is over all low (Figure 4-7). The highest number of stakeholders involved is only five out of a possible number of 12. Some of the clinics with higher stakeholder diversity (green areas) occur in the more rural areas and far from towns (Sun City, Rustenburg, Swaruggens and Brits) (Figure 4-7). Madibeng Local Municipality has four clinic gardens with only one stakeholder and Rustenburg has one clinic garden with one stakeholder.

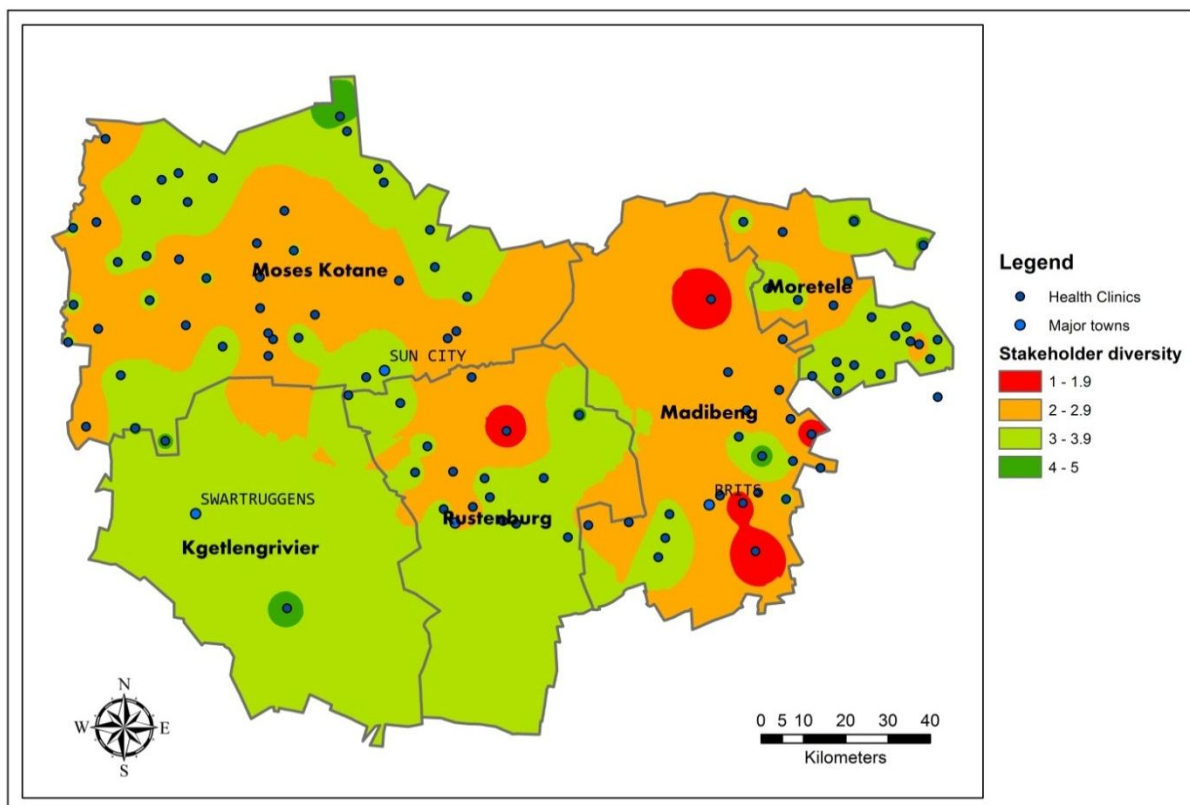


Figure 4-7: Stakeholder diversity of health clinic gardens in the Bojanala District Municipality (green areas indicate high diversity and red areas, low diversity)

4.3.4 Stakeholder abundance

Moretele seems to have the highest abundance of stakeholders while all the other local municipalities consist of both high and low abundance areas (Figure 4-8). Clinics with higher abundance occur again in the more rural areas away from larger towns. Most clinic gardens in the Bojanala District have only 1-8 stakeholders while some clinics in Moretele and Kgetlengrivier have up to 50 stakeholders involved at the clinic gardens.

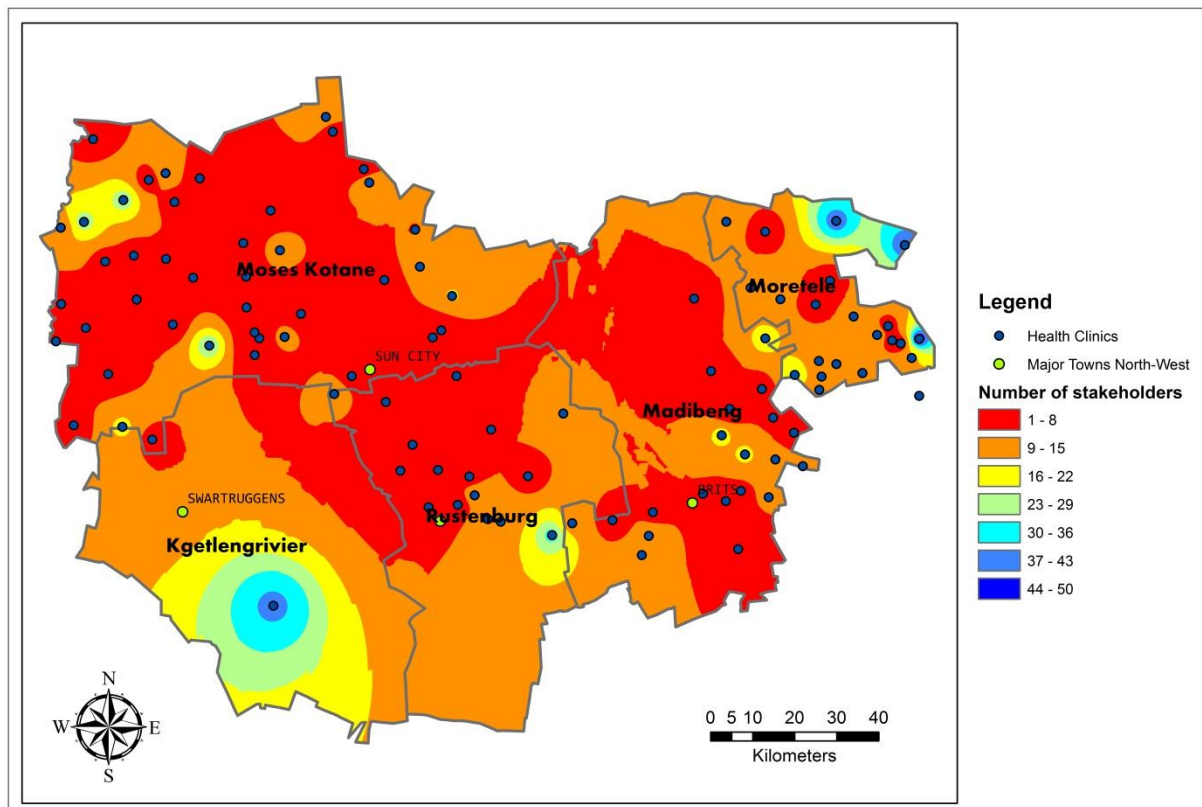


Figure 4-8: Stakeholder abundance at health clinic gardens in the Bojanala District Municipality

Madibeng Local Municipality has much fewer groundsmen (paid gardeners) than the other local municipalities but in contrast, much higher participation from NGO's (Non-governmental organisation) and THP's (Traditional Health Practitioners) (Figure 4-9). Dieticians and Private Companies are involved at clinics gardens only in the Rustenburg Local Municipality. There are no patients involved in the clinic gardens at Rustenburg Local Municipality. Other stakeholders such as mine workers, correctional service and prisoners are involved in Rustenburg and Moretele Local Municipalities. There is a noticeable higher percentage of clinics in Madibeng Local Municipality where CWP (Community Works Program), community members, other clinic

personnel (cleaners and security guard) and the reengineering team are involved (between 10-20%).

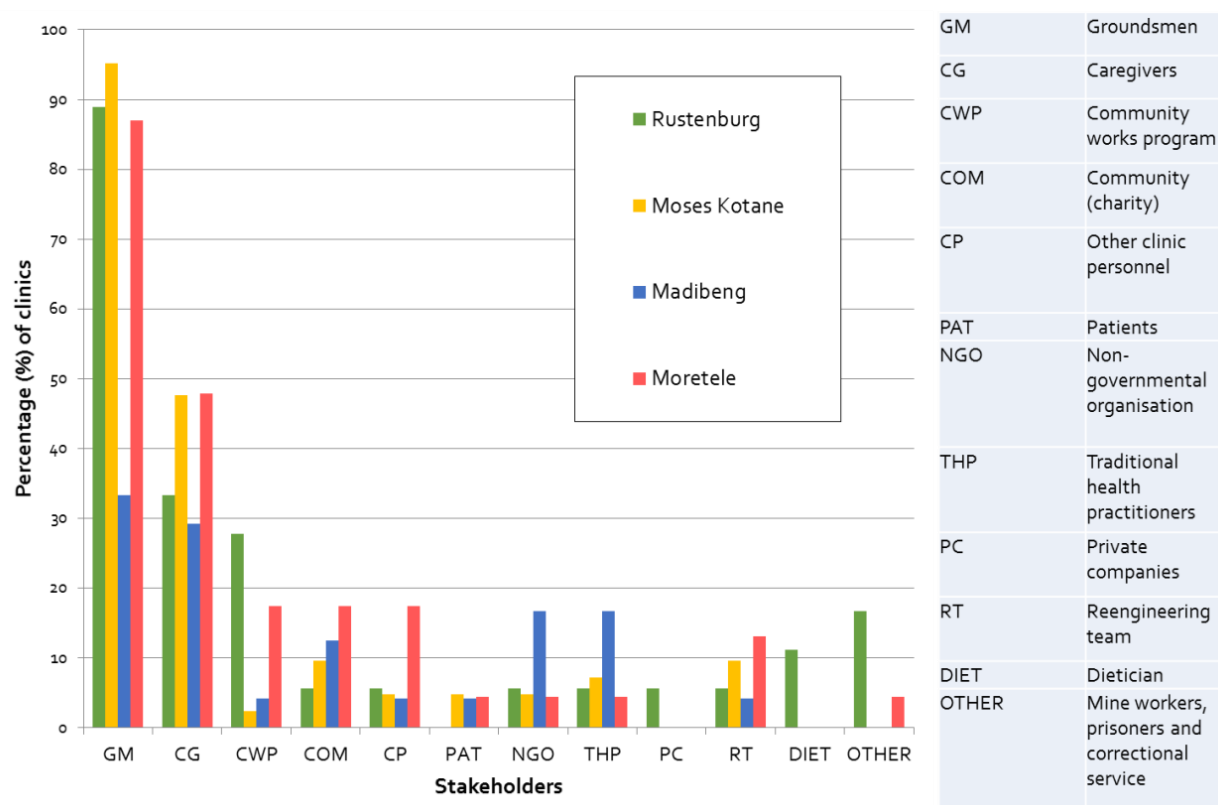


Figure 4-9: Percentage of health clinic gardens in the different local municipalities where stakeholders are involved

4.3.5 Knowledge about gardening

Moretele Local Municipality has a significantly higher score regarding gardening knowledge at the clinics (Figure 4-10). Interviews on gardening knowledge were not applicable to facility managers so the results reflect the knowledge of all stakeholders besides the facility manager. All stakeholders have basic knowledge, some intermediate and there was even one person with advanced skills in gardening. Madibeng Local Municipality has a significantly lower score for individuals with training in gardening (Figure 4-10). No correlation could be found between either gardening knowledge and distance to local municipality office ($r = 0.423$) or gardening knowledge and species richness at the gardens ($r = -0.054$) (Table 8-8 in appendix).

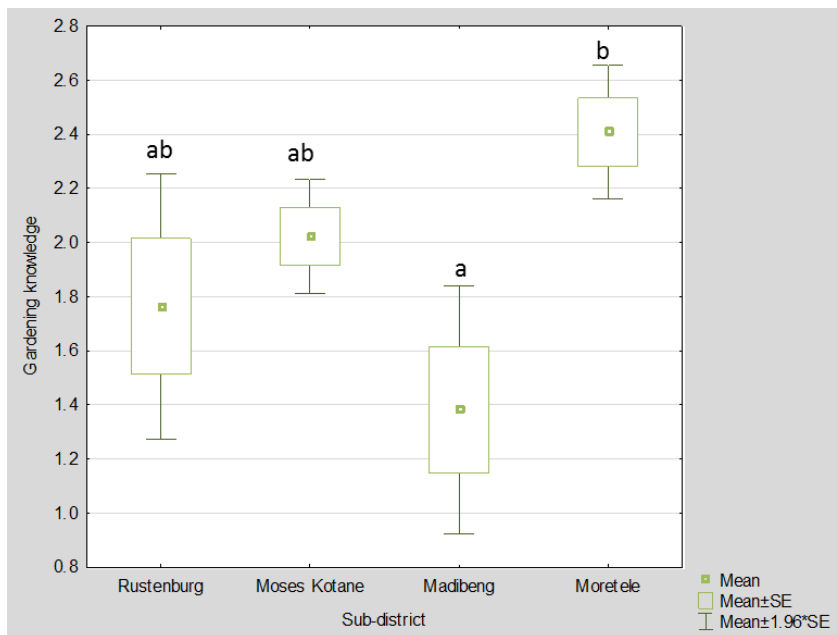


Figure 4-10: Gardening knowledge scores compared over the different local municipalities of Bojanala District Municipality

The average gardening knowledge at the clinics are 1.932 (where 1 = no experience; 2 = basic knowledge; 3 = intermediate training and 4 = advanced training). Figure 4-11 indicates some variation in all local municipalities except Moretele Local Municipality where all stakeholders have above average gardening knowledge.

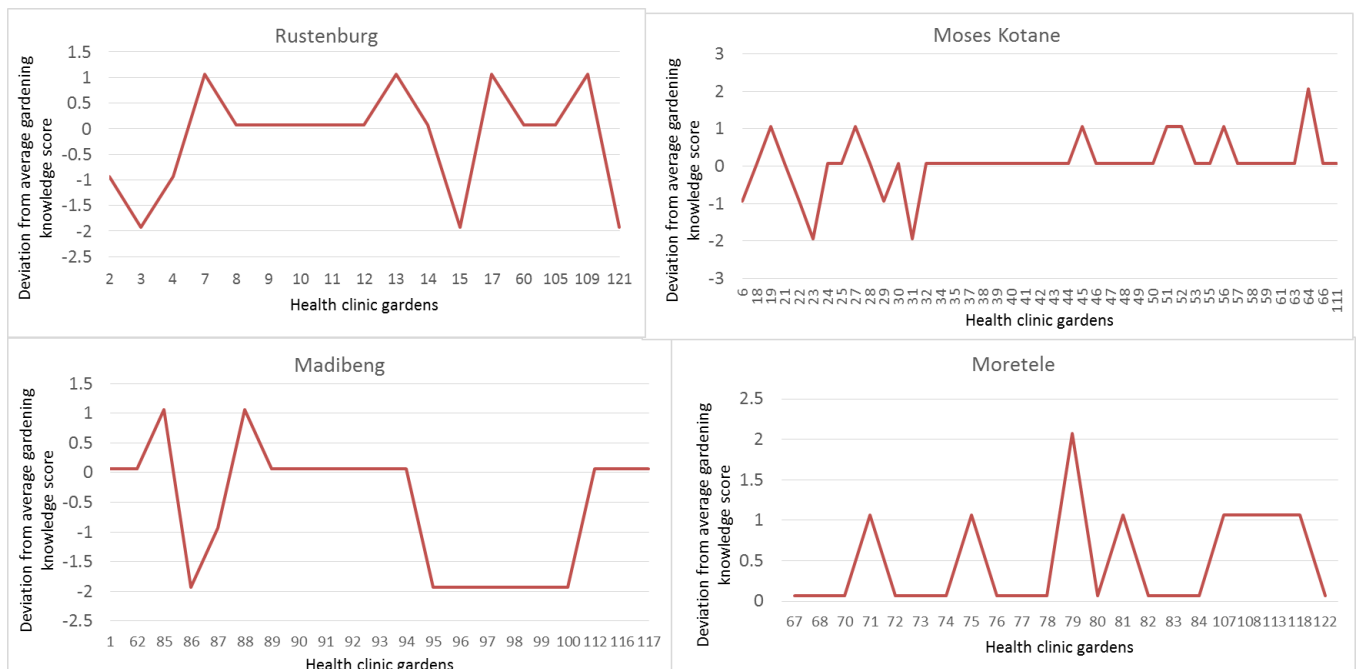


Figure 4-11: Deviation from average gardening knowledge scores at health clinic gardens in the different local municipalities of Bojanala District Municipality

Figure 4-12 indicates that no correlation exists ($r = -0.054$) between the number of species with potential uses at the gardens (blue line) and the gardening knowledge at the gardens (orange

line). There is no increase in number of species with potential uses as the scores for gardening knowledge increase.

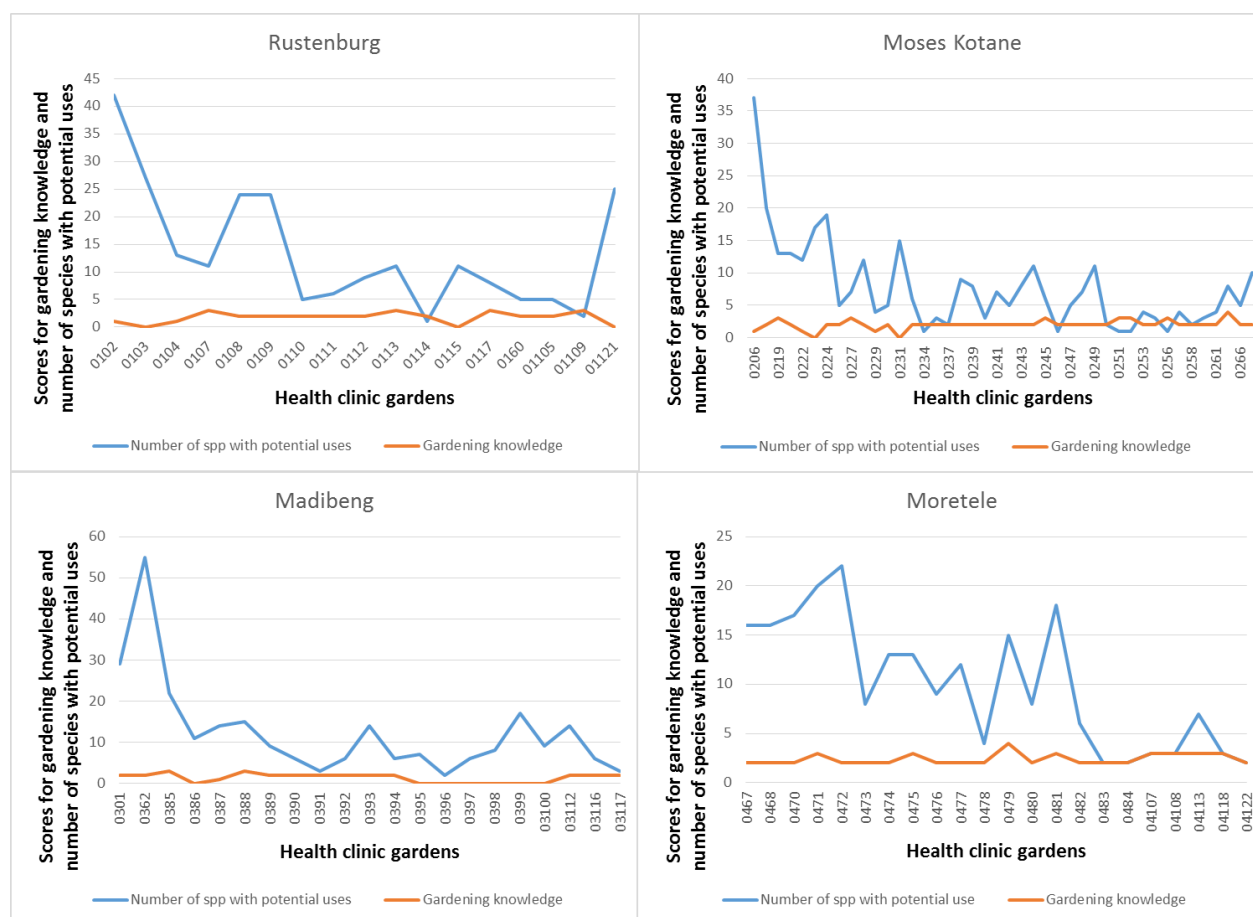


Figure 4-12: Gardening knowledge vs. number of species with potential uses in different local municipalities

4.3.6 Time spent in the garden

People involved at the clinic gardens in Madibeng Local Municipality spend significantly less time in the gardens than Moses Kotane and Moretele Local Municipalities. Gardeners in Moretele and Moses Kotane Local Municipality spend the most time in the gardens (Figure 4-13, Table 8-10 in appendix). There is a weak correlation ($r = 0.55$) between gardening knowledge and time spent in the gardens.

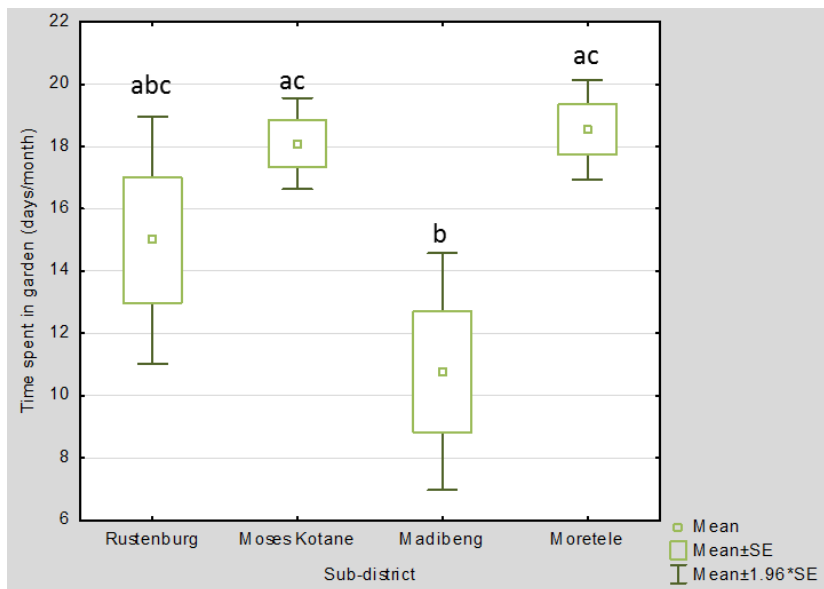


Figure 4-13: Time spent in health clinic gardens (days per month) compared over the different local municipalities in the Bojanala District Municipality

4.3.7 Motivations for starting a garden

Motivation for starting a garden was in all local municipalities firstly linked to HIV and Aids patients, secondly to TB (Tuberculosis) and thirdly, malnourished women and children. The motivations behind starting some of the gardens in Moretele were also linked to diabetics, underweight babies, hypertension and vulnerable children (Figure 4-14).

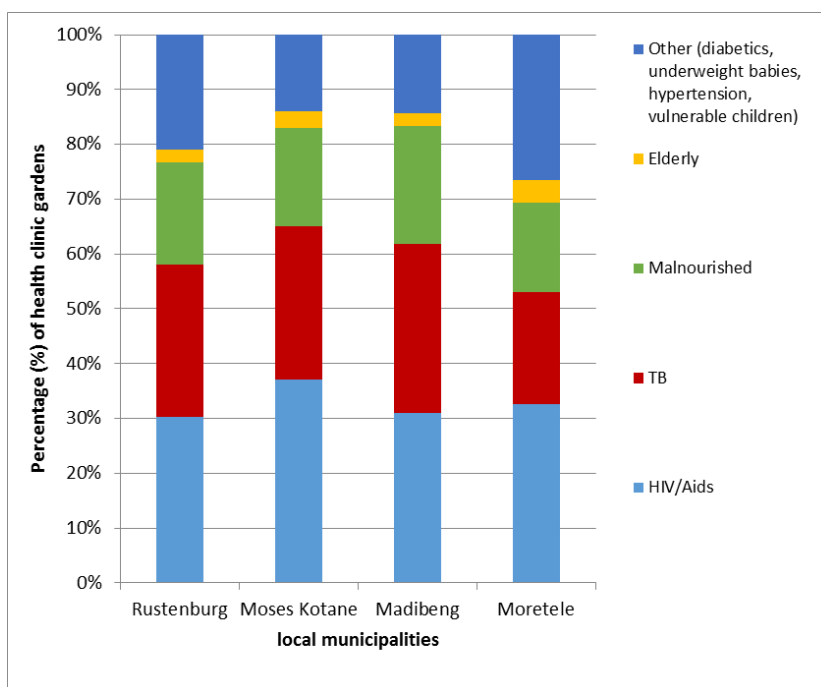


Figure 4-14: Motivations for starting a garden at the clinics in the different local municipalities

4.4 Discussion

4.4.1 Total cover area and available areas

The concept of space as an urban resource has great value because of its potential to serve as a starting point or opportunity to create something with a positive effect (e.g. improve diversity of plant species in a garden). Space in urban areas can be connected to both sociological and ecological concepts where both can be as important as the other such as spiritual experiences, food provisioning, identity, biodiversity, ecosystem services, shelter, habitat etc (Barthel *et al.*, 2013; Cilliers *et al.*, 2013; Reuther & Dewar, 2006; McConnachie & Shackleton, 2010; Galluzzi *et al.*, 2010; Jansen van Rensburg *et al.*, 2007; Grewal & Grewal, 2012). Space can also be owned by a community or individual and be part of someone's identity or political agenda (McConnachie & Shackleton, 2010; Lubbe *et al.*, 2010; Molebatsi *et al.*, 2010). Available space is, therefore, an important aspect to take into consideration when trying to solve complex or "wicked" problems in South Africa regarding nutrition deficiencies. The available areas in health clinic gardens can be seen as physical resources since it provides space for expansion of the garden (especially vegetable garden) which could create potential for increased natural, physical and social diversity. Health clinic gardens in Moses Kotane Local municipality can, therefore, be seen as providing windows of opportunity and possible solutions because of the availability of large spaces (Figure 4-1 (B)). Moses Kotane Local Municipality cover a larger area (Figure 1-1) and contains a much smaller population size (238516) than Rustenburg Local Municipality (population size: 486411). Plot sizes in Moses Kotane villages will, therefore, be larger with more open spaces than plots in densely populated areas in Rustenburg Local Municipality.

4.4.2 Total physical resources

Distribution of physical resources and the availability thereof is quite poor throughout the Bojanala District (Figure 4-2). The few clinics in Rustenburg and Madibeng where the total resource scores were lower are examples of poor management and poor provision of resources as well as a lack of equal distribution of resources. Previous studies indicated that the unequal distribution of resources can be attributed to a lack of proper communication between local government and facilities or local government and the overarching district office (McHale *et al.*, 2013; Landman & du Plessis, 2002). Adding to this, there are in some cases remains of past political agendas which caused certain areas to be advantaged and others neglected (McHale *et al.* 2013; Landman & du Plessis, 2002). Areas with lower socio-economic status also tend to depend more on the immediate resources because of a lack of communication, transport and financial capital for transferring resources (McHale *et al.*, 2013). The distribution of resources is an important aspect when striving towards food and nutrition security and should therefore be

part of the resolving plan to improve nutrition security at health clinic gardens. According to Abramson *et al.*, (2015) it is an attribute of a resilient community to have capable governance and efficient distribution of resources. Clinics which scored high on physical resources can serve as examples by creating management strategies in the distribution of resources which is applicable and specific to the setting and area (Table 4-6). On the other hand, clinics with a great lack of resources can be examples of what to avoid in management strategies. The difference in scores for physical resources of Rustenburg and Moretele (Figure 4-4) indicates difference in management of the local municipalities and how it affects the combination of resources at the clinics. Moretele and Moses Kotane seem to have less variance in resource distribution even though they are based in more rural settings (Figure 4-4). Since there was no correlation between resource distribution and distance, there might be something else causing the distribution of resources to differ from place to place. It can be dependent on the enthusiasm of the stakeholders (further explored in Chapter 5) or the quality of communication and service from the local municipality office.

This data is also deficient in some ways since it does not necessarily convey the different combinations of resources - some clinics lack more crucial resources (such as water) while others lack negligible resources such as a hose pipe or a rake and other gardening equipment. This is evident in the next set of results (Figure 4-5 & Figure 4-6). Water supply – a crucial element not only needed for gardening, but also for the functionality of the clinic itself – seems to be the most precariously distributed over Bojanala District. South Africa is rated as one of the 30 driest countries in the world and is currently in a water crisis because of the weather pattern phenomenon, *El Niño* (Government Communications, 2015). The North-West Province was one of four provinces in South Africa that were declared as disaster areas due to drought (Government Communications, 2015). According to the North West Province State of Dams report on 23 November 2015, the current average dam levels in North West are 49% where it was 64.7 % this time last year (Department of Water and Sanitation, 2015). More than half (57%) of the health clinic gardens surveyed indicated that they have a water problem. It is interesting that water supply is not necessarily better in urbanized areas. Moretele, which consists only of 4 % urban area, rated highest in water supply (Statistics South Africa, 2011). In contrast, Rustenburg consists of 68 % urban area and was rated lowest in water supply at the clinics (Statistics South Africa, 2011). The problem in most of the clinics, especially Rustenburg, was not the availability of water, but a lack of maintenance. Many clinics reported to have potential water resources such as a borehole or rainwater tank, but the pump or tank is deficient in some way. Because clinic gardens has such a potential to ensure long-term food security and to encourage patients to develop nutritional diets, water management should be the top priority of managing authorities (Barthel & Isendahl, 2012). By building relationships with local government, facility managers and the community members such as the caregivers and

groundsmen better communication and mutual understanding can enhance solutions and service delivery to be more accurate (Fabricius & Collins, 2007). In this way, one can also alleviate problems with a lack of equipment or fertiliser. Great potential also lies within the use of indigenous species as alternative food sources such as African leafy vegetables (of whom many were found in this study area: *Amaranthus sp*, *Cleome gynandra*, *Corchorus asplenifolius*, *Cucurbita maxima*, *Cucurbita pepo*, *Momordica balsamina*, *Solanum nigrum* and *Vigna unguiculata*) (as found in Chapter 3). These species are not only adapted to the climatic conditions of the area and inherently drought tolerant, but also contain a very high nutrition content (Jansen van Rensburg *et al.*, 2007; Nesamvuni *et al.*, 2001; Van Jaarsveld *et al.*, 2014). Maintenance of these species is therefore lower and will alleviate the pressure on local authorities for delivering extra water, irrigation and fertiliser. Since none of the resource supplies correlated with distance to the local municipality offices, Moses Kotane's high score for resource delivery must indicate to other solutions which might be found at the clinics which had the highest scores for physical resources.

4.4.3 Stakeholder diversity and abundance

The greater involvement of stakeholders at clinics in the rural areas promotes the idea that health clinics are more of a focal point of the rural communities than with urban communities and might be one of the main sources of job opportunities. Since people in rural areas are much more dependent on immediate natural resources, they tend to identify more with gardening as a source of food rather than going to a supermarket for instance (Galhena *et al.*, 2013). It is therefore more common that rural communities will have a larger number or diversity of stakeholders involved at the clinic garden. The difference in management of each local municipality has a clear influence on the combination of stakeholders involved at the clinics. An example of this can be seen in Figure 4-9 where the low percentage score for groundsmen at Madibeng illustrates a different management strategy - a team of groundsmen serve the clinic gardens on a monthly basis, instead of an individual at each clinic. It was found that when the participation of individual groundsmen decreases, other members of the community (such as THP's and NGO's) become more involved in health clinic gardens in Madibeng Local Municipality. No clear reason could be found for this, but it might be an indication of redundancy where one member can replace the role of others in times of need - which is an important characteristic to increase resilience in social-ecological systems (Colding & Barthel, 2013). The involvement of prisoners and mine workers can contribute to new perspectives, innovations and solutions to problems which can enrich the knowledge systems attributed to health clinic gardens. Rustenburg Local Municipality is the only local municipality with a current source of academic knowledge (dietitians) and technical knowledge (private companies), increasing the diversity of knowledge systems and the scope of knowledge generation (Tengö *et al.*, 2014).

Groundsmen are potentially valuable at clinic gardens not only for their gardening skills and physical contribution to gardening, but also to enhance indigenous knowledge since they are community members which might have learned from older community members or obtained experience by working in gardens in the surrounding areas. Groundsmen play an important role in transferring knowledge to the community and to the younger generation since they have a good relationship with the community and are connected to the traditional and tribal authorities (Peu *et al.*, 2001). Caregivers at Moses Kotane and Moretele are both a source of indigenous knowledge as well as practitioner's knowledge since they include community members, retired nurses and patients (Cilliers *et al.*, in press). The CWP was initiated by the South African government to enhance employment in the social grant program (Vawda *et al.*, 2013). The higher number of clinics with CWP, other clinic personnel and reengineering team members also indicate the strong influence management have on the variety of stakeholders involved at the clinic gardens.

4.4.4 Knowledge about gardening

Knowledge about gardening can be very important since the plant species in the garden have several potential uses (further explored in Chapter 3) which can, or cannot be successfully or sustainably exploited. It is therefore important that a knowledge network should be established where knowledge can be shared and the stakeholders can network to create new relations and find new solutions as explained by Tengö *et al.*, (2014). Although Madibeng Local municipality depends more on the participation of other stakeholders such as NGO's and THP's on a regular basis (which enhance diversity), there are still much room for improvement on gardening knowledge. Knowledge networks create a perfect opportunity for stakeholders from Moretele (which have above average gardening knowledge) to share their knowledge with stakeholders from other local municipalities. Since there is such a variation in level of knowledge with no correlation with the potential useful species at the gardens, it is necessary to seriously improve on the knowledge networks throughout Bojanala District Municipality. Knowledge networks stand in the centre of building perspective on social-ecological systems and create understanding on how to unravel problems in such a way that more resilient solutions can be developed (Folke, 2006; Fabricius & Collins, 2007).

4.4.5 Time spent in the garden

The positive mindset and attitude of rural communities are also reflected in the increased time spent in the gardens in both Moses Kotane and Moretele Local municipalities. Stakeholders at Madibeng spend much less time in the clinic garden. The reason for this can be the lack of groundsmen (which are usually at the garden on daily basis) and higher involvement of NGO's and THP's which do not visit the clinic garden as regularly as groundsmen. The more urbanized

setting of Madibeng can also affect the motivation of the stakeholders to spend time on gardening instead of buying what they need at a supermarket. The weak correlation with gardening knowledge might indicate that stakeholders have other sources of motivation for working in the garden than simply understanding certain concepts about gardening. It might indicate that traditional habits of gardening are a stronger motivation (Schapera, 1934) or the lack of nutritious food a more desperate motivation to turn to food gardening (Galhena *et al.*, 2013) than knowledge about gardening.

4.4.6 Motivations for starting a garden

The motivations behind starting a food garden at health clinic gardens is better explained by Figure 4-14 which indicates the great impact that HIV/Aids and TB has on the community and how it can drive people to start a garden as an attempt to improve on their situation. We found that diabetics and hypertension is also becoming a more urgent reason for providing nutritious food which can be a result of “nutrition transition” suggested by Vorster *et al.*, (2011). This often occurs in developing countries where a traditional African diet is gradually replaced by a more westernised diet which is richer in fats, oils and sugar (Vorster *et al.*, 2011).

4.4.7 Constraints & problems in resource provision

Corruption is a continuous theme when researching resource management in Africa (Mensah, 2014; Hove *et al.*, 2013; Bolnick *et al.*, 2006) - which might also be the case at health clinic gardens. Corruption is an aggravating factor contributing to the ongoing struggle to manage the lack of resources. When the authorities are corrupt, there is no sense of leadership in the community which also contributes to the lack of motivation for citizens to try to improve their situation. It is crucial to build trust between different parties (Chan *et al.*, 2015), especially if a diverse set of stakeholders are needed to build a more resilient system at health clinic gardens. Social networking, trust and relational ties play an important role to improve sharing, exploitation and trade of resources (Chan *et al.*, 2015). “Champions” (which are inspiring, enthusiastic people in the community) can also stimulate social cohesion and motivate others to take action against corruption (Fabricius & Collins, 2007; Koester *et al.*, 2006; Tsegay & Rusare, 2014). A few good examples of “champions” were also found at health clinic gardens where one person is motivated to ensure the success of the clinic garden and also inspire the rest of the community to take action. These people should be treasured and empowered to take over the role of corrupt governmental institutions.

4.5 Conclusion

Figure 4-15 depicts a summary of the results found on resource diversity at health clinic gardens in the Bojanala District Municipality. On first observation one can conclude that Moses

Kotane and Moretele Local municipalities (rated green and yellow) contain more physical and social resources than Rustenburg and Madibeng Local Municipalities (rated yellow and red). Because of this greater diversity of resources, Moses Kotane and Moretele therefore have better potential to improve on resilience.

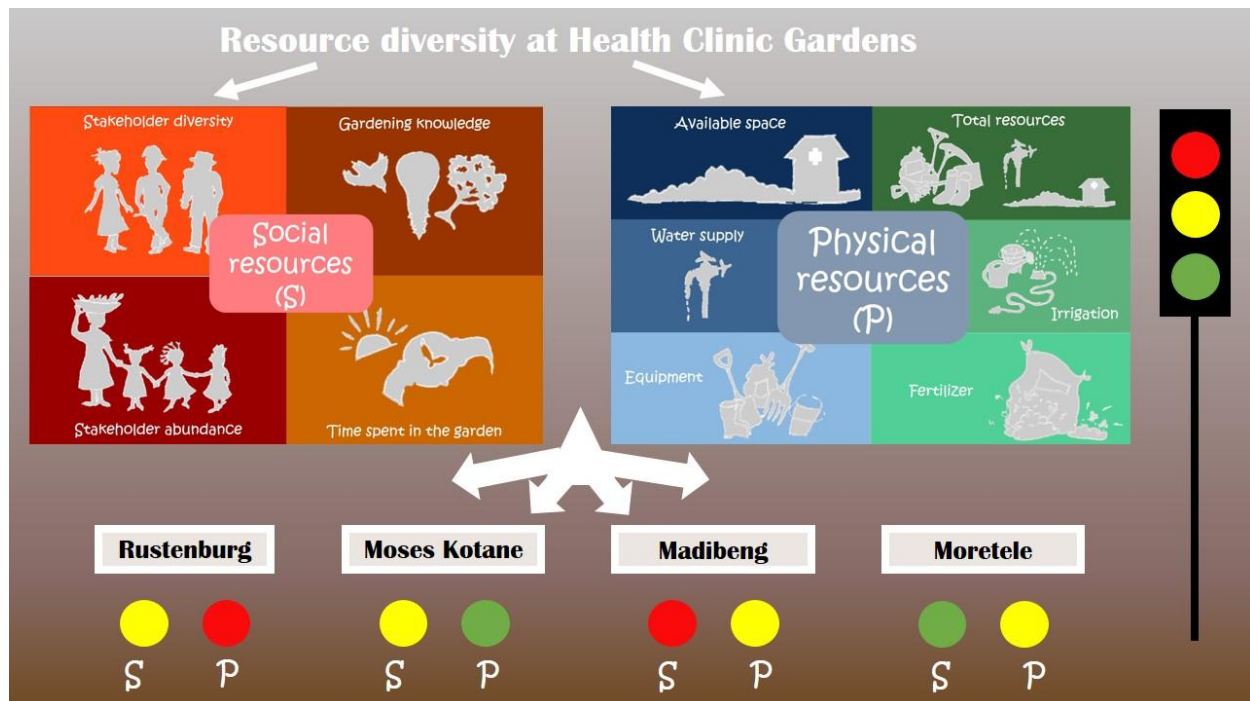


Figure 4-15: Rating of social (S) and physical (P) resources at each local municipality of the Bojanala District Municipality regarding the traffic light concept: green = good; yellow = medium; red = bad

Since resilience is not an attribute of a certain place or local municipality, but more an attribute of a system, one should look at the results from a broader perspective (Elmqvist *et al.*, 2013; Holling, 2001). This study is a reflection of a larger problem reaching past the boundaries of the country and stretch into major areas of Africa (McHale *et al.*, 2013; Popkin, 2004; Prain *et al.*, 2010; Vorster *et al.*, 2011). The most conspicuous concepts in this study were the lack of water and nutrition which could have been aggravated by poor communication and corruption within facilities as well as between facilities and the local municipality offices. These links need to be fixed before any potential for improving on resilience can exist. By starting with the “red” areas in the system, we can build up to the “yellow” areas and from there we can aim for “green”. There are no short cuts.

The solution to the lack of water in this study is quite challenging. One would assume that installing boreholes at each clinic should be the best solution, but several clinics reported that boreholes are not a good solution, since the pump gets broken and no access to a suitable technician exists. With the current drought, the level of the groundwater table lowered to an unreachable distance and rainwater tanks are also useless with no rain (Department of Water

and Sanitation, 2015). According to Faber *et al.* (2010); Faber *et al.* (2002) and Landman & du Plessis (2002) boreholes are becoming less popular as a result of urbanisation. Ironically, some people still buy water from those with boreholes (Coetzee & Du Toit, 2011). Boreholes with manual pumps that do not break as easily might therefore be a possible solution in some areas. Alternatives such as “play pumps” (a roundabout which plays a dual role by entertaining children while pumping water from a borehole) can be explored as possible solutions (UNICEF, 2007). It is important though, to involve all stakeholders in decisions about water (Olsson *et al.*, 2004; Fabricius & Collins, 2007), since it is one of the crucial problems at clinics. The best possible solution might be found in combining several sources of water (diversity of resources) such as having rainwater tanks together with plastic water tanks for storage as well as boreholes for in case the municipal water supply fails. In this manner, little by little enough water might be saved.

Adaptation in urban areas should be a key component in coping strategies of the government (Roberts *et al.*, 2012). By using ecological indicators to form part of an adaption strategy (“ecosystem-based adaptation”), a more detailed understanding of ecosystems can improve the sustainability of practices and increase the resilience of the social-ecological system (Roberts *et al.*, 2012). Camps-Calvet *et al.*, (2015) suggested four categories that can be seen as possible areas for improving on adaptive capacity in social-ecological systems and in the end improving on resilience which can also apply to health clinic gardens in Bojanala (Table 4-7).

Table 4-7: Resilience-building categories (adapted from Camps-Calvet *et al.*, (2015)) and its application for health clinic gardens in the Bojanala District Municipality.

Categories of Camps-calvet <i>et al.</i> , (2015)	Application for health clinic gardens
1) Learning to live with change and uncertainty	Learning from past crises (such as the current drought) and creating strategies which include future uncertainties.
2) Nurturing diversity for reorganisation and renewal	Nurture traditional knowledge and practices in favour of gardening, improve stakeholder diversity and involvement of other organisations – perhaps more mining companies?
3) Combine different types of knowledge for learning	Local (community, caregivers, CWP), traditional (groundsmen, caregivers and THP’s) and experiential (Dep. of Agriculture, scientific expertise, private companies, trained gardeners, retired sisters) knowledge should be encouraged and treated with equal levels of importance. Using health clinic gardens as sources of education and communication to the community.
4) Create opportunities for self-organization	Encourage support systems for THP’s as well as more regular network meetings where knowledge exchange can occur between all stakeholders of the gardens. Empowerment of community members.

Adaptive capacity seems, therefore, to be locked inside the social resources and if that treasure is unlocked, it might give rise to enriched physical resource diversity. In most cases, physical resources are therefore dependent on the social resources and networks between the social

systems. A greater diversity and abundance of social resources broadens the scope of opportunities and therefore also enhance the diversity of physical resources available. An example of this is when Department of Agriculture is involved, access to governmental financial support is created.

Enormous potential exists for building adaptive capacity at health clinic gardens. It is often the assembling point of the community which creates opportunity for gaining new ideas, knowledge and involvement of stakeholders and also provide opportunity for obtaining more physical resources. At clinic gardens people from different backgrounds join and exchange of knowledge takes place by creating a community of practice (Bendt *et al.*, 2013; Wenger, 1998) which is further discussed in Chapter 5. This makes it a rich learning environment and a real treasure chest for unlocking adaptive capacity, since it represents the source of transferring knowledge from one generation to the other so that future generations may be better equipped to handle future crises. Clinics are also seen as places where healing takes place and where help can be sought. It is, therefore, natural that clinic gardens should be part of the solution to nutrition security. Patients visiting the clinics are also of the most vulnerable, which should be the first group of people considered for finding solutions to alleviate nutrition deficiency in South Africa.

Chapter 5 – Health clinic gardens as communities of practice: stakeholders' perceptions on ecosystem services and disservices



CHAPTER 5 - HEALTH CLINIC GARDENS AS COMMUNITIES OF PRACTICE: STAKEHOLDERS' PERCEPTIONS ON ECOSYSTEM SERVICES AND DISSERVICES

5.1. Introduction

Throughout South Africa, 4277 public health facilities are distributed to provide better health care for South Africans - especially in rural areas where no access to proper hospitals exists (Pillay & Barron, 2011). At these health clinics, gardens were also established as part of an attempt to improve the living conditions and to alleviate the food and nutrition deficiency of the surrounding community. Natural, physical and social resources are present at health clinic gardens and integrated to provide a sustainable food supply. A large diversity of potential stakeholders (social resources) can be involved at the clinic gardens which include facility managers, paid gardeners (groundsmen), caregivers (stipend paid by Department of Health), Community Works Program (CWP – stipend paid by Department of Works), NGO's (may include caregivers, Community Health Workers and retired nurses), charity workers from the community (includes churches), Re-engineering team consisting of retired nurses, Community Health Workers (stipend paid by Department of Health) and other clinic personnel, Traditional Health Practitioners (THP's – Stipend paid by Department of Health), experts (including dieticians and trainers from Department of Agriculture), private companies and some of the patients (Figure 5-1) (Cilliers *et al.*, in press). Facility Managers are present at the majority of clinics while private companies and mine workers or prisoners are not so often involved at the clinic gardens (Figure 5-1). Facility managers play mostly a facilitating role and are not always directly involved with the garden. Groundsmen are present at the majority of clinics and take care of the food garden as well as the ornamental gardens.

These different stakeholders share professional interests, skills and knowledge at the clinic gardens and the need to engage, discuss and analyse will develop to solve problems regarding the availability of water, seeds and fertiliser, as well as other issues such as nutrition deficiencies of the patients and the distribution of vegetables produced at the clinic garden. This could lead to regular meetings of the stakeholders and eventually the creation of a community of practice as described by MacPhail *et al.* (2014) and Taylor & Lovell (2014).



Figure 5-1: Potential stakeholders at health clinic gardens in the Bojanala District Municipality indicating their current involvement

Apart from formal courses, these stakeholders experience a certain form of incidental learning which is part of being engaged in a community of practice (MacPhail *et al.*, 2014; Taylor & Lovell, 2014). Each of the stakeholders participating in the community of practice at clinic gardens perceives situations differently, make various assumptions and come to unique conclusions since their personality, background, academic knowledge, culture and traditions differ (Bendt *et al.*, 2013; Wenger, 1998). The diversity of knowledge gathered at clinic gardens contribute to the co-production of knowledge and creation of an enriched understanding of issues (such as ecosystem services and disservices as well as problems and methods to improve sustainability) at the gardens which will enhance innovation and the potential to improve on resilience (Armitage *et al.*, 2011; Andersson, 2014; Durose *et al.*, 2012; Pohl *et al.*, 2010; Tengö *et al.*, 2014). Ecosystem services can be seen as benefits for humans derived from ecosystem functions (Gómez-Baggethun & Barton, 2013; Millennium Ecosystem Assessment (MEA), 2005; TEEB, 2011). According to Millennium Ecosystem Assessment (MEA) (2005),

ecosystem services can be divided into four main groups: provisioning services, regulating services, supporting services and cultural services. Ecosystem disservices, however, are negative aspects associated with ecosystems which can also cause deterioration of human well-being such as: pests, diseases, allergies, poisonous plants and animals, storms and earthquakes (Lyytimäki *et al.*, 2008; Von Döhren & Haase, 2015).

A great number of studies have been done on ecosystem services in urban areas and cover several subjects regarding the manner in which ecosystem services can be used in governance and the valuation of ecosystem services especially towards economic and monetary value (Ahern *et al.*, 2014; Andersson *et al.*, 2014; Barthel *et al.*, 2010; Barthel, *et al.*, 2014; Bennett *et al.*, 2009; Costanza *et al.*, 2014; Gómez-Baggethun & Barton, 2013; Schultz *et al.*, 2015; TEEB, 2011; Wamsler *et al.*, 2014). Studies have also been done on social-ecological aspects of ecosystem services and the manner in which ecosystem services can be researched to accommodate both sociology and ecology in equal depth in urban environments (Andersson *et al.*, 2007; Cook *et al.*, 2012; Hamann *et al.*, 2015; Mastrangelo *et al.*, 2015; Redman *et al.*, 2004; Schewenius *et al.*, 2014). Another topic covered in literature is about the trade-offs of ecosystem services and its benefits for the health and well-being of humans as well as the role ecosystem services play in providing resilient systems (Cilliers *et al.*, 2013; Lavorel *et al.*, 2012; McPhearson *et al.*, 2014; Sandifer *et al.*, 2015; Suich *et al.*, 2015; Tzoulas *et al.*, 2007; Yang *et al.*, 2015).

Less literature can be found on ecosystem services provided at urban gardens (Barthel *et al.*, 2010; Beumer & Martens, 2014; Calvet-Mir *et al.*, 2012; Cameron *et al.*, 2012; Mohri *et al.*, 2013; Reyes-García *et al.*, 2012; Taylor & Lovell, 2015; Van Heezik *et al.*, 2012). Some studies found that home gardens make a substantial contribution towards food production and can make even a meaningful difference towards financial income and food security (Reyes-García *et al.*, 2012; Taylor & Lovell, 2014). The quality of benefits derived from home gardens, however, is influenced by the gardening practices and changes in chemical and physical properties of the soil might also cause ecosystem disservices (Cameron *et al.*, 2012; Reyes-García *et al.*, 2012; Taylor & Lovell, 2014). Culture plays an important role at urban gardens and in several cases is also the most important ecosystem service provided by these gardens (Calvet-Mir *et al.*, 2012). Many urban gardens are used as an expression of the citizens' culture and traditional practices (Barthel *et al.*, 2010; Mohri *et al.*, 2013; Taylor & Lovell, 2014). Other studies also determined the role of urban gardens in harbouring biodiversity and results showed that rural home gardens played a stronger role, but with good management, maintenance of biodiversity can also occur in urban gardens (Mohri *et al.*, 2013; Van Heezik *et al.*, 2012). Benefits derived from allotment gardens in Sweden was also found to be transferred from one generation to the next through social-ecological memory (Barthel *et al.*, 2010).

Citizen's perceptions on ecosystem services have only been sparsely researched (Andersson *et al.*, 2014; Casado-arzuaga *et al.*, 2013; Chan *et al.*, 2012; Koyenikan, 2007). Some studies found that perceptions on ecosystem services greatly impact management decisions and demand and perceptions on ecosystem services change in correlation with each other between different communities (Andersson *et al.*, 2014; Casado-arzuaga *et al.*, 2013;). Women in EDO South Ecological Zone, Nigeria, had positive perceptions on ecosystem services provided by home gardens especially in enhancing food security and building toward better health and nutritious food (Koyenikan, 2007). According to Andersson *et al.*, (2014) and Chan *et al.*, (2012) perceptions are closely linked to cultural ecosystem services and this can be the key to promote civic engagement and stewardship.

Although cultural services play such a pivotal role in communities, it has been greatly neglected in previous research (Andersson *et al.*, 2014; Calvet-Mir *et al.*, 2012; Chan *et al.*, 2012; Szücs *et al.*, 2015). Because of the intangibility of cultural services, it has been difficult to accurately determine its financial value which made it too complicated to implement in management strategies (Chan *et al.*, 2012). Cultural dynamics of each community also differs to a great extent and this paralyses any attempts to create a common framework to enhance the awareness of ecosystem services in each area (Taylor & Lovell, 2015). In a study of Calvet-Mir *et al.* (2012) in Spain, cultural services were found to be the most valued of all ecosystem services.

Ecosystem disservices in urban areas have also been researched, but little information exists on ecosystem disservices in the Southern hemisphere and should be investigated in more depth in future (Beumer & Martens, 2014; Cilliers *et al.*, 2013; Cook *et al.*, 2012; Elmqvist *et al.*, 2013; Gómez-Baggethun & Barton, 2012; Lyytimäki *et al.*, 2008; Szücs *et al.*, 2015; Taylor & Lovell, 2014; Von Döhren & Haase, 2015). Most studies on ecosystem disservices were done in Western Europe and North-America with the focus on urban areas (Von Döhren & Haase, 2015). Investigation was also done on the link between people and ecosystem services and disservices in the home environment or residential gardens (Beumer & Martens, 2014; Cook *et al.*, 2012). Other studies focused on economic valuation and classifying of ecosystem services and how disservices influence its value (Gómez-Baggethun & Barton, 2012).

Ecosystem services and disservices are important in monitoring and managing natural areas in cities and perceptions of the different stakeholders on these services at clinic gardens can therefore be essential in creating an objective, enriched picture of the situation and problems at hand. There is value in every stakeholder's knowledge contribution to the management of the garden. Since health clinic gardens create communities of practice, enormous potential exist within the gardens to alleviate nutrition deficiency, preserve traditional gardening practices and knowledge, build knowledge networks and to stimulate environmental stewardship and social

cohesion (Barthel *et al.*, 2010; Taylor & Lovell, 2014; Wenger, 1998). The public visibility of health clinic gardens enhances reification of the social-ecological knowledge obtained by the stakeholders involved (Barthel *et al.*, 2010; Taylor & Lovell, 2014; Wenger, 1998). Visitors and patients visiting the clinic can reproduce this knowledge obtained from the clinic garden at their own homes – contributing to community development and building resilience in the urban system (Barthel *et al.*, 2010; Taylor & Lovell, 2014; Wenger, 1998). Goddard *et al.* (2010) also found that the scale in which urban gardens are managed should be enlarged to accommodate an entire network of green patches within the city, which through their interconnectedness and sharing of information, can also cause an up-scaling of knowledge. Cross-culture relations and understanding can also be built throughout the community in this way, since trust and respect are essential to a community of practice (Taylor & Lovell, 2014; MacPhail *et al.*, 2014).

Local stewards together with social-ecological systems are important in generating ecosystem services and land-use planning and management often fail to take this into consideration (Andersson *et al.*, 2014). The various perceptions of the local stakeholders involved at the clinic garden could therefore be the link between health clinic gardens and human well-being (Andersson *et al.*, 2014; Tzoulas *et al.*, 2007)

The aim of this study is therefore to identify the perception of each of the stakeholders on ecosystem services and disservices which will also provide some understanding on their involvement at the clinic garden as well as their interactions with the other stakeholders. This will contribute to understand the community of practice existing at health clinic gardens. We also want to determine the scope of knowledge that exists at clinic gardens which will enable us to make recommendations that are logic and will help to unlock the potential contained in health clinic gardens.

5.2. Material and methods

Data was gathered using questionnaires where the theme of the questions was on ecosystem services and disservices. Each stakeholder at the clinic gardens was interviewed to obtain his/her perception on ecosystem services and disservices. Most of the stakeholders involved at the clinic gardens are not proficient in English or are illiterate. The answers of the participant were therefore rated according to the perceived reaction to the question during interviews. A rating of one to five was given where one indicates strongly disagree and five indicates strongly agree. Setswana speaking interpreters were also sometimes available. The majority of questions were yes/no questions with a few open questions to give some insight on the perception of the person interviewed (Table 5-1). Questions were divided into the four main categories of ecosystem services: provisioning, regulating, habitat and cultural services

(Millennium Ecosystem Assessment (MEA), 2005). Questions were also asked on ecosystem disservices.

Table 5-1: Example of questions asked in the interview of different stakeholders at health clinic gardens of the Bojanala District Municipality.

1. Stakeholder perceptions on ecosystem services	Ecosystem service
A: Provisioning Services	
Provision of nutritious food	Food
Provision of wood for fire or any other sources of energy	Fuelwood
Provision of plants with medicinal value	Medicinal resources
Provision of material that can be used in construction of buildings	Building material
Provision of fodder and green manure	Fodder (for animals)
B: Regulating Services	
Are there birds and insects such as bees, wasps, beetles and butterflies sitting on the flowers?	Biological control/Pollination
Are there earthworms present in the garden?	Soil quality
Is the soil soft and easy to dig into with a spade?	Soil quality
Do the trees provide protection from wind/ sun?	Local climate
C: Habitat/ Supporting Services	
Are there any birds, animals or insects living in the garden? (making it their home)	Habitat for species
Are there any plants here, that you don't have in your home garden or that you don't see elsewhere in the community e.g. type of vegetables and trees etc?	Maintenance of genetic diversity
D: Cultural Services	
Are there sometimes children playing in the garden?	Recreational/ Mental/ Physical health
Do you like to be in the garden? Or do you enjoy working in the garden?	Spiritual/Sense of place
Are there sometimes visitors which are just sitting around in the garden?	Aesthetical appreciation
What makes a garden beautiful for you?	Aesthetical appreciation
Do you think this garden is beautiful? (throughout the year or only certain parts of the year?)	Aesthetical appreciation
What would you plant to make this garden more beautiful?	Aesthetical appreciation
Do you think that working in the gardens is a good way to meet new people?	Social network
Where did you learn how to make a garden?	Education and Science
Did you gain some new knowledge by working in the garden/ being involved in the garden?	Education and Science
Will you be willing to transfer (teach) your knowledge to someone else?	Education and Science

Table 5-1 continues

2. Stakeholder perceptions on ecosystem disservices	Ecosystem disservice
Do you think any of the plants in the garden can make you sick/ill/allergic?	Allergies/ Decline in health
Do you think any of the plants in the garden can harm you e.g. branches falling on you etc.?	Accidents
Do you think it is expensive to have this garden?	Financial costs
Do you think it is a waste of water to have this garden?	Financial/ Environmental costs
Do you feel safe in the garden?	Crime (Fear and stress)
Does the fallen leaves clog the gutters?	Damage to infrastructure
Do the branches of the trees sometimes fall on the building?	Damage to infrastructure
Do you think some of the plants (trees) can be harmful to the building?	Damage to infrastructure
Do you prefer to be able to see outside the fences or do you like to be secluded?	Blockage of view
Do you think the garden obstruct your view?	Blockage of view

The Likert scale was used to rate the answers from 1 to 5 where 1 indicates strong disagreement and 5 indicates strong agreement (Gliem & Gliem, 2003) (Table 5-2). Although the rating is subjective, the Likert scale has previously been successfully used in several other urban garden studies (Calvet-Mir *et al.*, 2012; Goddard *et al.*, 2013; van Heezik *et al.*, 2012). Table 5-2 indicates the type of questions asked for the survey. The applicable score was encircled according to the reaction of the stakeholder after the question was asked. This will then be the score of that stakeholder for “spiritual/sense of place” at the garden.

Table 5-2: Example of how the Likert scale was used in the questionnaire

1. Stakeholder perceptions on ecosystem services					Date:	
Clinic name:					Number:	
A: Health Clinic Garden						
Do you like to be in the garden? Or do you enjoy working in the garden?						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Spiritual/Sense of place	

To ensure the credibility of the data, the method was applied by only one person throughout the study. As far as possible, every stakeholder involved at the clinic garden was interviewed. Questions were originally structured according to the different categories of ecosystem services namely provisioning services, regulating services, supporting services and cultural services

(Millennium Ecosystem Assessment (MEA), 2005). The order of the questions was then changed to provide a more logic flow of thoughts throughout the interview. The data was analysed by using interpolating techniques in ArcMap (ArcGIS) as well as several analyses in MS Excel (ESRI, 2011; Excel, 2013). In Excel, all the stakeholders who gave a score of 4 or 5 out of 5 were counted for each ecosystem service or disservice as well as in each local municipality and a percentage of stakeholders with “high” scores were calculated (stakeholders who gave a score of 4 or 5). Statistical differences between the percentages of high scores were tested by using STATISTICA version 12 (StatSoft, Inc. 2013). With ArcMap the data was conveyed in a more spatially explicit manner which made it easier to identify differences between opinions. The interpolating technique used is called Inverse Distance Weighted (IDW) (ESRI, 2011). This technique was specifically chosen, since it uses the measured value and assumes that the value decreases with increasing distance (ESRI, 2011). This means that the stakeholders’ opinions will have a decreasing influence on others as the distance to the clinic garden increases. At each clinic, an average of 2 stakeholders was interviewed and therefore the total number of interviews for the study was ± 213 .

5.3. Results

5.3.1 Comparison of ecosystem services as perceived by stakeholders

The interviews revealed that most stakeholders perceive spiritual/sense of place ecosystem service to be the most valuable of all services at the clinic gardens (98.61 %) with an average score of 4.42 (Table 5-3; Figure 5-2). Other important services as perceived by the stakeholders were: food provisioning (94.42%, average score 4.29), biological control through insects in the garden (94.4%, average score 4), local climate and protection from wind and sun provided by trees (96.06%, average score 4.19), social networking through the garden (96.6%, average score 4.14) and education and science from the garden (93.44%, average score 3.89). Habitat and supporting services were scored to be the least valuable (average score of 2.56 out of 5). Most stakeholders also do not think that any plants in the garden can be used as building material (average score 2.42 out of 5). Regulating services were scored the highest with an average of 3.83 out of 5.

Table 5-3: Ecosystem services at health clinic gardens as perceived by the stakeholders

Ecosystem services at health clinic gardens			
Provisioning services	Percentage (%) of stakeholders that perceived the service as valuable	Average score between 0 and 5	Average
Food	94,42	4,29	3,18
Firewood	58,87	2,95	
Medicinal resources	56,63	2,86	
Building material	29,87	2,42	
Fodder	60,39	3,37	
Regulating services			
Biological control	94,4	4	3,83
Soil quality	65,81	3,31	
Local climate	96,06	4,19	
Habitat/Supporting services			
Habitat for species	33,29	2,68	2,56
Maintenance of genetic diversity	31,24	2,44	
Cultural services			
Recreation/Mental health	54,99	3,08	3,78
Spiritual/sense of place	98,61	4,42	
Aesthetical appreciation	77,9	3,39	
Social network	96,6	4,14	
Education and science	93,44	3,89	

From Figure 5-2 two main observations can be made from the perceptions of stakeholders on ecosystem services: 1) cultural and regulating services play a dominating role of importance and 2) there is a lack of value associated to habitat/supporting services. The differences between the high scores (4/5 or 5/5) given by the stakeholders for the various ecosystem services is statistically significant ($p = 0.000004$) (Figure 5-3). Moretele Local municipality has the highest percentage of stakeholders who gave a high score for several of the cultural services, regulating services and provisioning services, while Rustenburg has the least stakeholders with a positive perception of these ecosystem services (Figure 5-2). It is only with cultural services, however, that a statistically significant difference occurs between the local municipalities (Rustenburg had a significantly lower score than Moretele ($p = 0.035615$)) (Figure 5-3).

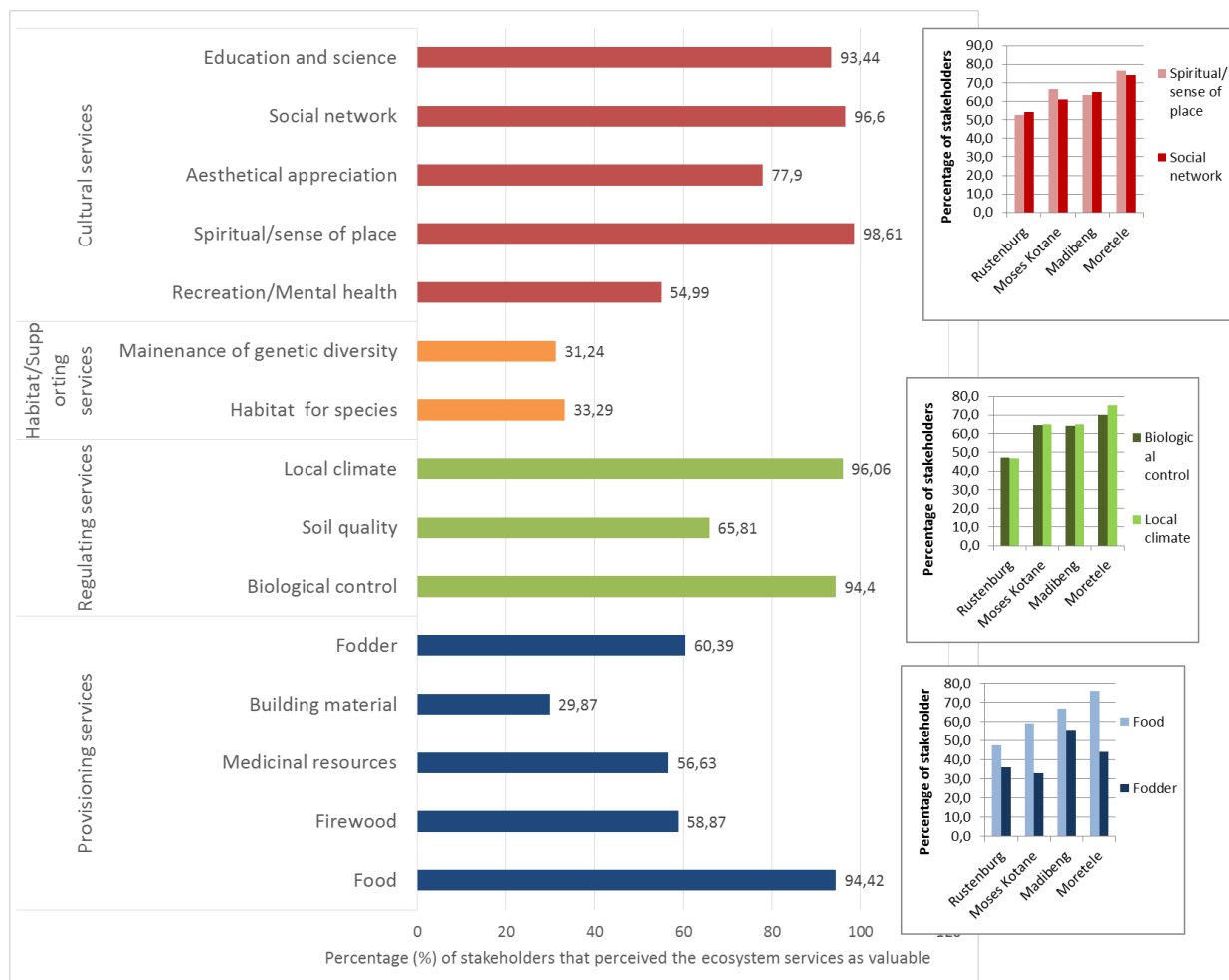


Figure 5-2: Percentage of stakeholders that perceived the ecosystem service at health clinic gardens in the Bojanala District Municipality, as valuable (that gave a score of 4/5 out of 5 to the service) and a comparison between the scores given by the stakeholders at the different local municipalities.

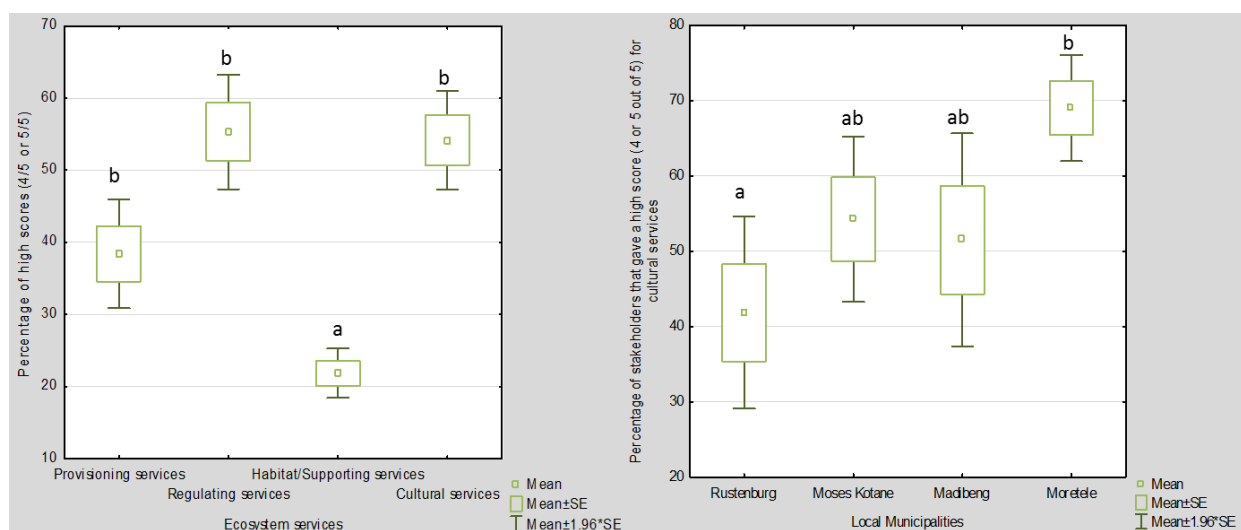


Figure 5-3: A) Differences between the high scores (4/5 or 5/5) given by the stakeholders to the ecosystem services at health clinic gardens in the Bojanala District Municipality and B) the difference between local municipalities according to the percentage of stakeholders that gave a high score (4/5 or 5/5) for cultural services.

5.3.2 Comparison of ecosystem disservices as perceived by the stakeholders

The most dominant ecosystem disservice identified by the stakeholders is crime, fear and stress (82.67% with an average score of 3.88) (Table 5-4). During the interviews, danger was often associated with the garden and with the area surrounding the garden. The average score for ecosystem disservices was only 2.58 which indicate that other disservices such as allergies, accidents, financial/environmental costs, blockage of view and damage to infrastructure were not considered to be such important threats at the gardens.

Table 5-4: Ecosystem disservices as perceived by the stakeholders involved in health clinic gardens of the Bojanala District Municipality

Ecosystem disservices	Percentage (%) of stakeholders that perceived the service as valuable	Average score between 0 and 5	Average
Allergies	20.9	2.71	2.58
Accidents	33.9	2.72	
Financial costs	31.93	2.22	
Environmental costs	20.12	1.58	
Crime, fear and stress	82.67	3.88	
Damage to infrastructure	42.36	2.9	
Blockage of view	2.3	2.02	

From Figure 5-4 it is clear that crime, fear and stress were perceived as the most important disservice by the stakeholders at all local municipalities. Although no statistically significant difference occurs, this disservice was rated slightly higher in Moses Kotane and Moretele Local municipalities than in the other Local municipalities.

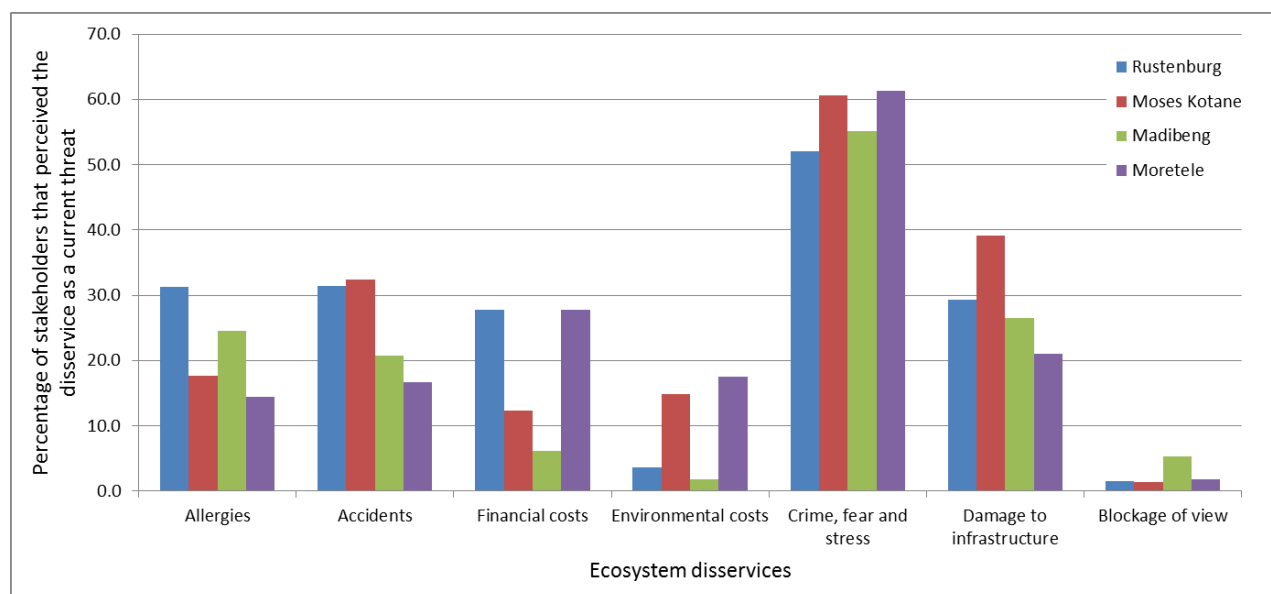


Figure 5-4: Comparison of rated disservices at the different local municipalities in the Bojanala District Municipality.

5.3.3 Difference in stakeholders' perceptions

Differences in the perceptions of some of the stakeholders (facility managers, caregivers and groundsmen) can be seen throughout Bojanala District Municipality (Figure 5-5). Orange areas indicate a lower score conveying a negative idea about the ecosystem services (represent “disagree” on the questionnaire) , while the green areas represent higher scores and therefore more positive attitude (represent “agree” and “strongly agree” on the questionnaire). It is clear that facility managers overall have a more negative perception than groundsmen and caregivers. The groundsmen’s and caregivers’ perceptions were more similar.

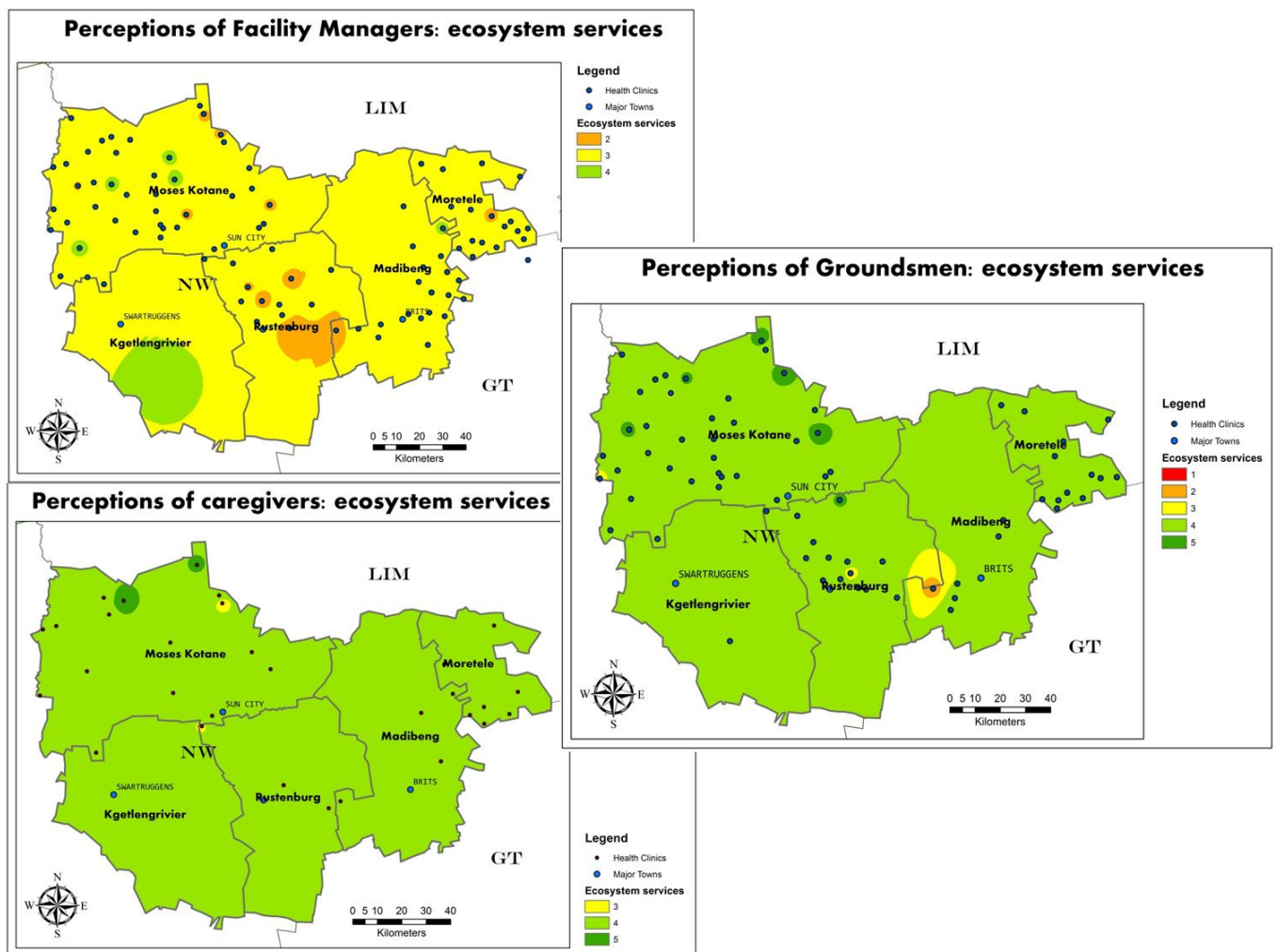


Figure 5-5: Comparison of perceptions of facility managers, caregivers and groundsmen on ecosystem services at health clinic gardens in the Bojanala District Municipality. Red and orange areas indicate a low score and negative perception, while green areas indicate high scores and positive perceptions.

In several health clinic gardens there are quite large differences in opinion between the facility manager and the groundsman which can cause either severe arguments or enrich the diversity of opinions and in the end also knowledge at the clinic gardens (Figure 5-6). Only a few health

clinic gardens in Madibeng Local Municipality where both a Facility Manager and groundsman were present, could be surveyed.

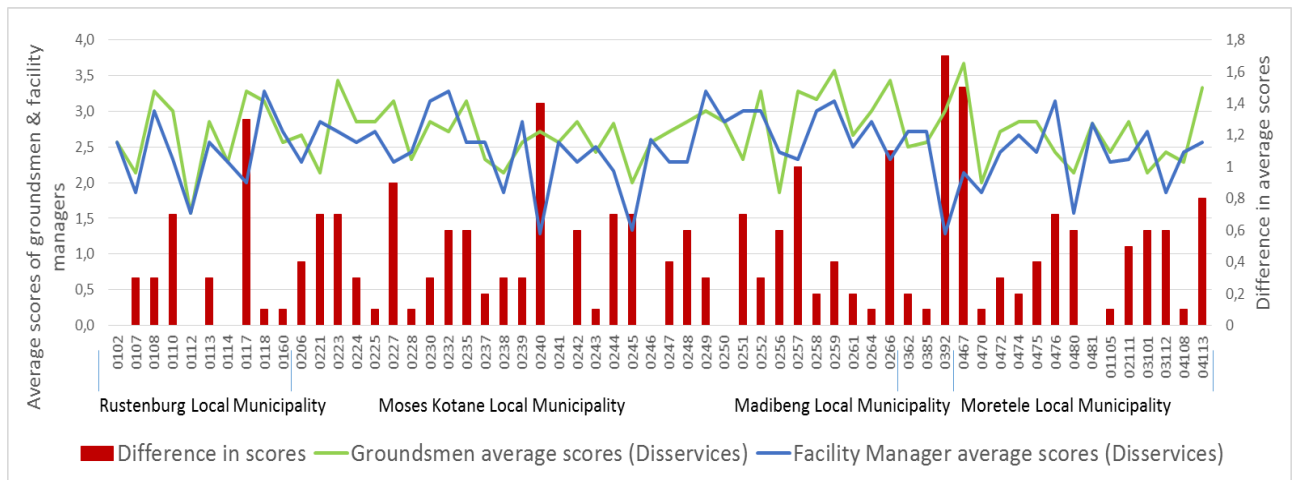


Figure 5-6: Difference in perceptions of groundsman and facility managers on ecosystem services at health clinic gardens in the Bojanala District Municipality.

5.3.4 Themes derived from open questions

During the interviews, a few open questions were also asked which produced interesting results unique to the cultures in the Bojanala District. A few themes can be highlighted which were dominant throughout the survey occurring in the answers of most of the stakeholders (Figure 5-7). The first theme indicates that aesthetical appreciation for most of the stakeholders was less about ornamental plants, but more about cleanness, openness, the growing of vegetables and the greenness of the garden. There was also a constant reference to the fear of snakes in the garden which links the garden to a place where danger occurs. Great appreciation was expressed for the growing of plants and the development of fruit and vegetables, which links to the concept of biophilia (Tzoulas *et al.*, 2007; Mitchell & Mueller, 2011). The concept “garden” was mostly only associated with the growing of food and not linked with recreation or aesthetical appreciation. Gardens were also often referred to as a place of education where knowledge was obtained from a small age from an older community member such as a grandparent, teacher or aunt/uncle. Soil quality was in most cases an unknown factor and very few knowledge existed on its importance for the health of plants. The positive effect of earthworms on soil fertility and the growing of the plants was a strange and unknown concept to most stakeholders.



Figure 5-7: Themes obtained from the open questions asked in the interviews at health clinic gardens in the Bojanala District Municipality.

5.4. Discussion

5.4.1 Comparison of ecosystem services as perceived by stakeholders

Interviews with the stakeholders revealed interesting results which contributes to the fact that clinic gardens can be seen as a community of practice where the presence of cultural values in all ecosystem services can be seen (Barthel *et al.*, 2010; Taylor & Lovell, 2014; Wenger, 1998). This is evident in the fact that stakeholders scored sense of place or spiritual value of the garden as the most important ecosystem service (98.61 % rated it as valuable, with an average of 4.42/5). Most stakeholders enjoy being in the clinic garden and enjoy working in it. This is evidence of the important role gardens play in creating identity and social cohesion, since it is an enjoyable thing to do with others (Barthel *et al.*, 2010; Taylor & Lovell, 2014; Wenger, 1998). The fact that food provisioning is also rated high, enhance the potential of clinic gardens to be seen as sources of food which can be an excellent solution for nutrition deficiencies in the area – especially for the patients which are the most vulnerable (Vorster *et al.*, 2005). Another aspect of appreciation the stakeholders expressed in the results is that the garden attracts insects which play a role in pollination and biological control. Trees are also seen as important to provide protection from the wind and the sun. This proves that the stakeholders consciously or unconsciously have a deeper understanding of the regulating services the garden provides and can possibly embrace such services without knowing. This knowledge might have been obtained by working in the garden or passed on by previous generations which needed this knowledge as a survival mechanism (Wenger, 1998). Working in the gardens was perceived to be a good opportunity to meet others and most stakeholders also valued the importance of

clinic gardens to education and science. Most were of opinion that they learned something new by working at the garden and will be more than willing to transfer the knowledge to someone else (Barthel *et al.*, 2010; Taylor & Lovell, 2014; Wenger, 1998).

Most stakeholders did not see clinic gardens as possible habitats for insects, birds or animals, but thought more of the gardens as places where these organisms are passing through. There might be a lack of understanding on the importance of gardens as habitats for species. Calvet-Mir *et al.*, (2012), Galuzzi *et al.* (2010), Molebatsi *et al.*, (2013) and Rudd *et al.*, (2002) determined that urban gardens play an important role in the conservation of genetic diversity. The fact that stakeholders perceive health clinic gardens as a passage between more permanent habitats for organisms, can indicate that the stakeholders (consciously or unconsciously) see gardens as ecological corridors which are crucial in connecting urban and rural areas for migrating species and maintaining biodiversity throughout the urbanized areas (Rudd *et al.*, 2002; Gómez-Baggethun & Barton, 2013; Davoren, 2009). The stakeholders also did not perceive clinic gardens to contain many exotic or unique plant species in comparison with the rest of the community. According to them clinic gardens are not a good source for maintaining genetic diversity. The reason for this might be that the plants usually planted in these gardens are mostly native or indigenous which are well adapted to the dry and warm climate. This can be ideal for promoting the use of African Leafy Vegetables as an alternative food source (*Morogo*) (Jansen van Rensburg *et al.*, 2007; Faber *et al.*, 2010), since these plants are also well adapted to African climate and can survive in harsh environments. The negative aspect of this perception is that genetic diversity will not necessarily be promoted and maintained in clinic gardens.

Faber *et al.*, (2010) did a study in Limpopo and Kwazulu-Natal Provinces of South Africa and determined that many sources (such as food water and energy) in rural areas are directly obtained from nature (such as African leafy vegetables, water from a stream or river and wood for fire) while in urbanized areas, these sources are provided by the infrastructure. Several other studies also determined that people can lose their “connectedness” to nature by living in urbanized areas and can become less sensitive for their dependence on natural resources (Barthel *et al.*, 2010; Miller, 2005; Rosenzweig, 2003). Since Rustenburg Local municipality is overall more urbanized, it might influence the stakeholders to be less conscious of the benefits nature can provide than the people living in Moretele and Moses Kotane which are more rural local municipalities. These stakeholders probably have a much closer relationship with nature and are more dependent on the direct benefits derived from it. It is important to embrace this mind-set, since it provides a window of opportunity to inspire the stakeholders to be more involved at health clinic gardens. Windows of opportunity play an important role in the adaptive cycle of social-ecological systems and could increase the resilience of the system (Holling,

2001). This close interdependent relationship between humans and nature also conveys the potential of health clinic gardens to be a symbol for sustainable gardening practice and a source of inspiration for the rest of the community that will alleviate nutrition deficiency of the most vulnerable patients.

5.4.2 Comparison of ecosystem disservices as perceived by the stakeholders

In contrast with results found in several community gardens in the past (Guitart *et al.*, 2012; Okvat & Zautra, 2011), crime, fear and stress were identified as the most prominent disservice at health clinic gardens. Other studies also found that the social organization resulting from community gardening as well as the increase of tree cover in cities help to reduce crime (Kendal *et al.*, 2012; Kuo & Sullivan, 2001; McPhearson *et al.*, 2016; Troy *et al.*, 2012). Clinic gardens often resemble the traditional Tswana Tshimo layout which is a garden consisting of several micro-gardens such as Lebala (open area), Naga (natural vegetation), ornamental beds, vegetable garden, lawn, and orchard (Molebatsi *et al.*, 2010). The Lebala is specifically placed around the buildings to provide visibility for dangers such as snakes and possible attackers and burglars (Molebatsi *et al.*, 2010). The Naga, however, is mostly an overgrown natural area kept for harvesting native plant species such as African Leafy Vegetables (*Morogo*) used as alternative food sources (Molebatsi *et al.*, 2010; Von Döhren & Haase, 2015; Elmqvist *et al.*, 2013; Tzoulas *et al.*, 2007). This overgrown area can be a possible reason for the fear in clinic gardens perceived by the stakeholders. At the less urbanized Local municipalities (Moses Kotane and Moretele), the natural areas between villages are much bigger and less disturbed by human practices. Some wild animals such as small antelope, reptiles and jackal are still present in these areas and therefore the inhabitants are more cautious. Apart from this negative association with gardens the overall score for disservices at clinic gardens was quite low, which means that the perception of the usefulness of clinic gardens is mostly positive.

5.4.3 Difference in stakeholders' perceptions

Background, upbringing, culture and education play an important role in the knowledge of a person and can also have an influence on his/her perception (Barthel *et al.*, 2010; Bendt *et al.*, 2013; Wenger, 1998). The differences between the perceptions of the different stakeholders serve as proof of this fact. The facility manager, for instance, has education in human health and well-being and will therefore perceive the condition of the garden from that perspective. The groundsman, on the other hand, might perceive the garden according to his knowledge of plants and how well they are growing. It also often occurred that the groundsman is much closer related to traditional gardening practices of the Setswana culture and indigenous knowledge (many gardens had the Tswana tshimo lay-out which is a typical lay-out of Setswana gardens) (Molebatsi *et al.*, 2010). He will therefore also rate the garden according to its function in

traditional practices, such as trading with medicinal plants (Ndawonde *et al.*, 2007). The perception of each person can influence the manner in which he/she will be involved in the garden as well as the level of enthusiasm they will have to contribute. This can help with creating management strategies for the clinic gardens. A stakeholder with a positive perception of the garden can be very valuable - regardless of his/ her knowledge of gardening. This person has the potential to be a “champion”. A “champion” is someone who plays an important role in social cohesion and motivating others to take responsibility for sustainable practices (e.g. gardening practices) (Fabricius & Collins, 2007; Koester *et al.*, 2006; Tsegay & Rusare, 2014). A stakeholder’s perception can also reflect on the kind of knowledge he/she possesses, since knowledge can change the way in which a person perceive things (Scheffer *et al.*, 2015). In this way every stakeholder can contribute to co-produce knowledge which will enhance the objectivity in which problems can be solved and in the end improves the resilience at health clinic gardens (Tengö *et al.*, 2014).

While considering the results, we also realised that each stakeholder has a different role to play in the garden which also affected his/her perception about the garden. Figure 5-8 indicates the manner in which the different stakeholders are usually involved in the clinic gardens and the possible contribution he/she can make towards a diversity of knowledge. The Facility Manager and Groundsman are in most cases present and have the highest level of involvement. The facilitators are usually not physically involved in the gardening, but are important in managing the garden practices and ensure the availability of equipment and other resources such as water, fertilisers and seeds. They can also provide expert knowledge about nutrition and alternative agricultural practices that will increase soil health and be more sustainable (Akpalu, 2013; Chappell & LaValle, 2011; Edmondson *et al.*, 2014; Knight *et al.*, 2013; Oldewage-Theron *et al.*, 2004). The re-engineering team can also play a major role in education about childcare, a healthy lifestyle and a balanced, nutritious diet which will also increase the transfer of knowledge and social-networking (Pillay & Barron, 2011). NGO’s and Private companies (usually mining companies of the area) can be financially involved and in some cases they also provided equipment (Manson & Mbenga, 2003). They scarcely contribute knowledge or physical help. The caregivers and Community Works Programme play a dual role, since they do not only physically participate, they also have a special relationship with the community and could transfer their knowledge about gardening (Vawda *et al.*, 2013; Van Pletzen & MacGregor, 2013). This can stimulate reification (to copy information and making it concrete) throughout the community and in this way resilient gardening practices will spread (Krasny & Tidball, 2009; Wenger, 1998). The groundsman, charity workers, patients, Traditional Health Practitioners etc. are the committed workers who maintain the garden on a daily basis and without them the garden would not exist in the first place. They play an important role in social networking and preservation of indigenous knowledge by transferring information from one generation to the

next (Alaimo *et al.*, 2010; Barthel *et al.*, 2010; Peu *et al.*, 2001). Traditional Health Practitioners are especially important in building a good relationship with the community through trade with medicinal plants and keeping the cultural heritage alive (Ndawonde *et al.*, 2007).



Figure 5-8: The roles of the stakeholders involved at health clinic gardens in the Bojanala District Municipality. NGO's and THP's are abbreviations for Non-governmental Organisations and Traditional Health Practitioners respectively.

5.4.4 Themes derived from open questions

Many of the themes that surfaced during interviews reflected something of the cultural background of the stakeholder. Prominent features of the Setswana culture are evident in many clinic gardens as well as in the manner in which the interviewed answered the questions. The concept of an open space around the clinic was very dominant when the stakeholders were asked to describe a garden that is beautiful (Walton, 1956; Molebatsi *et al.*, 2010). One of the groundsman said that he likes a garden that is “clean and well cared for, without weed. It needs to be controlled”. The concept of “clean” was described in several ways. One stakeholder said he wants “no dirt on the flowers” while many others described that the garden should be free

from weeds. Since this is a water scarce area, it was also described as an important feature of a beautiful garden. Plants should be “well watered” and there should be “enough rain”. One groundsman even dreamed of “a pond or a waterfall” in his garden one day. A facility manager also mentioned that “plants such as Aloes” will be a good idea, since they need less water to survive. Many stakeholders said that a beautiful garden will be green and smell nice. One of the stakeholders showed some wisdom on regulating services and said that a beautiful garden gives oxygen. Another facility manager said that a garden is beautiful when you can pray in it which also reflects some of the cultural services the garden provides.

Although literature on this subject is scarce, some references are made to snakes as part of the traditional beliefs of the Setswana-speaking people (Alcock, 2014; Schapera, 1953). The water snake, for instance, is a dangerous supernatural being which should not be offended (Alcock, 2014). Disobedient young women can also be transformed into snakes (Alcock, 2014). There is thus a dominant fear filled respect for snakes which was also evident at health clinic gardens. The open space around Tswana homes (*lebala* (Molebatsi *et al.*, 2010)) are also kept clean to detect snakes easier. It is generally believed that snakes hide in the grass and bushes and it is therefore important to have an open garden with no or very short grass to ensure visibility. Other fears associated with the garden that surfaced were a fear of bees, the damaging potential of roots of big trees and syringe needles lying around in the health clinic garden.

Many stakeholders said that they find joy in watching the plants (especially the vegetables) grow as well as the blooming of flowers in the garden. Traditionally, the Tswana people lived in a much closer relationship with nature as their economy existed mostly of hunting, small scale farming and gardening which made them dependent on nature for their basic needs (Schapera, 1934, 1953; Walton 1956). This theme of biophilia detected in the answers of the stakeholders could be a sign of their original relationship with nature (Tzoulas *et al.*, 2007; Mitchell & Mueller, 2011). The biophilia hypothesis proposes that humans have an innate need to connect with processes occurring in ecosystems (Tzoulas *et al.*, 2007).

Often when the term “garden” was used in the interview, we realised that the stakeholder’s reference to “garden” was only associated with a food garden (vegetables and herbs) and not necessarily with an ornamental garden. In colonial times, modernization and the western culture started to influence the manner in which the Tswana’s arrange plants in their gardens (Davoren *et al.*, 2015). Ornamental plants are part of this intervention of westernization which was not originally part of Tswana gardens (which consisted mostly of natural vegetation and a food garden) (Davoren *et al.*, 2015). At health clinic gardens, most stakeholders stated that if they could improve on their garden, they would like to plant more vegetables and/or fruit trees. The

beauty of the garden was therefore often associated with the amount and quality of food it produces.

It was also striking to hear that many of the stakeholders grew up in an environment where tending to a food garden is part of everyday life. One of the stakeholders responded: “I learned to make a food garden growing up planting in the fields with my grandmother.” Grandparents, parents and even brothers seem to be the inspiration behind maintaining a garden, whether for food or ornamental purposes. Many stakeholders indicated that they learn either from home or from school to make a garden. Some schools even have a programme where children must tend to a certain plot at the school gardens and are evaluated according to the condition of the plot at the end of the semester or year. This is a clear example of social-ecological memory suggested by Barthel *et al.*, (2010) where knowledge of previous generations was preserved in allotment gardens in Sweden by transferring the information to children and grandchildren. One Facility Manager told us that she got her knowledge about gardening by “visiting farms and looking at other farms as well as with reading”. This also emphasises how important role the community plays in distributing information and inspiring others to copy what they have seen elsewhere (reification) (Barthel *et al.*, 2010; Bendt *et al.*, 2013; Chan *et al.*, 2015; Jongerden *et al.*, 2014; Wenger, 1998).

5.5. Conclusion

Ecosystem services were conventionally divided into four different categories namely: provisioning services, regulating services, supporting services and cultural services (Millennium Ecosystem Assessment (MEA), 2005), but with further investigation, Chan *et al.* (2012), Chan *et al.* (2012 a) and Daniel *et al.* (2012) realised that all ecosystem services actually exist within a cultural sphere. This means that every ecosystem service is perceived from a certain cultural perspective and has therefore cultural value (Daniel *et al.*, 2012). Culture plays an intricately important role in the livelihoods of humans and therefore it also contributes to the relationship between humans and the environment. It is also central to communities of practice since it is part of how humans perceive their own identity, the manner in which they participate, socialise and interact with other people. It is thus essential to understand the relationships between humans as well as the relationship between humans and nature within the community (which are formed by cultural aspects and contribute to the creation of the community of practice).

Some of the above results are a confirmation of Chan *et al.*'s (2012) statement that all ecosystem services have a layer of cultural value which increases or decreases in importance according to the stakeholder's relationship with the community and his/her background. When considering the culture and background of the ethnic groups which originally lived in the

Bojanala District, it makes sense that food and sense of place (as well as the spiritual value of the garden) were considered as the most important ecosystem services of clinic gardens.

From a community of practice perspective, clinic gardens provide an excellent opportunity for sustainable garden practices to be implemented and also to be considered throughout the community (Table 5-5). The mind-set embedded in the Tswana culture of this region is already tuned to the concept of using nature to provide in the basic needs of the people. With the interplay of participation and reification at clinic gardens, people's identification with their culture and social learning, the path to creating a more resilient clinic garden and community, is paved.

Table 5-5: The manner in which communities of practice are fostered in home gardens versus health clinic gardens (adapted from Taylor & Lovell, (2014))

Home gardens as communities of practice (adapted from Taylor & Lovell 2014)	Health clinic gardens as communities of practice
Communities of practice are established by gardeners (Barthel et al., 2010).	Different stakeholders involved at the clinic garden form a community of practice.
Reification and reproduction of social-ecological knowledge and practices obtain tangibility through the creation of home gardens (Barthel et al., 2010).	Physical expression of social-ecological knowledge and practices takes place at health clinic gardens.
Sense of place is created through home gardens which also contribute to the atmosphere of the neighbourhood (Holland, 2004; Sinew et al., 2004).	Health clinic gardens create the opportunity for stakeholders to express their identity and boost their self-esteem by contributing to a successful project.
Social networking between gardeners and gardeners and non-gardeners are fostered by home gardens (Calvet-Mir et al., 2012; Glover, 2004).	Sharing of food and knowledge at health clinic gardens foster social networking.
Home gardens foster cross-cultural understanding (Glover, 2004; Kingsley and Townsend, 2006).	Health clinic gardens create a safe and neutral setting where different social groups can freely interact which enhance respect between cultures.
Values and passion about gardening are shared at home gardens and enhance social cohesion (Glover, 2004; Kingsley and Townsend, 2006).	Mutual goals and interest in gardening at health clinic gardens promotes social cohesion.

Chapter 6 - Best practice health clinic gardens



CHAPTER 6 – BEST PRACTICE HEALTH CLINIC GARDENS

6.1 Introduction

In this chapter a subset of health clinic gardens are identified which has the most potential to increase resilience. These best practice health clinic gardens are therefore representations of gardens where a diverse set of social, physical and ecological aspects exists so that they have the ability to adapt when disturbances (such as drought, poverty and a lack of nutrition security) occur (Redman *et al.*, 2004; Walker *et al.*, 2004). They also contribute to community resilience by providing a space where food can be sustainably supplied, where communication between the community and health workers are facilitated, where information on health issues and gardening are shared, where co-learning takes place between diverse stakeholders with various skills, knowledge and backgrounds and where co-production of knowledge can stimulate innovation toward more sustainable food supply (King, 2008; Okvat & Zautra, 2011; Tengö *et al.*, 2014). The purpose of best practice health clinic gardens is also to represent a community of practice where participation and reification interact in a social-ecological system and social-ecological memory is created (Barthel *et al.*, 2010; Krasny & Tidball, 2009). As participation between the different stakeholders occurs, sustainable gardening practices at the health clinic gardens become a mutual enterprise where shared knowledge are taken home and have the potential to be reified elsewhere in the community (Barthel *et al.*, 2010; Marianne E Krasny & Tidball, 2009). In this way knowledge are spread and transferred to the next generation, causing social-ecological memory to be established (Barthel *et al.*, 2010).

The best practice health clinic gardens will be identified by three different aspects namely diversity of natural, social and physical resources as well as positive perceptions towards ecosystem services provided by the gardens.

According to Kent (2012), highly disturbed areas (such as in the urban environment) are often characterised by physiognomic data (data describing the external morphology (life-form, growth form, stratification and size) of the species present) containing a wide diversity of life-forms. The morphology (e.g. Raunkiaer's life-forms) of plant species also influences the way in which they function in an ecosystem. Each plant species has therefore certain functional traits which contribute to the functional diversity of the garden ecosystem. When there are many species in each functional group (functional redundancy), there will always be some species to maintain the functions within the system if some are lost in the case of a disturbance (Elmqvist *et al.*, 2003). Functional diversity therefore enhances resilience within a system by reducing the risk that a specific ecosystem function becomes lost in damaged systems (Colding & Barthel, 2013). This will also enhance response diversity which means that each of the species in the functional

group reacts different to a disturbance and will therefore create various levels of absorbance (Colding *et al.*, 2003; Colding & Barthel, 2013). Biodiversity and response diversity (functional diversity and redundancy) are essential in maintaining the resilience of an ecosystem (Colding & Barthel, 2013; Elmqvist *et al.*, 2003). Utilitarian plants also contribute to plant diversity in an ecosystem and are important to improve the livelihood of the community (Cilliers & Siebert, 2012; Lubbe *et al.*, 2010; Pandey *et al.*, 2007).

A diversity of physical resources will also contribute to the adaptive capacity of health clinic gardens. When a wide range of sources for water supply infrastructure, gardening equipment and seed supply exist, the ability of gardens to keep their functions when some of the sources are damaged or lost will be improved (Fabricius & Collins, 2007). Social diversity contributes to the ability of a system to adapt to change and unpredicted circumstances, to reorganise itself and to integrate various kinds of knowledge for learning such as expert knowledge and traditional knowledge, improving the resilience of the system (Camps-Calvet *et al.*, 2015; Colding & Barthel, 2013).

It is also important to nurture positive perceptions on ecosystem services at health clinic gardens. A person with a positive perception adds value to the system. Positive attitudes can be contagious and grant someone the ability to be a “champion” which is someone who enhances social cohesion and civic engagement (Fabricius & Collins, 2007; Koester *et al.*, 2006; Tsegay & Rusare, 2014) and motivates the community members to take responsibility for resilient gardening practices.

6.2 Methods

Three aspects of health clinic gardens were taken into consideration to identify the best practice gardens namely, physiognomic and floristic diversity, physical and social resources diversity and perceptions of ecosystem services and disservices of various stakeholders. Data of the previous result chapters were used and analysed in more detail to identify specific health clinic gardens. It is important to note that clinics are only compared in relation to each other and in relation to each local municipality. This means that even though a clinic might obtain a high score for either of these attributes, it does not mean that this clinic is in an ideal condition.

The following aspects were taken into consideration for each health clinic garden (the clinic with the highest count was identified):

6.2.1 Physiognomic and floristic diversity

- Number of different life-forms (based on Raunkiaer’s description (Kent, 2012))

- Number of different growth forms (trees, tree succulents, shrubs, shrub succulents, herbs, herb graminoids, herb succulents, climbers)
- Number of different plant species
- Number of species with different potential uses (ornamental, food (including african leafy vegetables, edible fruit, tubers or rhizomes, grain, fruit trees, leafy vegetables, spice or herbs, vegetables and roots used for coffee or as yeast), shade, hedge, medicinal uses and other (including uses in producing wooden handles for tools, brooms, hats, string, toothbrushes and perfume, dye for leather or wood, thatch grass and spiritual uses) (Sources of this information is as in Chapter 3).

6.2.2 Physical and social resources diversity

- Diversity of physical resources
 - Problem with water supply (yes = 0; no = 1)
 - Water supply infrastructure (tap, borehole, plastic /metal tank)
 - Irrigation methods (hose pipe, fixed irrigation system, water bucket, flooding)
 - Fertilising (presence of compost/manure or both)
 - Gardening equipment (spade, fork, rake, axe/pick, wheel barrow, lawn mower, grass cutter, saw, pruning shears, netting)
 - Number of sources of seeds (bought by responsible persons, donations, own nursery, provided by local municipality management, Royal Bafokeng or mine companies (LONMIN))
 - Available space in square meters (includes paving and bare soil (Lebala))
- Diversity of social resources
 - Stakeholders diversity (number of different categories of stakeholders – facility manager, groundsmen, caregivers, CWP, NGO's, charity workers, re-engineering team, community health workers, traditional health practitioners, experts, private companies, patients)
 - Stakeholder abundance (number of stakeholders over all categories)
 - Days per month spent in the garden
 - Level of knowledge on gardening (no experience = 1; basic experience = 2; intermediate knowledge = 3; advanced training = 4)

6.2.3 Perceptions of ecosystem services and disservices

As mentioned in chapter 5, perceptions of the stakeholders were rated by using a Likert scale from 1 to 5 where 1 indicates strong disagreement and 5 indicates strong agreement. The average perception of all stakeholders in each clinic on ecosystem services and disservices

were calculated and disservices were subtracted from services since it represents a negative perception.

6.2.4 Consolidation of data

Each health clinic garden was given a score for all three aspects respectively (information was based on Chapters 3-5) and its position in the local municipality in relation with the other health clinic gardens was determined. The health clinic gardens were then ranked from highest to lowest scores (for all three aspects) in the local municipality. The total area cover of the health clinic gardens was also taken into consideration. The sum of each health clinic garden's ranking in each of the categories (natural, physical and social resources as well as the perceptions of ecosystem services) was then used to indicate the health clinic garden's ranking position in the local municipality with all three aspects combined. Health clinic gardens with the lowest scores (sum of rankings in each aspect and not total score for each aspect) therefore indicated the highest ranking position in comparison with other health clinic gardens in the local municipality.

This ranking position was divided with the total number of health clinic gardens in the local municipality to make the scores of the health clinic gardens comparable with other local municipalities. Health clinic gardens with the best ranking (highest positions) in Bojanala District Municipality were then identified as best practice clinics.

All of the analyses were done in MS Excel (Excel, (2013)).

6.3 Results

Population sizes of villages were also added in the result tables to give an indication of the number of potential individuals that can be served by the clinic.

6.3.1 Rustenburg Local Municipality

The three health clinic gardens with the highest ranking in Rustenburg Local Municipality were: Reagile Clinic (population = 17157), Monakato (population = 8076) and Tlhabane CHC (population = 50073). Tlhabane had a lower ranking score for plant species composition, Monakato for physical and social resources and Reagile also for plant species composition (Figure 6-1). All three clinics had positive scores toward perceptions on ecosystem services in relation to each other. As seen in Table 6-1 Reagile Clinic is actually classified in Kgetlengrivier Local Municipality. As explained in Chapter 1, only one clinic in Kgetlengrivier Local Municipality could be surveyed and data of this clinic was therefore merged with Rustenburg Local Municipality for statistical analysis.

Table 6-1: Health clinic gardens with the highest ranking in Rustenburg Local municipality

Clinic Number	Local Municipality	Clinic Name	GPS Coordinates	Total Population in village	Position	Ranking score according to position in local municipality for all aspects
105	Kgetlengrivier	Reagile (Koster) Clinic	S25 50.961 E26 53.027	17157	1	12
9	Rustenburg	Monakato	S25 21.480 E27 16.557	8076	2	19
2	Rustenburg	Tlhabane CHC	S25 38.308 E27 12.975	50073	3	21
60	Rustenburg	Boitekong	S25 36.790 E27 18.875	79786	4	21
7	Rustenburg	Rankelenyane	S25 34.337 E27 25.737	1502	5	22
4	Rustenburg	Thekwane	S25 40.167 E27 22.220	2665	6	23
17	Rustenburg	Chaneng	S25 24.800 E27 07.458	4529	7	23
12	Rustenburg	Luka	S25 30.296 E27 10.909	15350	8	25
14	Rustenburg	Kana	S25 34.374 E27 18.196	10907	9	28
15	Rustenburg	Hartbeesfontein	S25 26.290 E27 30.253	26337	10	29

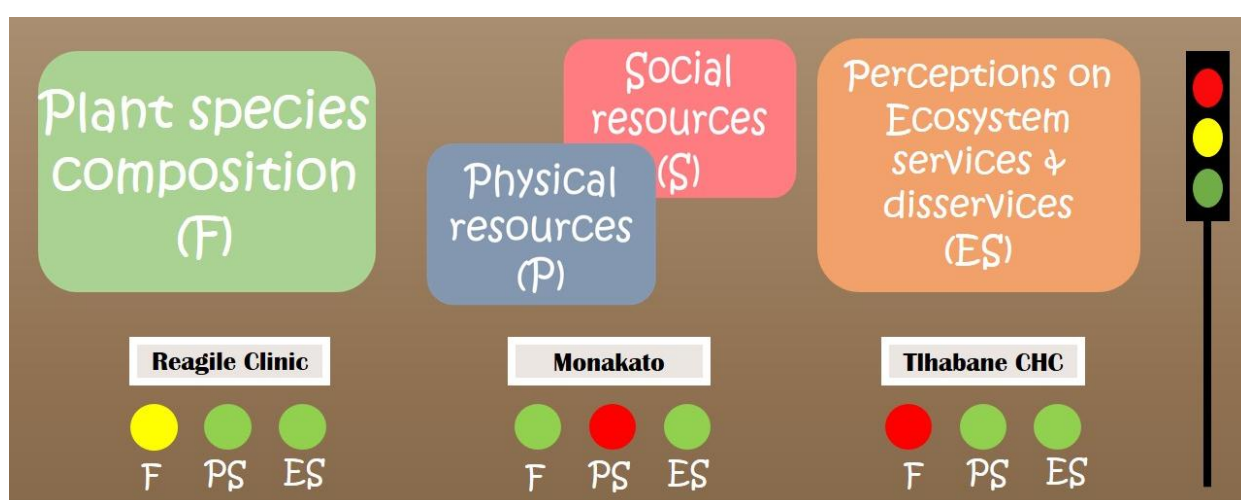


Figure 6-1: Health clinic gardens with the highest ranking in Rustenburg Local Municipality

6.3.2 Moses Kotane Local Municipality

The three health clinic gardens with the highest ranking in Moses Kotane Local Municipality were: Phalane (population = 7583), Linchwe (population = 7493) and Witrandjies (population = 2149) (Table 6-2). Perceptions on ecosystem services and resource (physical and social) diversity were aspects with a lower ranking score at Witrandjies, Linchwe also performed weaker in physical and social resources and Phalane had a lower ranking score for plant species composition (Figure 6-2).

Table 6-2: Health clinic gardens with the highest ranking in Moses Kotane Local Municipality

Clinic Number	Local Municipality	Clinic Name	GPS Coordinates	Total Population in village	Position	Ranking score according to position in local municipality for all aspects
35	Moses Kotane	Phalane	S25 15.875 E26 50.623	7583	1	38
49	Moses Kotane	Linchwe	S24 48.215 E26 59.770	7493	2	40
18	Moses Kotane	Witrاندjiees	S25 16.455 E26 54.480	2149	3	44
47	Moses Kotane	Madikwe	S25 21.245 E26 31.820	3623	4	46
57	Moses Kotane	Dwarsberg	S24 56.308 E26 37.029	781	5	46
45	Moses Kotane	Modderkuil	S25 07.445 E27 11.855	16851	6	47
19	Moses Kotane	Welverdiend	S24 56.108 E26 43.567	795	7	48
27	Moses Kotane	Silwerkrans	S25 29.623 E26 37.494	11250	8	51
40	Moses Kotane	Montsana	S25 06.023 E26 35.110	68	9	51
66	Moses Kotane	Koedoesrand	S25 14.870 E26 40.123	2938	10	51

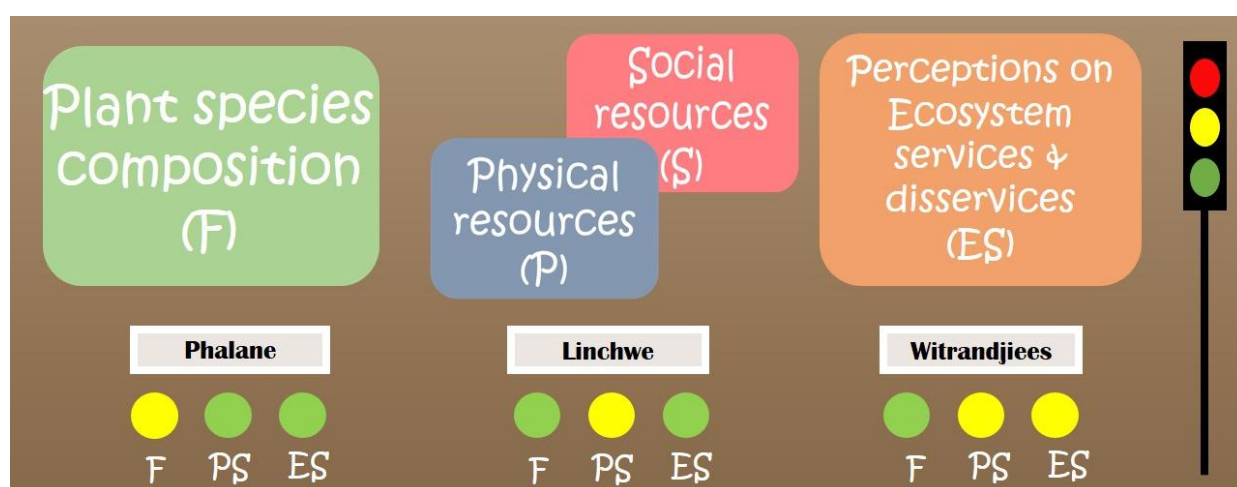


Figure 6-2: Health clinic gardens with the highest ranking in Moses Kotane Local Municipality

6.3.3 Madibeng Local Municipality

The three health clinic gardens in Madibeng Local Municipality with the highest ranking were: Damonsville (population = 3969), Moiletsoane (population = 1556) and Rabolaka (population = 5700) (Table 6-3). Lower scores in comparison with other health clinic gardens were resource diversity (physical and social) at Rabolaka and plant species composition at Moiletsoane (Figure 6-3).

Table 6-3: Health clinic gardens with the highest ranking in Madibeng Local Municipality

Clinic Number	Local Municipality	Clinic Name	GPS Coordinates	Total Population in village	Position	Ranking score according to position in local municipality for all aspects
100	Madibeng	Damonsville	S25 37.533 E27 51.120	3969	1	5
89	Madibeng	Moiletsoane	S25 23.126 E27 55.758	1556	2	24
116	Madibeng	Rabokala	S25 31.537 E27 53.584	5700	3	24
117	Madibeng	Refentse	S25 16.651 E27 56.202	917	4	24
98	Madibeng	Hartbeespoort	S25 43.691 E27 52.714	22374	5	28
101	Madibeng	Broederstroom	S25 25.709 E27 51.617	31113	6	29
90	Madibeng	Majakaneng	S25 44.452 E27 40.347	22683	7	31
94	Madibeng	Jericho	S25 20.844 E27 49.225	8612	8	33
112	Madibeng	Letlhabile	S25 29.088 E27 50.598	41334	9	33
87	Madibeng	Oukasie	S25 36.580 E27 48.193	27907	10	34

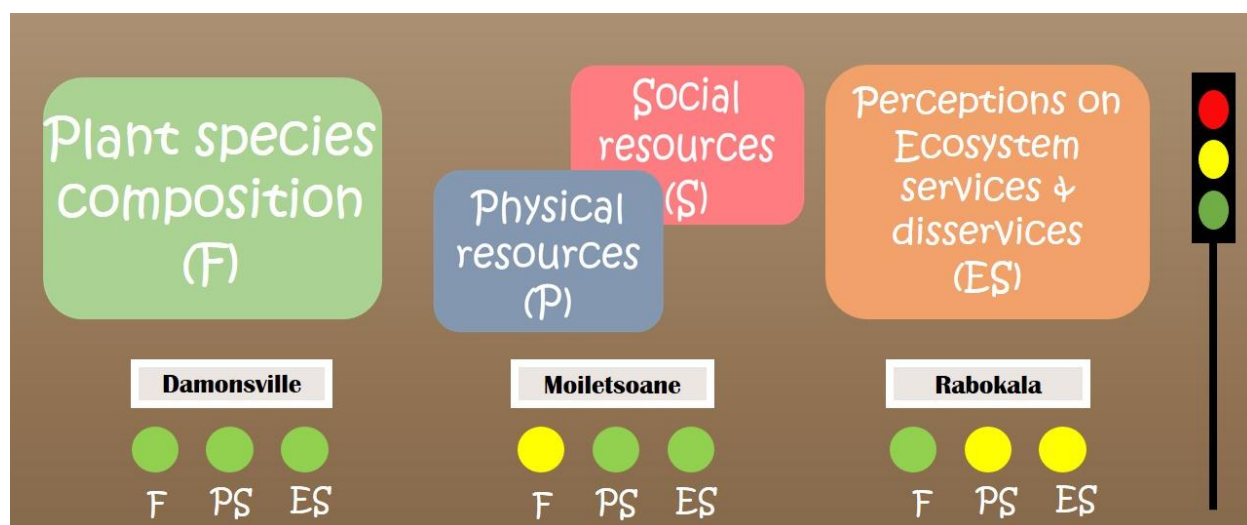


Figure 6-3: Health clinic gardens with the highest ranking in Madibeng Local Municipality

6.3.4 Moretele Local Municipality

The three health clinic gardens with the highest ranking in Moretele Local Municipality were: Leseding (population = 2996), Rugtesloot (population = 2455) and Relebogile (population = 3494) (Table 6-4). Both Relebogile and Rugtesloot scored lower for resource diversity (physical and social) and Relebogile had more negative perceptions on ecosystem services and Rugtesloot had a lower ranking score for plant species composition (Figure 6-4).

Table 6-4: Health clinic gardens with the highest ranking in Moretele Local Municipality

Clinic Number	Local Municipality	Clinic Name	GPS Coordinates	Total Population in village	Position	Ranking score according to position in local municipality for all aspects
78	Moretele	Leseding/Dertig	S25 17.298 E28 13.588	2996	1	9
70	Moretele	Rugtesloot	S25 01.674 E27 51.182	2455	2	21
71	Moretele	Relebogile(Ngobi)	S25 01.584 E28 05.294	3494	3	25
72	Moretele	Ratjiepane	S25 19.946 E28 05.316	4215	4	25
74	Moretele	Mogogelo	S25 21.091 E28 08.664	11425	5	26
82	Moretele	Kgomokgomo	S25 09.252 E28 04.504	1932	6	27
108	Moretele	Kromkuil/Mpho	S25 23.257 E28 03.131	3164	7	27
76	Moretele	Mathibestad	S25 16.213 E28 10.554	25945	8	28
79	Moretele	Lefatlheng	S25 16.917 E28 12.478	2996	9	28
83	Moretele	Ga-Motla	S25 21.542 E28 03.420	13001	10	28

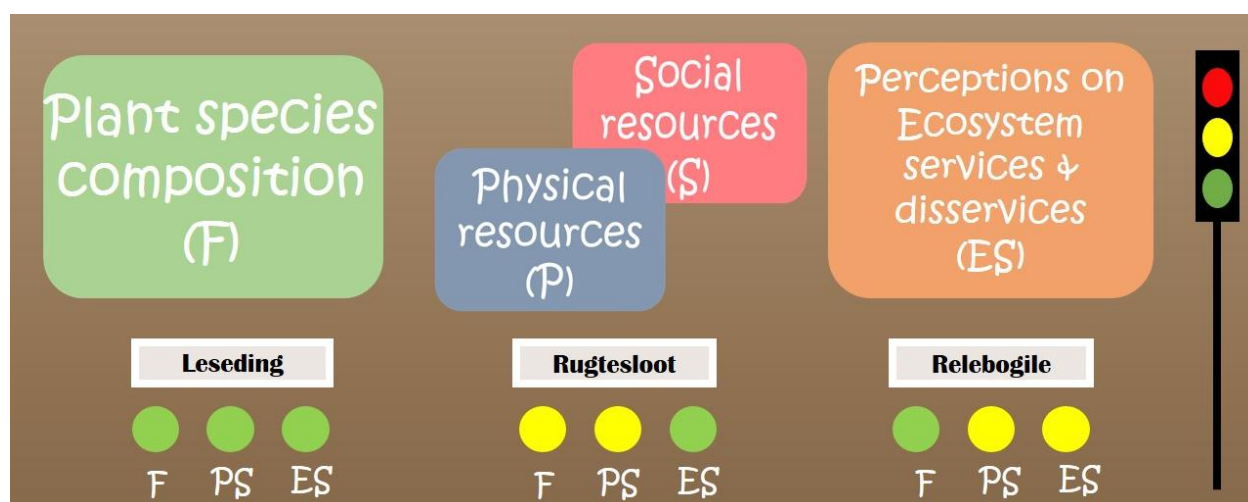


Figure 6-4: Health clinic gardens with the highest ranking in Moretele Local Municipality

6.3.5 Bojanala District Municipality

The three health clinic gardens with the highest ranking in Bojanala District Municipality of the North-West Province were: Damonsville (population = 3969 - Madibeng), Leseding (population = 2996 - Moretele) and Reagile Clinic (population = 17157 - Kgetlengrivier) (Table 6-5). When the scores of these three best practice clinics are compared across local municipalities, Leseding scored lower for plant species composition and perceptions on ecosystem services (Figure 6-5). Reagile had a lower ranking score for social and physical resources (Figure 6-5).

Table 6-5: Health clinic gardens with the highest ranking in Bojanala District Municipality

Clinic Number	Local Municipality	Clinic Name	GPS Coordinates	Total Population in village	Position	Ranking score according to position in local municipality/ the total health clinic gardens in the district
100	Madibeng	Damonsville	S25 37.533 E27 51.120	3969	1	0,23
78	Moretele	Leseding/Dertig	S25 17.298 E28 13.588	2996	2	0,41
105	Rustenburg	Reagile (Koster) Clinic	S25 50.961 E26 53.027	17157	3	0,71
35	Moses Kotane	Phalane	S25 15.875 E26 50.623	7583	4	0,88
49	Moses Kotane	Linchwe	S24 48.215 E26 59.770	7493	5	0,93
70	Moretele	Rugtesloot	S25 01.674 E27 51.182	2455	6	0,95
18	Moses Kotane	Witrandjies	S25 16.455 E26 54.480	2149	7	1,02
47	Moses Kotane	Madikwe	S25 21.245 E26 31.820	3623	8	1,07
57	Moses Kotane	Dwarsberg	S24 56.308 E26 37.029	781	9	1,07
89	Madibeng	Moiletsoane	S25 23.126 E27 55.758	1556	10	1,09

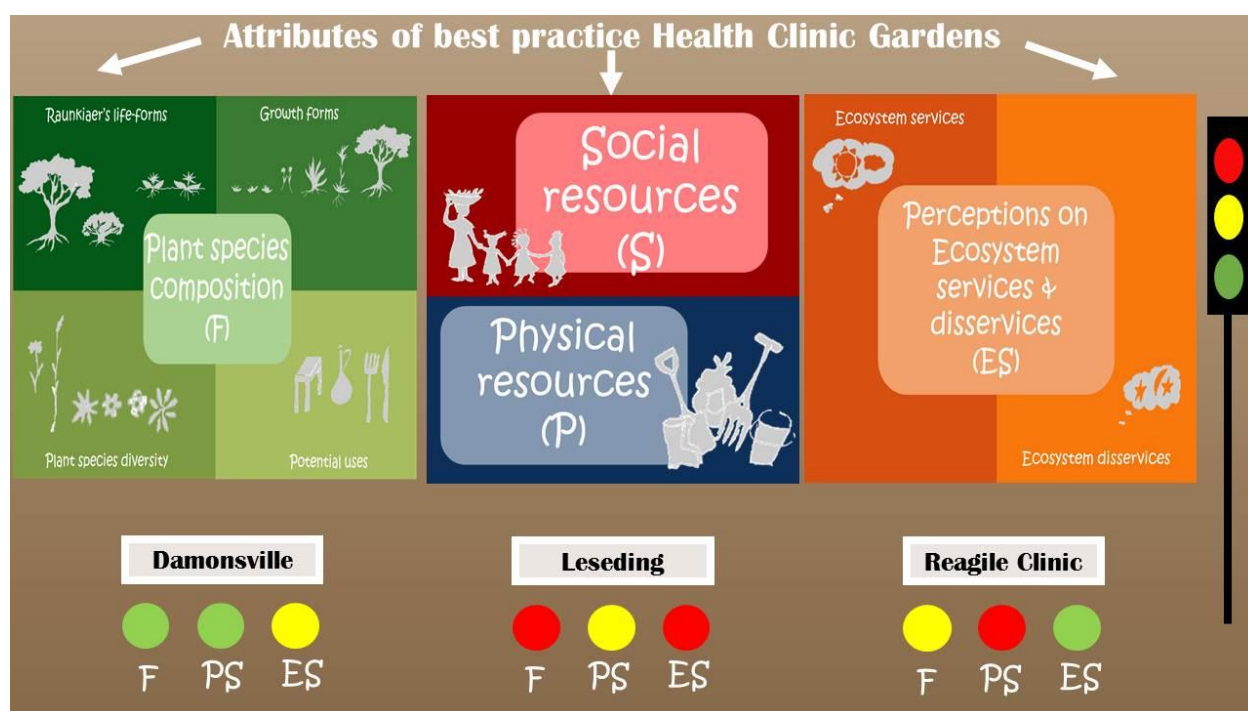


Figure 6-5: Health clinic gardens with the highest ranking in the Bojanala District Municipality

6.4 Discussion

As seen in Figure 6-1 - Figure 6-5, red and yellow circles indicate aspects at the health clinic gardens that need more attention, although this does not mean that the green scored attributes should be neglected.

6.4.1 Rustenburg Local Municipality

Tlhabane is a community health centre (described in Chapter 1) which is usually situated on a larger property and serves a greater number of people (50073). A large portion of the garden

consists of *Naga* (natural vegetation) and therefore the number of useful species is less than cultivated gardens. It is therefore recommended that more attention should be given to cultivated gardens to improve species diversity as well as enhance the usefulness of the gardens for nutrition and health purposes (Colding & Barthel, 2013; Elmqvist *et al.*, 2003; Lubbe *et al.*, 2011).

There is a lack of gardening equipment at Monakato Clinic and although the area for gardening is smaller, great potential still exists in the available space. There is, however, much room for improvement on the social diversity. Only two stakeholders are involved at the garden and it will be greatly beneficial to have a greater diversity of physical help and knowledge to improve the condition of the garden (Camps-Calvet *et al.*, 2015; Colding & Barthel, 2013; Tengö *et al.*, 2014).

Species with potential uses and diversity of plant species also lack at Reagile Clinic. Since there is a much smaller area for gardening at this clinic with much less available space, one should plan carefully and use crop-rotation methods (Chappell & LaValle, 2011; Elmqvist *et al.*, 2013) to improve the garden.

6.4.2 Moses Kotane Local Municipality

At Witrandjies Clinic there is a problem with water supply. As mentioned in Chapter 4, South Africa is rated as one of the 30 driest countries in the world and water scarcity in the North-West Province resulted in a severe drought during 2015 (Government Communications, 2015). Of all the clinics surveyed in Bojanala District, 57% have indicated that water supply is often deficient. It is, therefore, crucial that management of water resources should become a top priority at the district offices and available resources should be equally distributed, since the functioning of the clinic and clinic gardens are directly affected by the availability of water. As mentioned in Chapter 4, it is also important to improve relationships with local government, facility managers and community members to enhance communication and social cohesion which will develop better solutions and more accurate service delivery (Fabricius & Collins, 2007). Alternative ways to exploit available water sources should also be explored such as “play pumps” where a roundabout can play a dual role – entertaining children while pumping water from a borehole (UNICEF 2007). Since only basic knowledge of gardening exists at Witrandjies Clinic, education on gardening will also greatly benefit the condition of the garden (Krasny & Tidball, 2009; Ndawonde *et al.*, 2007). Gardening knowledge and education on benefits derived from nature can also help to change the stakeholders’ perception of ecosystem services to be more positive (Krasny & Tidball, 2009; Ndawonde *et al.*, 2007).

Knowledge is also crucial at Linchwe Clinic since available space is scarce and specialised knowledge on soil management and crop rotation will be greatly advantageous (Faber *et al.*, 2011; Guitart *et al.*, 2012; Chappell & LaValle, 2011).

It is also recommended that Phalane Clinic should give more attention to species diversity to improve functional diversity and redundancy enhancing the ability of the garden to respond to sudden disturbances (Colding & Barthel, 2013; Elmqvist *et al.*, 2003; Lubbe *et al.*, 2011).

6.4.3 Madibeng Local Municipality

Rabokala Clinic also have a problem with water supply and the same can be recommended for this clinic as Witrandjies Clinic - improving communication between facility managers and managing authorities to ensure equal distribution of available water resources (Fabricius & Collins, 2007) and exploring new ideas for exploiting available water sources such as play pumps (UNICEF, 2007).

Moiletsoane clinic scored lower for plant species diversity and utilitarian species. As mentioned before, by planting a higher diversity of species one can improve the ability of the garden to respond to disturbances which will contribute to a more sustainable harvest from the garden (Colding & Barthel, 2013). Knowledge on indigenous species with potential uses should be embraced and shared between communities by holding workshops and regular meetings (Ndawonde *et al.*, 2007).

Damonsville Clinic competed well regarding all aspects (natural, social and physical diversity of resources) and it will be recommended that future management should embrace this fact by ensuring that none of these aspects is neglected in any way.

6.4.4 Moretele Local Municipality

The attitude towards ecosystem services at Relebogile Clinic Garden is more negative than at the other clinics. Knowledge of nature and the benefits of community gardens for health and nutrition can help to broaden the perspective of the stakeholders involved in the garden (Barthel *et al.*, 2010; Chappell & LaValle, 2011). Workshops on gardening, indigenous species with potential uses and nutrient content of vegetables can cultivate a positive attitude and newly inspired enthusiasm at the clinic garden.

More attention should be given to gardening equipment and fertiliser at Rugtesloot Clinic. Alternative options such as producing compost from organic waste from the garden and the clinic should be further explored, since it can also provide habitat for some invertebrates that will not be found in other parts of the garden and stimulate recycling of material at the clinic (Smith

et al., 2006). It will also be beneficial for response diversity at the clinic garden to improve the plant species diversity (Colding & Barthel, 2013; Elmqvist *et al.*, 2003; Lubbe *et al.*, 2011).

At Leseding Clinic more attention should be given to plant species diversity and the number of plant species with potential uses in the cultivated garden and stakeholders should be educated on the benefits of nature to broaden their perspective on ecosystem services (Colding & Barthel, 2013; Chappell & LaValle, 2011; Lubbe *et al.*, 2011).

6.4.5 Bojanala District Municipality

By comparing the clinics with the highest ranking of all the local municipalities, results showed that Damonsville, Reagile and Leseding have the most potential for increasing resilience. Leseding Clinic had a lower score for plant species composition and perceptions on ecosystem services and at Reagile Clinic more attention should be given to physical and social resources. Compared to the other clinics, Damonsville Clinic performed the best in all the categories. Since there is no norm to compare the health clinic gardens with, Damonsville Clinic can only be seen as the most effective garden. All the clinics were compared in relation to each other and therefore results give only insight on which clinics have the most potential to become part of a resilient system. It is, therefore, these clinics that will serve as a starting point – a place where management authorities should invest and mobilize the current resources (natural, social and physical) to achieve its full potential.

6.5 Conclusion

A summary of recommendations are given in Table 6-6 explaining how the potential of each best practice health clinic garden can be improved in future management plans.

Table 6-6: Summary of results on best practice health clinic gardens

Clinic Name	Local Municipality	Aspects that need attention	Recommendations	Literature
Tlhabane CHC	Rustenburg	Diversity of plant species; species with potential uses.	Improve the number of plant species in cultivated gardens.	Colding & Barthel 2013; Elmqvist <i>et al.</i> 2003; Lubbe <i>et al.</i> 2011
Monakato Clinic	Rustenburg	Gardening equipment; stakeholder diversity	Get more stakeholders involved which will be willing to contribute to the number of equipment currently available	Camps-calvet <i>et al.</i> 2015; Colding & Barthel 2013; Tengö <i>et al.</i> 2014
Reagile Clinic	Rustenburg (Kgetlengrivier)	Diversity of plant species; species with potential uses; available space	Improve the number of plant species in cultivated gardens and use alternative gardening methods (crop rotation) for optimal use of small space	Colding & Barthel 2013; Elmqvist <i>et al.</i> 2003; Lubbe <i>et al.</i> 2011; Chappell & LaValle 2011; Elmqvist <i>et al.</i> 2013

Table 6-6 continues

Clinic Name	Local Municipality	Aspects that need attention	Recommendations	Literature
Witrandsjees Clinic	Moses Kotane	Water supply; gardening knowledge; perceptions on ecosystem services	Improving communication between facility managers and managing authorities; exploring new ideas for exploiting available water sources such as playpumps. Broaden the perspective of the stakeholders by improving their knowledge of nature and the benefits of community gardens for health and nutrition.	Fabricius & Collins, 2007; UNICEF 2007; Barthel et al. 2010; Chappell & LaValle 2011
Linchwe Clinic	Moses Kotane	Gardening knowledge; available space	Improve knowledge on soil management and crop rotation	Faber et al. 2011; Guitart et al. 2012; Chappell & LaValle 2011
Phalane Clinic	Moses Kotane	Plant species diversity; species with potential uses	Improve the number of plant species in cultivated gardens.	Colding & Barthel 2013; Elmqvist et al. 2003; Lubbe et al. 2011
Rabokala Clinic	Madibeng	Water supply	Improving communication between facility managers and managing authorities; exploring new ideas for exploiting available water sources such as playpumps	Fabricius & Collins, 2007; UNICEF 2007
Moiletsoane Clinic	Madibeng	Plant species diversity; species with potential uses	Improve the number of plant species in cultivated gardens.	Colding & Barthel 2013; Elmqvist et al. 2003; Lubbe et al. 2011
Damonsville Clinic	Madibeng	Competed well on all aspects, but care should be taken not to neglect any of these aspects in future	Monitor and manage natural, physical and social resources in such a way that none are neglected	
Relebogile Clinic	Moretele	Perceptions on ecosystem services	Broaden the perspective of the stakeholders by improving their knowledge of nature and the benefits of community gardens for health and nutrition.	Barthel et al. 2010; Chappell & LaValle 2011
Rugtesloot Clinic	Moretele	Plant species diversity; species with potential uses; gardening equipment; fertilizer	Improve the number of plant species in cultivated gardens. Explore alternative options such as producing compost from organic waste from the garden and the clinic which also stimulate recycling.	Colding & Barthel 2013; Elmqvist et al. 2003; Lubbe et al. 2011; Smith et al. 2006
Leseding Clinic	Moretele	Plant species diversity; species with potential uses; Perceptions on ecosystem services	Improve the number of plant species in cultivated gardens. Broaden the perspective of the stakeholders by improving their knowledge of nature and the benefits of community gardens for health and nutrition.	Colding & Barthel 2013; Elmqvist et al. 2003; Lubbe et al. 2011; Barthel et al. 2010; Chappell & LaValle 2011

From the results it seems that health clinic gardens mainly need to improve on plant species diversity. The main categories of utilitarian plant species in health clinic gardens (identified in

Chapter 3) are food, medicinal and ornamental. More plant species with these uses should be cultivated and care should be taken to increase the diversity of these species – especially the plant species with nutritional value such as ALV's (*Amaranthus spp.*, *Cleome gynandra*, *Vigna unguiculata*, *Cucurbita maxima*, *Citrullus lanatus* etc. (Faber *et al.*, 2002; Faber *et al.*, 2010; Van Jaarsveld *et al.*, 2014)). These species are particularly valuable in the sense that they need low maintenance and less water and fertiliser than the alternative edible species. It is therefore a great opportunity and crucial to spread the knowledge about these species. This also accentuates the importance to embrace indigenous knowledge containing information about these species.

The available social and physical resources at health clinic gardens are also fundamental in building adaptive capacity (Camps-Calvet *et al.*, 2015). Networks between social systems and the number of stakeholders involved at health clinic gardens can have a great influence on the access to physical resources. As explained in Chapter 4, the diversity and abundance of social resources increase the number of opportunities and therefore also create a window of opportunity to a diversity of physical resources. Resources such as water supply for instance, are highly dependent on the management authorities to maintain infrastructure and ensure regular delivery. Being an assembly point in the community, health clinic gardens contain enormous potential to facilitate new ideas, knowledge and involvement of stakeholders creating an opportunity for a greater diversity of physical resources to be gathered (Tengö *et al.*, 2014). It is a rich learning environment with the ability to create adaptive capacity by transferring knowledge to future generations and equipping them to respond better to disturbances and crises (Barthel *et al.*, 2010; Camps-Calvet *et al.*, 2015).

It is also important to support the different perceptions of the stakeholders on ecosystem services cultivating a community of practice at health clinic gardens (Bendt *et al.*, 2013). Both negative and positive ideas can contribute to provide new knowledge and perspective on the problems that may occur (Tengö *et al.*, 2014). Knowledge plays an important role in shaping perceptions of nature and human interactions with nature and should be the main focus of management authorities to enhance an awareness of the benefits and opportunities nature can provide.

Since health clinics are associated with healing, it is the perfect location to provide opportunities to alleviate nutrition deficiencies and poverty. Health clinics give access to the most vulnerable people in the community and are therefore the ideal starting point to build resilience in the community.

Chapter 7 - Conclusion

“Differences are not intended to separate, to alienate. We are different precisely in order to realize our need of one another.”

— Archbishop Desmond Tutu



CHAPTER 7 – CONCLUSION

7.1 Introduction

In this study, three main aspects of health clinic gardens were studied: the natural resource diversity, physical and social resource diversity as well as stakeholder perceptions on ecosystem services and disservices.

Health clinic gardens were successfully compared with peri-urban and urban domestic gardens and rural home gardens in the North-West Province and the results showed that the floristic and physiognomic diversity at health clinic gardens was similar. Only small differences occurred, such as less ornamental species were found in health clinic gardens as well as less endangered and protected plant species. The plant species composition and cover abundance were also compared across the different local municipalities and no significant differences could be found. The micro-gardens in health clinic gardens were also compared and the naga contained the greatest number of plant species and growth forms as well as a larger number of native plant species. The aim to determine the plant species composition, floristic and physiognomic diversity at health clinic gardens was therefore reached.

Comparison of the physical and social resources at the different local municipalities indicated that Moses Kotane and Moretele Local Municipalities have a greater diversity of these resources than Rustenburg and Madibeng Local Municipalities. Rustenburg Municipality needs to improve the supply of physical resources and Madibeng Local Municipality needs to increase the number of stakeholders involved at the health clinic gardens. The aim to compare the different local municipalities according to physical and social resource diversity was therefore reached and recommendations were made.

The perceptions of the different stakeholders on ecosystem services and disservices at health clinic gardens were also determined. Results indicated that opinions on ecosystem services and disservices can greatly differ from one person to the next and that each person has a unique contribution to make through their involvement at health clinic gardens. Every stakeholder plays a different role and is important for the existence and maintenance of the garden.

A subset of best practice health clinic gardens was also determined by using a scoring system in which the health clinic gardens were ranked from lowest to highest scores in each local municipality as well as in the Bojanala District Municipality.

These best practice clinics can serve as a starting point for developing a management strategy to ensure a more resilient system of health clinic gardens. Several aspects of health clinic

gardens were identified (Table 7-1) which can contribute to resilience-building strategies (Folke *et al.*, 2003) that can be used to manage the health clinic gardens in the local municipalities of Bojanala District Municipality.

The main aim of this study was to determine whether health clinic gardens have the potential to alleviate the nutrition deficiency in the Bojanala District Municipality. Results showed that a combination of natural, physical and social resources exists at health clinic gardens which could be mobilised to improve the gardening practices to be more sustainable and to increase resilience within the community.

7.2 Contributing aspects of health clinic gardens to resilience-building strategies

Health clinic gardens contain several aspects which can contribute to the three resilience-building strategies proposed by Folke *et al.*, (2003). Table 7-1 explains how plant species composition and floristic and physiognomic diversity (green), physical resource diversity (blue), social resource diversity (pink) and positive perceptions on ecosystem services (orange) can contribute to each of these categories.

There is a need to have a closer look at the multiple functions of health clinic gardens and the benefits they bring to individuals as well as the entire community. Health clinics have a unique location being accessible to all village dwellers from young to old. Gardens at health clinics are therefore in the perfect situation to serve as a source of social learning, sharing of knowledge, civic engagement, social cohesion, environmental stewardship, healing from nutrition deficiencies and addressing food security.

The exceptional way in which different kinds of resources (natural, physical and social) are gathered at health clinic gardens creates bridges and connections between rich and poor, academic and illiterate, young and old, exotic and indigenous, cultural and political as well as corporate and governmental parties. This distinguishes health clinic gardens from other community gardens and home gardens producing advantages which are far more extensive than noticed on first glance.

Table 7-1: Resilience-building strategies and contributing aspects at health clinic gardens in the Bojanala District Municipality.

Resilience-building strategies (adapted from Folke et al., 2003)	Aspects which could contribute at health clinic gardens	Literature
1. Learning to live with change and uncertainty	Native species adapted to drought and poor soil condition improve adaptive capacity	Colding & Barthel, 2013; Jansen van Rensburg <i>et al.</i> 2007; Lubbe <i>et al.</i> 2011.
	Alternative, more sustainable infrastructure and equipment such as solar panel energy and rainwater tanks	Lang <i>et al.</i> 2012; Wiek <i>et al.</i> 2012
	Knowledge passed on from generation to generation at health clinic gardens create social-ecological memory which enhances adaptive capacity	Barthel <i>et al.</i> 2010; Nykvist & Heland, 2014
	A positive mindset on benefits derived from nature creates endurance and flexibility to persist in crises	Andersson <i>et al.</i> 2014; Koyenikan, 2007
2. Nurturing diversity for reorganization and renewal	Diversity of plant species in vegetable, ornamental and natural gardens improve functional and response diversity at health clinic gardens	Colding & Barthel, 2013; Elmquist <i>et al.</i> 2003
	Durable equipment needing low maintenance such as playpumps (UNICEF, 2007) or hand pump boreholes and diversity of gardening equipment improve the ability to reorganise at health clinic gardens	UNICEF, 2007
	Diversity and abundance of stakeholders enhance co-production of knowledge and innovation	Armitage <i>et al.</i> 2011; Pohl <i>et al.</i> 2010; Tengö <i>et al.</i> 2014
	Different perceptions on ecosystem services could contribute to diversity of knowledge at health clinic gardens	Armitage <i>et al.</i> 2011; Bendt <i>et al.</i> 2013; Enqvist <i>et al.</i> 2014; Pohl <i>et al.</i> 2010; Tengö <i>et al.</i> 2014
3. Combining different types of knowledge for learning	Indigenous knowledge on plant species should be embraced as well as expert knowledge from extension officers from Department of Agriculture	Cilliers & Siebert, 2012; Jansen van Rensburg <i>et al.</i> 2007; Pohl <i>et al.</i> 2010
	Alternative and more durable equipment for gardening and infrastructure should be explored and information shared among different facilities	UNICEF, 2007
	Diversity and abundance of stakeholders engage in the community of practice at health clinic gardens which stimulates social learning and reification of ideas	Armitage <i>et al.</i> 2011; Bendt <i>et al.</i> 2013
	Stakeholders learn from each other's perceptions on ecosystem services producing a learning environment where different types of knowledge could contribute to new perspectives and ideas	Armitage <i>et al.</i> 2011; Pohl <i>et al.</i> 2010; Tengö <i>et al.</i> 2014

7.3 Implementation of the information from this dissertation

It is no easy task to embrace all of these aspects at health clinic gardens simultaneously, but with a step-by-step approach starting at the best practice clinics a difference in the livelihood of the people of Bojanala District Municipality can definitely be made. Since health clinics are associated with healing, it is the perfect location to provide opportunities to alleviate nutrition deficiencies and poverty. Health clinics give access to the most vulnerable people in the community and are therefore the ideal starting point to build resilience in the community.

It is very important that the information of the results of this dissertation should be communicated to the entire community (and stakeholders at the health clinic garden) in a way that is simple and understandable to everyone (such as by using pictures on posters). The first step is, therefore, to clearly communicate with all stakeholders as well as the community and to involve them from the start of the project. All stakeholders should also be part of the process in which the management strategies are developed.

The aspects in which each of the best practice clinics performed weaker (Chapter 6), should be addressed first. Further development of all the aspects can then take place and should be maintained to build relationships and trust between the members of the community and the stakeholders involved at the health clinic gardens over time.

7.4 Future studies

One of the major limitations of this study was communication with the stakeholders involved at the health clinic gardens. Since most of the data was collected using a questionnaire, there was a constant lack of understanding between the interviewer (which is Afrikaans and English speaking) and the interviewed (which was mostly Setswana-speaking and understood little English). An interpreter was sometimes available, but he/she often added his/her own perceptions to the interviewed person's answer and therefore gave unreliable information. It is suggested that a professional interpreter (who knows the background of the study) should be hired in future studies or the data should be collected in a different way – such as using pictures to communicate with the stakeholders instead of using words.

Another limitation was that many of the stakeholders were absent when the health clinic gardens were visited for the collection of data. In future studies, communication with the Department of Health on district municipality level and the health clinics beforehand should be more clear and transparent. It is important to ensure that facility managers at the health clinic gardens have a thorough background of the project and the methods that will be used to collect the data.

It is also suggested that the same data should be collected at health clinic gardens in the rest of the North-West Province. This will broaden the scope of information available on health clinic gardens and may provide more insight on the current problems at health clinic gardens. If these studies could be effectively used in management strategies for local municipalities, further research can be done on health clinic gardens in other provinces of South Africa. Comparisons of these results may provide a better perspective on the overall potential of health clinic gardens to increase resilience.

Other aspects of health clinic gardens can also be investigated such as the ecological, political and economic valuation of ecosystem services and disservices. This will add a more accurate, quantitative value to the perceptions of the stakeholders on ecosystem services and disservices at health clinic gardens.

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ANNEXURES

Table 8-1: Questionnaire used for the survey at health clinic gardens in the Bojanala District Municipality, North-West Province, South Africa

Clinic name:				Number:			
GPS:				Date:			
A. Responsible person				Key:			
Names:				LB= Lebala	N=Naga	L=Lawn	
				ORN=Ornamental	VG=Vegetable	MG=Medicinal	
Responsibility in garden:	No.	Gender		Years of service	Area in garden		
		Male	Female				
1. Groundsman					LB	N	L
					ORN	VG	MG
2. Caregivers					LB	N	L
					ORN	VG	MG
3. Community Works Program					LB	N	L
					ORN	VG	MG
4. Community (Charity)					LB	N	L
					ORN	VG	MG
5. Facility manager					LB	N	L
					ORN	VG	MG
6. Other clinic personnel					LB	N	L
					ORN	VG	MG
7. Patients					LB	N	L
					ORN	VG	MG
8. NGO's					LB	N	L
					ORN	VG	MG
9. Traditional Health Practitioners (THP)					LB	N	L
					ORN	VG	MG
10. Private companies					LB	N	L
					ORN	VG	MG
11. Experts					LB	N	L
					ORN	VG	MG
12. Other					LB	N	L
13. Specify					ORN	VG	MG
Time spent on garden activity:	Days/week	Days/month					
Gardening knowledge:	No Experience	Basic	Intermediate	Advanced			
Motivation to garden - vegetables and other plants:							
HIV/Aids	TB	Malnourished	Registered patient	Elderly	Other	chronical	
B: Lay-out of garden (Tswana Thsimo) and area covered (transfer from H)							
Ornamental	Livestock pen	Orchard	Medicinal garden	Wind break	Shade trees	Lawn	
Natural area	Vegetable garden	Succulents	Flower beds	Fire screen	Open space	Paving	
Other							
Total garden area:				Garden age:			

Table 8-2: Questionnaire used to determine stakeholders' perceptions on ecosystem services and disservices at health clinic gardens

1. Stakeholder perceptions on ecosystem services					Date:	
Clinic name:					Number:	
A: Provisioning Services						
Provision of nutritious food						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Food	
Provision of wood for fire or any other sources of energy						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Fuelwood	
Provision of plants with medicinal value						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Medicinal resources	
Provision of material that can be used in construction of buildings						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Building material	
Provision of fodder and green manure						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Fodder (for animals)	
B: Regulating Services					Score:	
Are there birds and insects such as bees, wasps, beetles and butterflies sitting on the flowers?						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Biological control/Pollination	
Are there earthworms present in the garden?						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Soil quality	
Is the soil soft and easy to dig into with a spade?						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Soil quality	
Do the trees provide protection from wind/ sun?						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Local climate	

C: Habitat/ Supporting Services					Score:
Are there any birds, animals or insects living in the garden? (making it their home)					
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Habitat for species
Are there any plants here, that you don't have in your home garden or that you don't see elsewhere in the community e.g. type of vegetables and trees etc?					
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Maintenance of genetic diversity
D: Cultural Services					Score:
Are there sometimes children playing in the garden?					
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Recreational/ Mental/ Physical health
Do you like to be in the garden? Or do you enjoy working in the garden?					
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Spiritual/Sense of place
Are there sometimes visitors which are just sitting around in the garden?					
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Aesthetical appreciation
What makes a garden beautiful for you?					
Do you think this garden is beautiful? (throughout the year or only certain parts of the year?)					
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Aesthetical appreciation
What would you plant to make this garden more beautiful?					
Do you think that working in the gardens is a good way to meet new people?					
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Social network

Where did you learn how to make a garden?						
Did you gain some new knowledge by working in the garden/ being involved in the garden?						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Education and Science	
Will you be willing to transfer (teach) your knowledge to someone else?						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Education and Science	
2. Stakeholder perceptions on ecosystem disservices						Score:
Do you think any of the plants in the garden can make you sick/ill/ allergic?						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Allergies/ Decline in health	
Do you think any of the plants in the garden can harm you e.g. branches falling on you etc.?						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Accidents	
Do you think it is expensive to have this garden?						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Financial costs	
Do you think it is a waste of water to have this garden?						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Financial/ Environmental costs	
Do you feel save in the garden?						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Crime (Fear and stress)	
Does the fallen leaves clog the gutters?						
Do the branches of the trees sometimes fall on the building?						
Do you think some of the plants (trees) can be harmful to the building?						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Damage to infrastructure	
Do you prefer to be able to see outside the fences or do you like to be secluded?						
Do you think the garden obstruct your view?						
1. Strongly disagree	2. Disagree	3. Neither agree nor disagree	4. Agree	5. Strongly agree	Blockage of view	

Table 8-3: List of total physical resources at each clinic garden

Sub-district	Clinic name	Total physical resources score	Sub-district	Clinic name	Total physical resources score
Rustenburg (Kgetleng)	Reagile (Koster) Clinic	10	Moses Kotane	Dwarsberg	12
Rustenburg	Tlhabane CHC	9	Moses Kotane	D.Katnagel	12
Rustenburg	Tlaseng	2	Moses Kotane	Brakkuil	10
Rustenburg	Thekwane	12	Moses Kotane	Bapong 2	13
Rustenburg	Rankelenyane	9	Moses Kotane	Baleema	10
Rustenburg	Phatsima	9	Moses Kotane	Bakubung Clinic	13
Rustenburg	Monakato	8	Moses Kotane	Koedoesrand	10
Rustenburg	Mfidikwe	9	Moses Kotane	Pella	11
Rustenburg	Marikana	7	Moretele	Tladistad	10
Rustenburg	Luka	12	Moretele	Thulwe	2
Rustenburg	Karlienkamp/Zinniaville	7	Moretele	Rugtesloot	11
Rustenburg	Kana	9	Moretele	Relebogile(Ngobi)	14
Rustenburg	Hartbeesfontein	3	Moretele	Ratjiepene	12
Rustenburg	Chaneng	11	Moretele	Moretele	11
Rustenburg	Boitekong	8	Moretele	Mogogelo	10
Rustenburg	Sunrise Park	5	Moretele	Maubane	12
Rustenburg	Bafokeng	1	Moretele	Mathibestad	14
Moses Kotane	Rietfontein	11	Moretele	Makapanstad/Seapara	8
Moses Kotane	Witrandsjies	11	Moretele	Leseding/Dertig	12
Moses Kotane	Welverdiend	11	Moretele	Lefatlheng	11
Moses Kotane	Vlakplaas	11	Moretele	Lebotlwane	12
Moses Kotane	Verde 2	11	Moretele	Kutlwano (New)	14
Moses Kotane	Uitkyk	10	Moretele	Kgomokomo	14
Moses Kotane	Tweelaagte	13	Moretele	Ga-Motla	9
Moses Kotane	Tlhakeng	9	Moretele	Bosplass	14
Moses Kotane	Silwerkrans	12	Moretele	Dikebu(Sediane)	10
Moses Kotane	Siga	11	Moretele	Kromkuil/Mpho	9
Moses Kotane	Sesobe	11	Moretele	Mmakaunyane	12
Moses Kotane	Seolong	10	Moretele	Rekopantswe	12
Moses Kotane	Sandfontein	6	Moretele	Ga-Habedi	10
Moses Kotane	Rampampaspoort	13	Madibeng	Wonderkop	13
Moses Kotane	Pitsedisulejang	12	Madibeng	Bapong	13
Moses Kotane	Phalane	11	Madibeng	Sonop	7
Moses Kotane	Obakeng	13	Madibeng	Segwaelane	10
Moses Kotane	Neo Disake/ Magong	9	Madibeng	Oukasi	4
Moses Kotane	Motlhabe	11	Madibeng	Mothotlung	9
Moses Kotane	Montsana	9	Madibeng	Moletsoane	10
Moses Kotane	Mononono	11	Madibeng	Majakaneng	11
Moses Kotane	Molorwe	12	Madibeng	Madidi	11
Moses Kotane	Molatedi	11	Madibeng	Maboloka	11
Moses Kotane	Mogwase	9	Madibeng	Kgabalatsane	11
Moses Kotane	Modderkuil	12	Madibeng	Jericho	12
Moses Kotane	Mmankaipaa	12	Madibeng	Ikhutseng/Klipgat	8
Moses Kotane	Madikwe	12	Madibeng	Hoekfontein	8
Moses Kotane	Mabeskraal	10	Madibeng	Hebron	8
Moses Kotane	Linchwe	13	Madibeng	Hartbeespoort	1
Moses Kotane	Lesetheng	8	Madibeng	Fafung	7
Moses Kotane	Kraalhoek	14	Madibeng	Damonsville	2
Moses Kotane	Koffiekraal	12	Madibeng	Broederstroom	11
Moses Kotane	Khayakhulu	12	Madibeng	Lethabile	11
Moses Kotane	Ipopeng	7	Madibeng	Rabokala	12
Moses Kotane	Elandskuil	11	Madibeng	Refentse	12

Table 8-4: Post hoc test (ANOVA) of water supply at the different local municipalities

Sub-district	Unequal N HSD; Variable: Water supply Marked differences are significant at $p < ,05000$			
	{1} M=1,1765	{2} M=1,9302	{3} M=2,0909	{4} M=2,7727
Rustenburg {1}		0,002716	0,000290	0,000139
Moses Kotane {2}	0,002716		0,816927	0,000203
Madibeng {3}	0,000290	0,816927		0,001934
Moretele {4}	0,000139	0,000203	0,001934	

Table 8-5: Post hoc test (ANOVA) of equipment at the different local municipalities

Sub-district	Unequal N HSD; Variable: Equipment Marked differences are significant at $p < ,05000$			
	{1} M=3,2353	{2} M=4,5349	{3} M=4,1500	{4} M=3,8636
Rustenburg {1}		0,010472	0,119828	0,418596
Moses Kotane {2}	0,010472		0,736867	0,247759
Madibeng {3}	0,119828	0,736867		0,871944
Moretele {4}	0,418596	0,247759	0,871944	

Table 8-6: Post hoc test (ANOVA) of fertilising used at the different local municipalities

Sub-district	Unequal N HSD; Variable: Fertilizing (Compost & Manure_combined) Marked differences are significant at $p < ,05000$			
	{1} M=,58824	{2} M=,95349	{3} M=,30000	{4} M=,77273
Rustenburg {1}		0,369590	0,576414	0,844591
Moses Kotane {2}	0,369590		0,011418	0,797057
Madibeng {3}	0,576414	0,011418		0,109596
Moretele {4}	0,844591	0,797057	0,109596	

Table 8-7: Pearson correlation of resources and distance to local municipality offices

Resource	Pearson Correlation with distance to local municipality office
Water supply	-0.0403
Irrigation methods	0.156692
Compost	0.07603
Manure	0.294149
Equipment	0.316979

Table 8-8: Post hoc test (ANOVA) of gardening knowledge over the different local municipalities

Sub-district	Unequal N HSD; Variable: Gardening knowledge Marked differences are significant at $p < .05000$			
	{1} M=1,7647	{2} M=2,0233	{3} M=1,3810	{4} M=2,4091
Rustenburg {1}		0,800947	0,535585	0,114256
Moses Kotane {2}	0,800947		0,065266	0,417488
Madibeng {3}	0,535585	0,065266		0,000779
Moretele {4}	0,114256	0,417488	0,000779	

Table 8-9: Correlation between distance to local municipality office as well as species richness in the garden and gardening knowledge of the groundsmen

Gardening knowledge	Pearson Correlation
Distance to local municipality office (km)	0.042255565
Number of spp	-0.05438

Table 8-10: Post hoc test (ANOVA) of time spent in the gardens over the different local municipalities

Sub-district	Unequal N HSD; Variable: Time spent in garden (days per month) Marked differences are significant at $p < .05000$			
	{1} M=15.000	{2} M=18.095	{3} M=10.773	{4} M=18.545
Rustenburg {1}		0.489078	0.217638	0.367633
Moses Kotane {2}	0.489078		0.001950	0.995823
Madibeng {3}	0.217638	0.001950		0.000944
Moretele {4}	0.367633	0.995823	0.000944	

Table 8-11: List of plant species recorded at health clinic gardens in the Bojanala District Municipality (exotic species are indicated with an asterisk (*))

No.	Plant Species				
1	<i>Abelia floribunda</i> Decne.*	162	<i>Corchorus argillicola</i> M.J.Moeaha & P.J.D.Winter	323	<i>Hymenocallis littoralis</i> (Jacq.) J.F.Macbr.*
2	<i>Abelia x grandiflora</i> (Andre) Rehder*	163	<i>Corchorus asplenifolius</i> Burch	324	<i>Hyparrhenia hirta</i> (L.) Stapf
3	<i>Acacia burkei</i> Benth.	164	<i>Coreopsis lanceolata</i> L.*	325	<i>Hypoxis hemerocallidea</i> Fisch., C.A.Mey. & Ave-Lall.
4	<i>Acacia caffra</i> (Thunb.) Willd.	165	<i>Cosmos bipinnatus</i> Cav.*	326	<i>Impatiens balsamina</i> L.*
5	<i>Acacia erioloba</i> E.Mey	166	<i>Cosmos sulphureus</i> Cav.*	327	<i>Indigofera comosa</i> N.E.Br.
6	<i>Acacia galpinii</i> Burt Davy	167	<i>Cotyledon orbiculata</i> L. var. <i>oblonga</i> (Haw.) DC.	328	<i>Indigofera cryptantha</i> Benth. ex Harv. var. <i>cryptantha</i>
7	<i>Acacia karroo</i> Hayne	168	<i>Cotyledon</i> sp	329	<i>Indigofera daleoides</i> Benth. ex Harv. var. <i>daleoides</i>
8	<i>Acacia mellifera</i> (Vahl) Benth. subsp. <i>detinens</i> (Burch.) Brenan	169	<i>Crabbea angustifolia</i> Nees	330	<i>Indigofera hedyantha</i> Eckl. & Zeyh.
				484	<i>Portulaca oleracea</i> L.*
				485	<i>Portulaca quadrifida</i> L.*
				486	<i>Portulacaria afra</i> Jacq.
				487	<i>Pouzolzia mixta</i> Solms var. <i>mixta</i>
				488	<i>Prunus armeniaca</i> L.*
				489	<i>Prunus persica</i> (L.) Batsch. var. <i>persica</i> *
				490	<i>Prunus x domestica</i> L.*
				491	<i>Pseudognaphalium undulatum</i> (L.) Hilliard & B.L.Burt

9	<i>Acacia nilotica</i> (L.) Willd. ex Delile subsp. <i>kraussiana</i> (Benth.) Brenan	170	<i>Crassula capitella</i> Thunb. subsp. <i>capitella</i>	331	<i>Indigofera heterotricha</i> DC.	492	<i>Psidium guajava</i> L.*
10	<i>Acacia pendula</i> A.Cunn.*	171	<i>Crassula obovata</i> Haw. var. <i>dregeana</i> (Harv.) Toelken	332	<i>Indigofera holubii</i> N.E.Br.	493	<i>Punica granatum</i> L.*
11	<i>Acacia robusta</i> Burch. subsp. <i>robusta</i>	172	<i>Crassula</i> sp	333	<i>Ipomoea batatas</i> (L.) Lam.*	494	<i>Pyrus communis</i> L.*
12	<i>Acacia sieberiana</i> DC. var. <i>woodii</i> (Burt Davy) Keay & Brenan	173	<i>Crinum bulbispermum</i> (Burm.f.) Milne-Redh. & Schweik	334	<i>Ipomoea coccinosperma</i> Hochst. ex Choisy *	495	<i>Raphanus sativus</i> L.*
13	<i>Acacia tortilis</i> (Forssk.) Hayne subsp. <i>heteracantha</i> (Burch.) Brenan	174	<i>Crinum macowanii</i> Baker	335	<i>Ipomoea crassipes</i> Hook.	496	<i>Raphionacme hirsuta</i> (E.Mey.) R.A.Dyer
14	<i>Acacia xanthophloea</i> Benth.	175	<i>Crotalaria burkeana</i> Benth.	336	<i>Ipomoea magnusiana</i> Schinz var. <i>magnusiana</i>	497	<i>Rhoeo discolor</i> L.*
15	<i>Acalypha indica</i> L.	176	<i>Crotalaria sphaerocarpa</i> Perr.ex DC. subsp. <i>sphaerocarpa</i>	337	<i>Ipomoea obscura</i> (L.) Ker Gawl.	498	<i>Rhynchosia nervosa</i> Benth. ex Harv. var. <i>nervosa</i>
16	<i>Acalypha wilkesiana</i> *	177	<i>Cucumis anguria</i> L.	338	<i>Ipomoea ommanneyi</i> Rendle	499	<i>Rhynchosia totta</i> (Thunb.) DC. var. <i>totta</i>
17	<i>Acanthaceae</i> sp.	178	<i>Cucumis metuliferus</i> E.Mey. ex Naudin	339	<i>Ipomoea purpurea</i> (L.) Roth*	500	<i>Rhynchosia</i> sp
18	<i>Acca sellowiana</i> (O.Berg) Burret*	179	<i>Cucumis zeyheri</i> Sond.	340	<i>Iris germanica</i> L.*	501	<i>Richardia brasiliensis</i> Gomes*
19	<i>Acer buergerianum</i> Miq.*	180	<i>Cucurbita maxima</i> Duchesne ex Lam.*	341	<i>Ischaemum afrum</i> (J.F.Gmel.) Dandy	502	<i>Ricinus communis</i> L.*
20	<i>Acer negundo</i> L.*	181	<i>Cucurbita pepo</i> L.*	342	<i>Isoglossa</i> sp Oerst.	503	<i>Robinia pseudoacacia</i> L.*
21	<i>Achillea millefolium</i> L.*	182	<i>Cuminum cyminum</i> L.*	343	<i>Isoglossa woodii</i> C.B.Clarke	504	<i>Rosa</i> sp*
22	<i>Aeonium arboreum</i> (L.) Webb & Berthel.*	183	<i>Cuphea hyssopifolia</i> Kunth*	344	<i>Jacaranda mimosifolia</i> D.Don.*	505	<i>Rosmarinus officinalis</i> L. var. <i>officinalis</i> *
23	<i>Aerva leucura</i> Moq.	184	<i>Cuscuta campestris</i> Yunck.*	345	<i>Jasminum multipartitum</i> Hochst	506	<i>Ruellia cordata</i> Thunb.
24	<i>Agapanthus</i> sp.	185	<i>Cussonia spicata</i> Thunb.	346	<i>Jatropha curcas</i> L.*	507	<i>Rumex crispus</i> L.*
25	<i>Agave americana</i> L. subsp. <i>Americana</i> *	186	<i>Cycas revoluta</i> Thunb.*	347	<i>Jatropha gossypifolia</i> L. var. <i>elegans</i> (Pohl) Mill.Arg.*	508	<i>Ruschia</i> sp
26	<i>Agave angustifolia</i> Haw.*	187	<i>Cymbopogon citratus</i> (DC.) Stapf.*	348	<i>Jatropha zeyheri</i> Sond.	509	<i>Ruta graveolens</i> L.*
27	<i>Agave attenuata</i> Galeotti*	188	<i>Cymbopogon pospischilii</i> (K.Schum.) C.E. Hubb.	349	<i>Juniperus virginiana</i> L.*	510	<i>Sansevieria</i> sp
28	<i>Agave victoriae-reginae</i> T. Moore Engl.*	189	<i>Cynodon dactylon</i> (L.) Pers.	350	<i>Kalanchoe fedtschenkoi</i> Raym.-Hamet & H.Perrier*	511	<i>Sansevieria aethiopica</i> Thunb.
29	<i>Ailanthus altissima</i> (Mill.) Swingle*	190	<i>Cynodon hirsutus</i> Stent	351	<i>Kalanchoe longiflora</i> Schltr. ex J.M.Wood	512	<i>Sansevieria pearsonii</i> N.E.Br
30	<i>Ajuga reptans</i> L.*	191	<i>Cyperus esculentus</i> L. var. <i>esculentus</i>	352	<i>Kalanchoe sexangularis</i> N.E.Br. var. <i>sexangularis</i>	513	<i>Sansevieria trifasciata</i> Prain*
31	<i>Albica setosa</i> Jacq.	192	<i>Cyperus involucratus</i> Rottb.	353	<i>Kalanchoe thyrsiflora</i> Harv.	514	<i>Saponaria officinalis</i> L.*
32	<i>Alcea rosea</i> L.*	193	<i>Cyperus rupestris</i> Kunth var. <i>rupestris</i>	354	<i>Kniphofia praecox</i> Baker	515	<i>Scadoxus puniceus</i> (L.) Friis & Nordal
33	<i>Allium cepa</i> L.*	194	<i>Cyphostemma juttae</i> (Dinter & Gilg) Desc.	355	<i>Kohautia caespitosa</i> Schnizl. var. <i>dolichostyla</i> Bremek.	516	<i>Schinus molle</i> L.*
34	<i>Allium sativum</i> L.*	195	<i>Dactyloctenium aegyptium</i> (L.) Willd.	356	<i>Lactuca capensis</i> Thunb.	517	<i>Schinus terebinthifolius</i> Raddi*
35	<i>Alocasia macrorrhizos</i> (L.) G.Don*	196	<i>Dahlia coccinea</i> Cav.*	357	<i>Lactuca inermis</i> Forssk.	518	<i>Schkuhria pinnata</i> (Lam.) Cabrera*
36	<i>Aloe arborescens</i> Mill.	197	<i>Dahlia pinnata</i> Cav.*	358	<i>Lactuca sativa</i> L.*	519	<i>Schmidtia pappophoroides</i> Steud. ex J.A.Schmidt
37	<i>Aloe greatheadii</i> Schonland var. <i>davyana</i> (Schonland) Glen & D.S.Hardy	198	Cv. <i>Dahlia pinnata</i> Cav.*	359	<i>Lactuca serriola</i> L.*	520	<i>Schotia brachypetala</i> Sond.
38	<i>Aloe marlothii</i> A.Berger	199	<i>Datura stramonium</i> L.*	360	<i>Lactuca</i> sp*	521	<i>Sclerocarya birrea</i> (A.Rich.) Hochst. subsp. <i>caffra</i> (Sond.) Kokwaro
39	<i>Aloe striata</i> Haw.	200	<i>Daucus carota</i> L.*	361	<i>Lagerstroemia indica</i> L.*	522	<i>Scolopia zeyheri</i> (Nees) Harv
40	<i>Aloe vera</i> (L.) Burm.f.*	201	<i>Dianthus barbatus</i> L.*	362	<i>Laggera decurrens</i> (Vahl) Hepper & J.R.I. Wood	523	<i>Searsia lancea</i> L.f.

41	<i>Alternanthera dentata</i> (Moench) Stuchlik ex R.E. Fr. *	202	<i>Dicerocaryum eriocarpum</i> (Decne.) Abels	363	<i>Lampranthus roseus</i> (Willd.) Schwantes	524	<i>Searsia leptodictya</i> Diels
42	<i>Alternanthera ficoidea</i> (L.) P. Beauv.*	203	<i>Dichanthium annulatum</i> (Forssk.) Stapf var. <i>papillosum</i> (A.Rich.) de Wet & Harlan	364	<i>Lannea discolor</i> (Sond.) Engl.	525	<i>Searsia pendulina</i> Jacq.
43	<i>Alternanthera pungens</i> Kunth*	204	<i>Dichondra micrantha</i> Urb.*	365	<i>Lantana camara</i> L.*	526	<i>Searsia pyroides</i> Burch.
44	<i>Amaranthus dubius</i> Mart. ex Thell.*	205	<i>Dichrostachys cinerea</i> (L.) Wight & Arn. subsp. <i>africana</i> Brenan & Brummitt var. <i>pubescens</i> Brenan & Brummitt	366	<i>Lantana</i> sp Garden Hybrid*	527	<i>Sedum spathulifolium</i> Hook.*
45	<i>Amaranthus hybridus</i> L.*	206	<i>Dicoma zeyheri</i> Sond. var. <i>thyrsiflora</i> Klatt	367	<i>Lantana rugosa</i> Thunb.	528	<i>Selago densiflora</i> Rolfe
46	<i>Amaranthus viridis</i> L.	207	<i>Dietes grandiflora</i> N.E.Br	368	<i>Lavandula angustifolia</i> Mill. var. <i>angustifolia</i> *	529	<i>Senecio barbertonicus</i> Klatt
47	<i>Amaryllis belladonna</i> L.	208	<i>Dietes</i> sp	369	<i>Lavandula</i> sp Garden Hybrid*	530	<i>Senecio consanguineus</i> DC.
48	<i>Amaryllis</i> sp* Garden Hybrid	209	<i>Digitaria eriantha</i> Steud.	370	<i>Lavatera arborea</i> L.*	531	<i>Senecio scaposus</i> DC. var. <i>scaposus</i>
49	<i>Ammocharis coranica</i> (Ker Gawl.) Herb.	210	<i>Digitaria sanguinalis</i> (L.) Scop.*	371	<i>Ledebouria</i> sp	532	<i>Senecio tamoides</i> DC.
50	<i>Angelonia angustifolia</i> L.*	211	<i>Digitaria ternata</i> (A.Rich.) Stapf	372	<i>Ledebouria</i> sp Garden Hybrid*	533	<i>Senna didymobotrya</i> (Fresen.) H.S.Irwin & Barneby*
51	<i>Apium graveolens</i> L.*	212	<i>Dimorphotheca fruticosa</i> (L.) Less.	373	<i>Leonotis dysophylla</i> Benth.	534	<i>Senna italica</i> Mill. subsp. <i>arachnoides</i> (Burch.) Lock
52	Apocynaceae sp.	213	<i>Dimorphotheca jucunda</i> E.Phillips	374	<i>Leonotis ocymifolia</i> (Burm.f.) Iwarsson	535	<i>Sesbania bispinosa</i> (Jacq.) W. Wight*
53	<i>Aptenia cordifolia</i> (L.f.) Schwantes	214	<i>Dimorphotheca sinuata</i> DC.	375	<i>Lepidium bonariense</i> L.*	536	<i>Sesbania transvaalensis</i> J.B.Gillett
54	<i>Aptosimum procumbens</i> (Lehm.) Steud.	215	<i>Diodia benguellensis</i> Hiern.*	376	<i>Lepidium</i> sp*	537	<i>Setaria pallide-fusca</i> (Schumach.) Stapf & C.E.Hubb.
55	<i>Arachis hypogaea</i> L.*	216	<i>Diospyros lycioides</i> Desf. subsp. <i>guerkei</i> (Kuntze) De Winter	377	<i>Leucaena leucocephala</i> (Lam.) de Wit*	538	<i>Setaria sphacelata</i> (Schumach.) Moss var. <i>torta</i> (Stapf) Clayton
56	<i>Araucaria</i> sp	217	<i>Dodonaea viscosa</i> Jacq. var. <i>angustifolia</i> (L.f.) Benth.	378	<i>Leucanthemum</i> × <i>superbum</i> (Bergmans ex J.W.Ingram) D.H.Kent*	539	<i>Setaria verticillata</i> (L.) P.Beauv.
57	<i>Araujia sericifera</i> Brot.*	218	<i>Dombeya rotundifolia</i> (Hochst.) Planch. var. <i>rotundifolia</i>	379	<i>Leucas capensis</i> (Benth.) Engl.	540	<i>Sida cordifolia</i> L.
58	<i>Argemone ochroleuca</i> Sweet subsp. <i>Ochroleuca</i> *	219	<i>Dovyalis caffra</i> (Hook.f. & Harv.) Hook.f.	380	<i>Leucas martinicensis</i> (Jacq.) R.Br.	541	<i>Sida rhombifolia</i> L.*
59	<i>Aristida bipartita</i> (Nees) Trin. & Rupr.	220	<i>Duranta erecta</i> L.*	381	<i>Ligustrum ibota</i> Siebold & Zucc.*	542	<i>Sida spinosa</i> L. var. <i>spinosa</i>
60	<i>Aristida canescens</i> Henrard subsp. <i>canescens</i>	221	<i>Duranta repens</i> L.*	382	<i>Ligustrum lucidum</i> W.T.Aiton*	543	<i>Sisymbrium thellungii</i> O.E.Schulz
61	<i>Aristida congesta</i> Roem. & Schult. subsp. <i>congesta</i>	222	<i>Echeveria elegans</i> A.Berger*	383	<i>Limeum viscosum</i> (J.Gay) Fenzl subsp. <i>viscosum</i>	544	<i>Solanum elaeagnifolium</i> Cav.*
62	<i>Aristida diffusa</i> Trin. subsp. <i>burkei</i> (Stapf) Melderis	223	<i>Echeveria</i> × <i>imbricata</i> Deleuil ex E. Morren*	384	<i>Lobelia erinus</i> L.	545	<i>Solanum incanum</i> auct
63	<i>Aristolochia elegans</i> Mast.*	224	<i>Echinocactus</i> sp*	385	<i>Lobularia maritima</i> (L.) Desv.*	546	<i>Solanum lycopersicum</i> L.*
64	<i>Artemisia afra</i> Jacq. ex Willd.	225	<i>Ehretia rigida</i> (Thunb.) Druce	386	<i>Lonicera sempervirens</i> L.*	547	<i>Solanum nigrum</i> L.*
65	Asclepiadaceae sp	226	<i>Elaeodendron transvaalense</i> (Burt Davy) R.H.Archer	387	<i>Lotononis calycina</i> (E.Mey.) Benth.	548	<i>Solanum panduriforme</i> E.Mey.
66	<i>Asclepias decipiens</i> N.E.Br.	227	<i>Elephantorrhiza elephantina</i> (Burch.) Skeels	388	<i>Lotononis listii</i> Polhill	549	<i>Solanum rantonnetii</i> Carriere*
67	<i>Asparagus africanus</i> Lam.	228	<i>Elephantorrhiza obliqua</i> Burt Davy var. <i>obliqua</i>	389	<i>Lotononis lotononoides</i> (Scott-Elliot) B.-E.van Wyk	550	<i>Solanum supinum</i> Dunal var. <i>supinum</i>

68	<i>Asparagus densiflorus</i> (Kunth) Jessop	229	<i>Eleusine indica</i> (L.) Gaertn.	390	<i>Lycium cinereum</i> Thunb.	551	<i>Solanum tuberosum</i> L.*
69	<i>Asparagus larinus</i> Burch.	230	<i>Eleutherine bulbosa</i> (Mill.) Urb.*	391	<i>Maerua cafra</i> (DC.) Pax	552	<i>Solidago canadensis</i> L.*
70	<i>Asparagus suaveolens</i> Burch.	231	<i>Encephalartos</i> sp	392	<i>Magnolia grandiflora</i> L.*	553	<i>Sonchus oleraceus</i> L.*
71	<i>Aster laevis</i> L.*	232	<i>Enneapogon cenchroides</i> (Licht. ex Roem. & Schult.) C.E.Hubb.	393	<i>Malus domestica</i> (Borkh.) Likhonos*	554	<i>Sorghum bicolor</i> (L.) Moench subsp. <i>arundinaceum</i> (Desv.) de Wet & Harlan*
72	<i>Aster squamatus</i> (Spreng.) Hieron.*	233	<i>Enneapogon scoparius</i> Stapf	394	<i>Malva neglecta</i> Wallr.*	555	<i>Sorghum halepense</i> (L.) Pers.*
73	<i>Atriplex semibaccata</i> R.Br. var. <i>typica</i> Aellen*	234	<i>Epigaea repens</i> L.*	395	<i>Malva parviflora</i> L. var. <i>parviflora</i> *	556	<i>Sorghum versicolor</i> Andersson
74	<i>Atriplex</i> sp*	235	<i>Equisetum ramosissimum</i> Desf.*	396	<i>Malva sylvestris</i> L.*	557	<i>Sphagneticola trilobata</i> (L.) Pruski*
75	<i>Bauhinia variegata</i> L.*	236	<i>Eragrostis aspera</i> (Jacq.) Nees	397	<i>Malvastrum coromandelianum</i> (L.) Garcke*	558	<i>Spinacia oleracea</i> L.*
76	<i>Berkheya radula</i> (Harv.) De Wild.	237	<i>Eragrostis biflora</i> Hack. ex Schinz	398	<i>Mangifera indica</i> L.*	559	<i>Spirostachys africana</i> Sond
77	<i>Beta vulgaris</i> L.*	238	<i>Eragrostis chloromelas</i> Steud.	399	<i>Medicago laciniata</i> (L.) Mill.*	560	<i>Sporobolus africanus</i> (Poir.) A.Robyns & Tournay
78	<i>Beta vulgaris</i> L. subsp. <i>cicla</i> (L.) W.D.J. Koch.*	239	<i>Eragrostis curvula</i> (Schrad.) Nees	400	<i>Medicago lupulina</i> L.*	561	<i>Sporobolus fimbriatus</i> (Trin.) Nees
79	<i>Bidens bipinnata</i> L.*	240	<i>Eragrostis gummiflua</i> Nees	401	<i>Melia azedarach</i> L.*	562	<i>Sprekelia formosissima</i> Herb.*
80	<i>Bidens pilosa</i> L.*	241	<i>Eragrostis lehmanniana</i> Nees var. <i>chaunantha</i> (Pilg.) De Winter	402	<i>Melinis repens</i> (Willd.) Zizka subsp. <i>repens</i>	563	<i>Stachys hyssopoides</i> Burch. ex Benth.
81	<i>Blepharis integrifolia</i> (L.f.) E.Mey. ex Schinz var. <i>integrifolia</i>	242	<i>Eragrostis micrantha</i> Hack.	403	<i>Mentha sachalinensis</i> (Briquet ex Miyabe & Miyake) Kudô*	564	<i>Strelitzia alba</i> (L.f.) Skeels
82	<i>Blepharis serrulata</i> (Nees) Ficalho & Hiern	243	<i>Eragrostis pectinacea</i> (Michx.) Nees ex Steud.*	404	<i>Merremia</i> sp	565	<i>Strelitzia reginae</i> Aiton
83	<i>Boerhavia erecta</i> L.*	244	<i>Eragrostis rigidior</i> Pilg.	405	<i>Merremia tridentata</i> (L.) Hallier f.	566	<i>Striga asiatica</i> (L.) Kuntze
84	<i>Bolusanthus speciosus</i> (Bolus) Harms	245	<i>Eragrostis superba</i> Peyr.	406	<i>Mimusops zeyheri</i> Sond.	567	<i>Styphnolobium japonicum</i> (L.) Schott*
85	<i>Boophone disticha</i> (L.f.) Herb	246	<i>Eragrostis tef</i> (Zucc.) Trotter*	407	<i>Mirabilis jalapa</i> L.*	568	<i>Sutherlandia frutescens</i> (L.) R.Br
86	<i>Boscia albitrunca</i> (Burch.) Gilg & Gilg-Ben	247	<i>Eragrostis trichophora</i> Coss. & Durieu	408	<i>Momordica balsamina</i> L	569	<i>Syagrus coronata</i> (Mart.) Becc.*
87	<i>Boscia foetida</i> Schinz subsp. <i>filipes</i> (Gilg) Lotter	248	<i>Erigeron glaucus</i> Ker Gawl.*	409	<i>Monadenium lugardiae</i> N.E.Br.	570	<i>Syagrus romanzoffiana</i> (Cham.) Glassman*
88	<i>Bothriochloa insculpta</i> (Hochst. ex A.Rich.) A.Camus	249	<i>Erythrina lysistemon</i> Hutch.	410	<i>Monsonia angustifolia</i> E.Mey. ex A.Rich	571	<i>Symphytum</i> sp*
89	<i>Bougainvillea x Buttiana</i> Holttum & Standl.*	250	<i>Erythrophysa transvaalensis</i> I.Verd.	411	<i>Morus alba</i> L. var. <i>alba</i> *	572	<i>Synadenium cupulare</i> (Boiss.) L.C.Wheeler
90	<i>Bougainvillea glabra</i> Choisy*	251	<i>Eucalyptus camaldulensis</i> Dehnh.*	412	<i>Musa paradisiaca</i> Hutchinson*	573	<i>Syzygium paniculatum</i> Gaertn.*
91	<i>Brachiaria eruciformes</i> (Sm.) Griseb.	252	<i>Euclea crispa</i> (Thunb.) Gurke subsp. <i>Crispa</i>	413	<i>Nandina domestica</i> Thunb.*	574	<i>Tagetes erecta</i> L.*
92	<i>Brachiaria nigropedata</i> (Fical. & Hiern) Stapf	253	<i>Euclea undulata</i> Thunb.	414	<i>Nephrolepis exaltata</i> (L.) Schott*	575	<i>Tagetes minuta</i> L.*
93	<i>Brachychiton acerifolius</i> (A.Cunn. ex G.Don) Macarthur & C. Moore*	254	<i>Eucomis autumnalis</i> (Mill.) Chitt.	415	<i>Nerium oleander</i> L.*	576	<i>Talinum arnotii</i> Hook.f.
94	<i>Brachychiton populneus</i> (Schott & Endl.) R.Br.*	255	<i>Euphorbia cotinifolia</i> L.*	416	<i>Nicotiana glauca</i> Graham*	577	<i>Talinum caffrum</i> (Thunb.) Eckl. & Zeyh.
95	<i>Brassica oleracea</i> L.*	256	<i>Euphorbia helioscopia</i> L.*	417	<i>Nidorella anomala</i> Steetz	578	<i>Talinum</i> sp
96	Cv. <i>Brassica oleracea</i> L.*	257	<i>Euphorbia hirta</i> L.*	418	<i>Nidorella hottentotica</i> DC.	579	<i>Taraxacum officinale</i> Weber*
97	<i>Breynia disticha</i> J.R.Forst. & G.Forst.*	258	<i>Euphorbia inaequilatera</i> Sond. var. <i>inaequilatera</i>	419	<i>Ocimum gratissimum</i> L. subsp. <i>gratissimum</i> var. <i>gratissimum</i>	580	<i>Tecoma capensis</i> (Thunb.) Lindl.

98	<i>Bryophyllum delagoense</i> (Eckl. & Zeyh.) Schinz*	259	<i>Euphorbia milii</i> Des Moul.*	420	<i>Oenothera</i> sp Garden Hybrid*	581	<i>Tecoma stans</i> (L.) Kunth*
99	<i>Buddleja salviifolia</i> (L.) Lam.	260	<i>Euphorbia peplus</i> L.*	421	<i>Oenothera rosea</i> L'Hér. ex. Aiton*	582	<i>Tephrosia burchellii</i> Burt Davy
100	<i>Bulbine frutescens</i> (L.) Willd.	261	<i>Euphorbia prostrata</i> Aiton*	422	<i>Oenothera speciosa</i> Nutt*	583	<i>Tephrosia longipes</i> Meisn. subsp. <i>longipes</i> var. <i>uncinata</i> Harv.
101	<i>Burkea africana</i> Hook.	262	<i>Euphorbia pulcherrima</i> Willd. ex Klotzsch*	423	<i>Olea europaea</i> L. subsp. <i>africana</i> (Mill.) P.S.Green	584	<i>Tephrosia polystachya</i> E.Mey. var. <i>latifolia</i> Harv
102	<i>Buxus sempervirens</i> L.*	263	<i>Euphorbia</i> sp*	424	<i>Ophiopogon</i> sp*	585	<i>Tephrosia purpurea</i> (L.) Pers. subsp. <i>canescens</i> (E.Mey.) Brummitt
103	<i>Caesalpinia ferrea</i> Tul.*	264	<i>Euphorbia tirucalli</i> L.	425	<i>Ophiopogon jaburan</i> Lodd.*	586	<i>Terminalia sericea</i> Burch. ex DC.
104	<i>Calendula officinalis</i> L.*	265	<i>Euphorbia tithymaloides</i> L.*	426	<i>Opuntia ficus-indica</i> (L.) Mill.*	587	<i>Themeda triandra</i> Forssk.
105	<i>Callistemon citrinus</i> (Curtis) Stapf*	266	<i>Euryops chrysanthemoides</i> (DC.) B.Nord.	427	<i>Opuntia</i> sp*	588	<i>Thesium utile</i> A.W.Hill
106	<i>Callistemon viminalis</i> (Sol. ex Gaertn.) Cheel.*	267	<i>Evolvulus alsinoides</i> (L.) L.	428	<i>Opuntia stricta</i> Haw.*	589	<i>Thevetia peruviana</i> (Pers.) K.Schum. (=T.ycotlii A.DC.)*
107	<i>Canna x generalis</i> L.H.Bailey*	268	<i>Faidherbia albida</i> (Delile) A.Chev.	429	<i>Orbea lutea</i> (N.E.Br.) Bruyns subsp. <i>lutea</i>	590	<i>Tipuana tipu</i> (Benth.) Kuntze*
108	<i>Capsella bursa-pastoris</i> (L.) Medik.*	269	<i>Felicia muricata</i> (Thunb.) Nees subsp. <i>muricata</i>	430	<i>Ornithogalum saundersiae</i> Baker	591	<i>Tithonia diversifolia</i> (Hemsl.) A.Gray*
109	<i>Capsicum annuum</i> L. var. <i>glabriusculum</i> (Dunal) Heiser & Pickersgill.*	270	<i>Ficus benjamina</i> L.*	431	<i>Osteospermum muricatum</i> E.Mey. ex DC. subsp. <i>muricatum</i>	592	<i>Tithonia rotundifolia</i> (Mill.) S.F.Blake*
110	<i>Carica papaya</i> L.*	271	<i>Ficus carica</i> L.*	432	<i>Oxalis corniculata</i> L.*	593	<i>Trachelospermum jasminoides</i> Lam.*
111	<i>Carissa macrocarpa</i> (Eckl.) A.DC.	272	<i>Ficus</i> sp*	433	<i>Oxalis</i> sp Garden Hybrid *	594	<i>Trachyandra saltii</i> (Baker) Oberm. var. <i>oatesii</i> (Baker) Oberm.
112	<i>Carpobrotus edulis</i> (L.) L.Bolus subsp. <i>edulis</i>	273	<i>Ficus thonningii</i> Blume	434	<i>Ozoroa paniculosa</i> (Sond.) R.& A.Fern. var. <i>paniculosa</i>	595	<i>Tradescantia pallida</i> (Rose) Hunt*
113	<i>Carpobrotus</i> sp	274	<i>Flaveria bidentis</i> (L.) Kuntze*	435	<i>Panicum coloratum</i> L. var. <i>coloratum</i>	596	<i>Tradescantia spathacea</i> Sw.*
114	<i>Casuarina cunninghamiana</i> Miq.*	275	<i>Flueggea virosa</i> (Roxb. ex Willd.) Voigt subsp. <i>virosa</i>	436	<i>Panicum maximum</i> Jacq.	597	<i>Tradescantia zebrina</i> Bosse*
115	<i>Catharanthus roseus</i> (L.) G.Don.*	276	<i>Foeniculum vulgare</i> Mill. var. <i>vulgare</i> *	437	<i>Pappea capensis</i> Eckl. & Zeyh	598	<i>Tragia rupestris</i> Sond.
116	<i>Celtis africana</i> Burm.f.	277	<i>Fraxinus pennsylvanica</i> Marsh*	438	<i>Parkinsonia aculeata</i> L.*	599	<i>Tragus berteronianus</i> Schult.
117	<i>Celtis australis</i> L.*	278	<i>Fraxinus velutina</i> Torr. var. <i>velutina</i> *	439	<i>Parthenium hysterophorus</i> L.*	600	<i>Tribulus terrestris</i> L.
118	<i>Celtis sinensis</i> Pers.*	279	<i>Gaillardia pulchella</i> Foug.*	440	<i>Paspalum dilatatum</i> Poir.*	601	<i>Trichilia emetica</i> Vahl subsp. <i>emetica</i>
119	<i>Cenchrus ciliaris</i> L.	280	<i>Galinsoga parviflora</i> Cav.*	441	<i>Pavonia burchellii</i> (DC.) R.A.Dyer	602	<i>Tridax procumbens</i> L.*
120	<i>Ceratonia siliqua</i> L.*	281	<i>Galium spurium</i> L. subsp. <i>africanum</i> Verdc.	442	<i>Pelargonium zonale</i> (L.) L'Hér.	603	<i>Trifolium repens</i> L.*
121	<i>Ceratotheca triloba</i> (Bernh.) Hook.f.	282	<i>Gardenia</i> sp Garden Hybrid*	443	<i>Peltophorum africanum</i> Sond.	604	<i>Triumfetta sonderi</i> Ficalho & Hiern
122	<i>Cereus jamacaru</i> DC.*	283	<i>Gaura lindheimeri</i> Engelm. & A.Gray*	444	<i>Pennisetum clandestinum</i> Hochst. ex Chiov.*	605	<i>Tropaeolum majus</i> L.*
123	<i>Cestrum aurantiacum</i> Lindl.*	284	<i>Gazania rigens</i> (L.) Gaertn. var. <i>leucolaena</i> (DC.) Roessler	445	<i>Pennisetum setaceum</i> (Forssk.) Chiov.*	606	<i>Tulbaghia simmleri</i> P.Beauv.
124	<i>Chamaecrista biensis</i> (Steyaert) Lock	285	<i>Geigeria burkei</i> Harv. subsp. <i>burkei</i>	446	<i>Pentarrhinum inspidum</i> E.Mey.	607	<i>Turraea obtusifolia</i> Hochst
125	<i>Chamaecyparis lawsoniana</i> (A.Murr.) Parl.*	286	<i>Gerbera jamesonii</i> Bolus ex Adlam	447	<i>Peristrophe</i> sp*	608	<i>Typha capensis</i> (Rohrb.) N.E.Br.
126	<i>Chenopodium album</i> L.*	287	<i>Gisekia</i> sp	448	<i>Persea americana</i> Mill. var. <i>americana</i> *	609	<i>Urginea multisetosa</i> Baker
127	<i>Chenopodium carinatum</i> R.Br.*	288	<i>Gladiolus dalenii</i> Van Geel	449	<i>Persicaria</i> sp*	610	<i>Urochloa mosambicensis</i> (Hack.) Dandy
128	<i>Chloris gayana</i> Kunth	289	<i>Gladiolus</i> sp Garden Hybrid*	450	<i>Petroselinum crispum</i> (Mill) A.W.Hill*	611	<i>Urochloa panicoides</i> P. Beauv.
129	<i>Chloris pycnothrix</i> Trin.	290	<i>Gomphrena celosioides</i> Mart.*	451	<i>Petunia x atkinsiana</i> (Sweet) D. Don ex W. H. Baxter*	612	<i>Urtica dioica</i> L.

130	<i>Chloris virgata</i> Sw.	291	<i>Gomphrena globosa</i> L.*	452	<i>Phaseolus vulgaris</i> L. var. vulgaris*	613	<i>Vangueria infausta</i> Burch. subsp. <i>infausta</i>
131	<i>Chlorophytum capense</i> (L.) Voss	292	<i>Grevillea robusta</i> A.Cunn. ex R.Br.*	453	<i>Philodendron selloum</i> K.Koch.*	614	<i>Vepris undulata</i> (Thunb.) I.Verd. & C.A.Sm.
132	<i>Chlorophytum comosum</i> (Thunb.) Jacq.	293	<i>Grewia bicolor</i> Juss. var. <i>bicolor</i>	454	<i>Phoenix canariensis</i> Hort. ex Chabaud*	615	<i>Verbena aristigera</i> S.Moore*
133	<i>Chorisia speciosa</i> A.St.-Hil.*	294	<i>Grewia flava</i> DC.	455	<i>Phormium tenax</i> J.R.Forst. & G.Forst*	616	<i>Verbena bonariensis</i> L.*
134	<i>Chrysanthemoides monilifera</i> (L.) Norl. subsp. <i>monilifera</i>	295	<i>Grewia flavescens</i> Juss.	456	<i>Phyllanthus parvulus</i> Sond.	617	<i>Verbena hybrida</i> Voss ex Rumpel*
135	<i>Chrysanthemum frutescens</i> L.*	296	<i>Guilleminea densa</i> (Willd. ex Roem. & Schult.) Moq.*	457	<i>Physalis angulata</i> L.*	618	<i>Vernonia oligocephala</i> (DC.) Sch.Bip. ex Walp
136	<i>Chrysanthemum sp*</i> Garden Hybrid	297	<i>Gymnosporia buxifolia</i> (L.) Szyszyl.	458	<i>Physalis viscosa</i> L.*	619	<i>Vernonia poskeana</i> Vatke & Hildebr. subsp. <i>botswanaica</i> G.V.Pope
137	<i>Chrysanthemum maximum</i> Ramond*	298	<i>Hakea sp*</i>	459	<i>Phytolacca dioica</i> L.*	620	<i>Viburnum odoratissimum</i> Ker Gawl.*
138	<i>Cinnamomum camphora</i> (L.) Nees & Eberm.*	299	<i>Harpagophytum procumbens</i> (Burch.) DC. ex Meisn. subsp. <i>procumbens</i>	460	<i>Pilularia sp*</i>	621	<i>Viburnum tinus</i> L.*
139	<i>Citrillus lanatus</i> (Thunb.) Matsum. & Nakai	300	<i>Harpagophytum zeyheri</i> Decne. subsp. <i>schijffii</i> Ihlenf. & H.E.K.Hartmann	461	<i>Pinus halepensis</i> Mill.*	622	<i>Vigna unguiculata</i> (L.) Walp.
140	<i>Citrus limon</i> (L.) Burm.f.*	301	<i>Harpephyllum caffrum</i> Bernh. ex Krauss	462	<i>Plantago lanceolata</i> L.*	623	<i>Vinca major</i> L.*
141	<i>Citrus limon</i> (L.) Burm.f.* Hybrid	302	<i>Haworthia fasciata</i> (Willd.) Haw.	463	<i>Plantago major</i> L.*	624	<i>Viola odorata</i> L.*
142	<i>Citrus reticulata</i> Blanco	303	<i>Hebe salicifolia</i> (G.Forst.) Pennell*	464	<i>Plectranthus fruticosus</i> L.	625	<i>Vitex zeyheri</i> Sond.
143	<i>Citrus sinensis</i> (L.) Osbeck.*	304	<i>Hedera helix</i> L.*	465	<i>Plectranthus neochilus</i> Schltr.	626	<i>Vitis vinifera</i> L.*
144	<i>Clematis brachiata</i> Thunb.	305	<i>Helianthus annuus</i> L.*	466	<i>Pectranthus sp</i> 'Variegata'	627	<i>Wahlenbergia stricta</i> (R.Br.) Sweet*
145	<i>Cleome gynandra</i> L.	306	<i>Heliotropium ovalifolium</i> Forssk.	467	<i>Plumbago zeylanica</i> L.*	628	<i>Waltheria indica</i> L
146	<i>Cleome monophylla</i> L.	307	<i>Hemerocallis fulva</i> (L.) L.*	468	<i>Plumbago auriculata</i> Lam.	629	<i>Washingtonia filifera</i> (L.Linden) H.Wendl.*
147	<i>Coix lacryma-jobi</i> L.	308	<i>Hermannia depressa</i> N.E.Br.	469	Cv. <i>Plumbago auriculata</i> Lam. Alba*	630	<i>Withania somnifera</i> (L.) Dunal*
148	<i>Colocasia esculenta</i> (L.) Schott.*	309	<i>Hermannia sp</i>	470	<i>Plumeria rubra</i> L.*	631	<i>Xanthium strumarium</i> L.*
149	<i>Combretum apiculatum</i> Sond. subsp. <i>apiculatum</i>	310	<i>Hermannia tomentosa</i> (Turcz.) Schinz ex Engl.	471	<i>Plumeria rubra</i> L.* Pink	632	<i>Yucca aloifolia</i> L.*
150	<i>Combretum erythrophyllum</i> (Burch.) Sond.	311	<i>Hermbstaedtia odorata</i> (Burch.) T.Cooke var. <i>aurantiaca</i> (Suess.) C.C.Towns.	472	<i>Plumeria rubra</i> L.* White	633	<i>Yucca elephantipes</i> Regel ex Trel., nom. illeg.*
151	<i>Combretum hereroense</i> Schinz	312	<i>Heteropogon contortus</i> (L.) P.Beauv.	473	<i>Poa annua</i> L.*	634	<i>Zaleya pentandra</i> (L.) Jeffrey
152	<i>Combretum imberbe</i> Wawra	313	<i>Hibiscus engleri</i> K.Schum.	474	<i>Podocarpus falcatus</i> (Thunb.) R.Br. ex. Mirb.	635	<i>Zantedeschia aethiopica</i> (L.) Spreng.
153	<i>Combretum zeyheri</i> Sond.	314	<i>Hibiscus nigricaulis</i> Baker f.	475	<i>Podocarpus henkelii</i> Stapf ex Dallim. & Jacks.	636	<i>Zea mays</i> L.*
154	<i>Commelina africana</i> L. var. <i>africana</i>	315	<i>Hibiscus pusillus</i> Thunb.	476	<i>Podranea ricasoliana</i> (Tanf.) Sprague	637	<i>Zephyranthes grandiflora</i> Lindl.*
155	<i>Commelina benghalensis</i> L.*	316	<i>Hibiscus rosa-sinensis</i> L.*	477	<i>Pogonarthria squarrosa</i> (Roem. & Schult.) Pilg.	638	<i>Zephyranthes candida</i> (Lindl.) Herb.*
156	<i>Commiphora glandulosa</i> Schinz	317	Cv. <i>Hibiscus rosa-sinensis</i> L.*	478	<i>Pollichia campestris</i> Aiton	639	<i>Zingiber officinale</i> Roscoe*
157	<i>Convolvulus arvensis</i> L.*	318	<i>Hibiscus sp*</i>	479	<i>Polygala hottentotta</i> C. Presl	640	<i>Zinnia elegans</i> Jacq.*
158	<i>Convolvulus sagittatus</i> Thunb.	319	<i>Hibiscus syriacus</i> L.*	480	<i>Polygala myrtifolia</i> L.	641	<i>Zinnia peruviana</i> (L.) L.*
159	<i>Conyza bonariensis</i> (L.) Cronquist*	320	<i>Hibiscus trionum</i> L.*	481	<i>Populus deltoideus</i> Bartram ex Marsh subsp. <i>wislizenii</i> (S.Watson) Eckenw.*	642	<i>Ziziphus mucronata</i> Willd. subsp. <i>mucronata</i>
160	<i>Conyza podocephala</i> DC.	321	<i>Hirpicium bechuanense</i> (S.Moore) Roessler	482	<i>Populus nigra</i> L. var. <i>italica</i> Moenchh.*	643	Unknown 1
161	<i>Corbichonia decumbens</i> (Forssk.) Exell	322	<i>Hydrangea macrophylla</i> (Thunb.) Ser.*	483	<i>Portulaca grandiflora</i> Hook.	644	Unknown 2
				183		645	Unknown 3