Assessing ecosystem services in the Fafung community of the North West Province, South Africa

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DECLARATION

I, Elvis Kgotjane Choma (25746669), hereby declare that the dissertation titled "Assessing ecosystem services in the Fafung community of the North West Province, South Africa" is my own work and that it has not been submitted previously for a degree qualification to another university.

Signature: Date: 15 November 2020

E.K. Choma

This dissertation has been submitted with my approval as a university supervisor, and I certify that the requirements of the applicable M.Sc. degree rules and regulations have been met.

Signed: ……………………………………

Prof Hendri Coetzee (Supervisor)

Date: ……………………….....................

Signed: ………………………………. .

Prof K. Kellner (Co-supervisor)

Date: 20 November 2020

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ABSTRACT

Fafung is a deep rural community in South Africa's North West Province that borders on the Borakalalo Nature Reserve. As with many communities of its kind, Fafung faces several needs and challenges such as unemployment, fragmented family structures and inadequate access to healthcare, education, food, housing and energy. Seeing that many of these can potentially be addressed by provisioning, regulating, cultural and supporting ecosystem services, this study set out to establish which of these are currently available to the community and the degree to which they are used, enjoyed and valued. Non-participant observations aided by spatial mapping revealed that 32 ecosystem services are readily available to the Fafung community but may be under threat mostly as a result of land degradation and the impacts of climate change. Given the value residents attach to these ecosystem services, albeit subconscious at times, it is anticipated that this study's findings and recommendations will, in future, encourage stakeholders to consider best ecosystem management practices when formulating policies and taking decisions that will impact the well-being of the Fafung community. Furthermore, involving Fafung residents in maintaining and restoring ecosystems can contribute towards attaining the United Nations' Sustainable Development Goals and help to counter health shocks the likes of Covid-19.

Key words: ecosystem services, degradation, restoration, Millennium Ecosystem Assessment, Sustainable Development Goals, Integrated Development Plan, National Development Plan

ACRONYMS

AIP – Alien Invasive Plants

CBD – Convention on Biological Diversity

CES – Cultural Ecosystem Services

COP – Conference of Parties

DEA – Department of Environmental Affairs

DEFF – Department of Environment, Forestry and Fisheries

DSS – Decision Support System

DWS – Department of Water and Sanitation

EDS – Ecosystem Disservices

EPWP – Expanded Public Works Programme

ES – Ecosystem Services

ESP – Ecosystem Services Partnership

GBVC – Green Business Value Chain

GHG – Greenhouse Gas

GIS – Geographical Information System

GIZ – *Gesellschaft für Internationale Zusammenarbeit* (Community for International Collaboration)

GVA – Gross Value Add

HREC – Human Research Ethics Committee

LDN – Land Degradation Neutrality

LPD – Land Productivity Dynamics

MDG – Millennium Development Goals

MEA – Millennium Ecosystem Assessment

NDMC – National Disaster Management Centre

NDP – National Development Plan

NLC – National Land-Cover

NRM – Natural Resource Management

NWU – North-West University

RESLIM – Resilience in the Limpopo River Basin

ROI – Return on Investment

SANLC – South African National Land-Cover

SDG – Sustainable Development Goals

SIC – Standard Industrial Classification

SLM – Sustainable Land Management

SMME – Small, Medium and Micro-enterprises

SPSS – Statistical Package for the Social Sciences

StatsSA – Statistics South Africa

UNCCD – United Nations Convention to Combat Desertification

UNDP – United Nations Development Programme

UNEP – United Nations Environmental Programme

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CHAPTER 1: INTRODUCTION

1.1 Background

People the world over are dependent on ecosystems and the services they provide for their well-being. There are, however, two sides to this coin: As much as ecosystem services (ES) provide in humankind's growing demand for food, fresh water, timber, fibre and fuel (MEA, 2005) and contribute to economic development, the spatio-temporal transformation (Farina, 2007) and degradation of ecosystems as a result of, amongst others, tree felling and over-grazing pose a huge threat to the environment and, by inference, human life (Shackleton *et al.*, 2008). Unfortunately, as illustrated in *The South African Carbon Sinks Atlas* (DEA, 2017), the consequences of environmental degradation (e.g. pollution, eutrophication and the emission of green-house gasses) know no boundaries and extend well beyond regional, national and even continental borders.

This study resorts under an investigation into a decision support system (DSS) called "Bush Expert" conducted by the North-West University (NWU) and funded by the Natural Resource Management (NRM) programme of the Department of Environment, Forestry and Fisheries (DEFF) (former Department of Environmental Affairs). The overarching objective is to assess and evaluate attempts to curb the encroachment/thickening of shrubs and trees (i.e. "bush encroachment") and to establish the impact these attempts have on ecosystem services (ES) on a local and regional scale in selected areas of the North West Province (Fafung, Taung, Ganyesa) and Limpopo (D'Nyala Nature Reserve) (Kellner, 2009a). It is envisaged that by documenting these studies, a system can be devised whereby decisions regarding the best and most appropriate rehabilitation methodologies to counter bush encroachment can be arrived at.

NRM projects are considered for inclusion in the Bush Expert programme on the basis of their potential to contribute to the DEFF's sustainability objectives which are based on the principle "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). In other words, as depicted in the three-pillar model below (Figure 1.1), these projects seek to achieve sustainability by ensuring that environmental, social and economic objectives are met. A practical demonstration of this can be found in Hoy *et al*. (2016), illustrating that an NRM project can combine ecological concerns and socio-economic development benefits successfully by addressing unemployment, empowerment and skills development which, in turn, generate direct financial benefits and improve communities' environmental conservation capacity. Nevertheless, as pointed out by the World Commission on Environment and Development (1987), poverty is simultaneously both a major cause and effect of the global environmental problem. This is exacerbated by the fact that in many developing countries, short-term economic growth and social delivery often take precedence over environmental conservation and resource management (Hoy *et al.,* 2016). For this reason, governments tend to assign a higher priority to hard infrastructure when it comes to resource allocation compared to investing in ecological infrastructure. Given this scenario, another objective of the Bush Expert programme is to ensure equity among social, economic and environmental benefits and to investigate decision support systems that will integrate or harmonise these benefits in an attempt to offset the extent of ecosystem degradation.

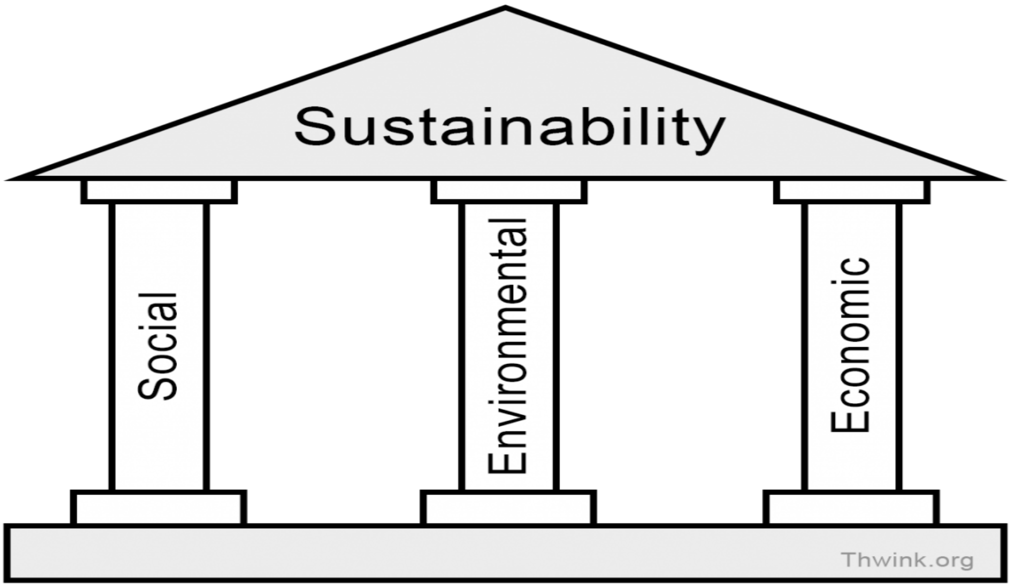

Figure 1.1: Three-pillar model of sustainability (Thwink.org).

According to Daily *et al*. (1997), many rural communities not only harvest material from nature but also rely on biological and natural processes to improve the yields of their crops and rangelands, to treat waste water, to counter erosion and to mitigate floods and droughts. This is one of the reasons why the former Department of Environmental Affairs identified the rehabilitation and restoration of degraded ecosystems as a priority and undertook to reverse and/or minimise the impact thereof in an attempt to attain land degradation neutrality (LDN) (DEA, 2018). Attaining LDN implies an improvement in grazing conditions and land productivity, healthy and resilient ecosystems that offer an abundance of ecosystem services and a low-carbon economy. Furthermore, restoration and rehabilitation enhance the conservation value of protected landscapes and productive land (Hobbs & Norton, as cited in Kellner, 2009b), hence investment made into this interventions by DEFF.

As is evident from the latest Fafung land-cover/-use map (Figure 3.3), this community is not resilient to environmental challenges since land use is gradually being altered. Like most of the landscapes in the North West Province, Fafung resorts under the pre-historic savanna-grassland biome (Mucina & Rutherford, 2006), the ecosystems and the services the open savanna and grassland offer are now severely impacted as a result of encroachment and severe degradation. The focus of this study is on a communal area, because many areas alike are confronted by various challenges such as not having stringent mechanisms in place to curb degradation impacting on ecosystems.

Like many other communities in South Africa, Fafung expects government to address its needs and to help overcome its challenges (Perret *et al*., 2005). It is highly unlikely that significant economic development in the area will bring relief for the impoverished community, although government spending on infrastructure and services may result in some improvement in inhabitants' basic quality of life and well-being.

The degradation of ecosystem services is regarded as a major barrier to the attainment of Millennium Development Goals (MEA, 2005) and the targets set in the 2030 National Development Plan (NPC, 2011) and the realisation of Madibeng's Integrated Development Plan and Spatial Development Framework (SDF, 2015). Without realising it, though, the community is already acquiring a number of goods and services from the local woodland ecosystem in the surrounding area. It is also likely that there are additional goods and services the community is unaware of that could also help them to address some of their unmet needs and challenges. It can be argued that if the community can be made aware of additional ecosystem goods and services in their community, it will not only benefit them directly, but it will also lessen the burden on government.

Clearly, human societies derive many essential goods from natural ecosystems (Daily *et al*., 1997). According to the UNCCD (2016), some of the socio-economic benefits that can be derived from attaining land degradation neutrality include economic gains and sustainable livelihoods as a result of enhanced agricultural and livestock production, an improvement in household income and social cohesion through job creation, food and water security, community ownership of sustainable land-based projects and synergy between the respective sectors and stakeholders with regards to attaining government priorities as highlighted in the National Development Plan (NDP). To date, though, the exact ecosystem services available to the Fafung community have not been documented, and no-one has ever investigated which of these goods and services are currently being used, enjoyed and valued by the community.

In the Fafung community, conservation, restoration and rehabilitation are crucial if ecosystems are to be improved, but if the intended objectives are to be obtained, it must be implemented within the broader context of sustainable land management (SLM). SLM in practice has the potential to address several socio-economic principles, namely maintaining or enhancing productivity, reducing production risks which, in turn, enhances the level of security and offering greater protection since natural resources are protected and the degradation of soil and water is prevented. In combination, all of the foregoing will contribute to economic viability and social acceptability (Kellner, 2009b).

Historically, many a project aimed at natural resource management, were launched without first conducting rigorous studies on the extent of the degradation, nor were attempts made to determine, at least on a local scale, which ecosystem services could potentially be enhanced as a result of restoration/rehabilitation projects for utilisation by local communities to improve their livelihoods.

Given that the community regards Fafung as prime grazing land, the obvious point of departure was to determine how rangelands' grazing capacity can be enhanced by curbing bush encroachment/thickening as an environmental phenomenon that impacts ecosystems at large and has a negative impact on those systems' ability to deliver services to inhabitants. The negative impacts of bush encroachment/thickening are well documented and include drought as a result of water loss in catchment areas (Midgley *et al*., 2013), impaired biodiversity resulting in habitat loss (Shackleton *et al*., 2008) and displacement of the grass layer which not only alters fire regime but also exacerbates soil erosion and sedimentation (Turpie *et al*., 2019). Due to the resultant loss of aesthetic value, all of the foregoing poses a real threat for tourism and, as Coscieme (2015) pointed out, detracts from the inspirational sense of place.

In the context of decision making, it is of critical importance to understand the links between ecosystem functioning and human welfare (Fisher *et al*., 2009). To this end, this study set out to make a positive contribution towards motivating which ecosystem services ought to be considered when conservation, restoration and rehabilitation projects are implemented and it is envisaged that the Fafung community will, in future, have a wealth of information to guide their decisions in this regard.

Representatives from all over the world who contribute to the United Nations' environmental programme (UNEP) agree that, broadly speaking, ecosystems services resort under one of four categories: provisioning (e.g. food and water), regulating (e.g. flood and disease control), cultural (e.g. spiritual and recreational) and supporting (e.g. nutrient cycling) services (MEA, 2005).

Note, though, that as pointed out by De Groot *et al.* (2018), the success of restoration, rehabilitation and conservation projects are dependent on acquiring detailed information on how projects such as these will impact the community's welfare at large (i.e. costs and benefits), which necessitates careful consideration of all externalities (positive and negative) that are associated with a change in land use and management. By way of example, information about the functional value of a forest may enable a community to decide whether to leave it in its current state or convert it to a resort (tourism value), to continue harvesting wood or to place the forest under conservation whereby harvesting is not allowed, to conserve it for carbon storage and oxygen circulation or for its role as a windrow/buffer, or to remove the forest so as to improve grazing capacity.

By inference this implies that if a project's outputs are to be measured, a baseline must first be established. Nevertheless, it is envisaged that the findings of this study will assist the DEFF to arrive at a support system that will inform decisions regarding the planning, design and implementation of restoration/rehabilitation projects that will reap a return on natural, social and financial capital as well as inspiration over the long term.

1.2 Problem statement

Of the 122 million hectares that constitute South Africa's land area, approximately 91% is dryland, making the country highly susceptible to desertification, land degradation and droughts. On top of that, aerial photography reveals that since 1940, there has been a marked increase in the abundance of indigenous woody vegetation (Turpie *et al.*, 2019) in grassland and savanna biomes, which represent 27.9% and 32.5% of the country's land surface area respectively. This is a sure sign of bush encroachment/thickening which is bound to have a negative effect on the flow of ecosystem services if left unchecked.

As part of the Bush Expert project, this study focused on assessing those services the Fafung community derives from ecosystems that meet their basic needs and contribute to their well-being with the intention to provide a context that will inform future decisions regarding ecosystem management and restoration projects (Fisher *et al*., 2009). Moreover, this study will enable people to make proper trade-offs (Le Maitre *et al*., 2007) among and between various ecosystem services based on scientifically sound information on the return on natural, social, financial and inspirational capital (De Groot *et al*., 2018).

In valuing the ecosystem services, the study used sustainability science as approach which is defined by Burns (cited by Le Maitre *et al.,* 2007) as follows: "Use-inspired basic research, located at the interface between society and the sustenance of natural environment, focused on the resilience of complex social ecological systems, having a transdisciplinary approach to understanding system complexity and resilience, acknowledging the validity of multiple epistemologies, and emphasizing learning and adaptation." From this definition it is clear that rather than following a 'business as usual' approach, sustainability science necessitates an approach that challenges different domains within the society (ordinary civilians, scientists, policy makers, et cetera) to consider trade-offs in their approach to managing ecosystems.

In rural communities the likes of Fafung where the provision of hard infrastructure such as water, electricity, housing and roads is already posing a major challenge, it is crucial to reinforce the community's capacity to preserve and sustain the ecosystem services they derive from grasslands, woodlands and water sources (rivers, wetlands and dams). Even though bush encroachment/thickening clearly poses a threat in the long run to the sustainability of several ecosystem services, many regard the bush thinning projects currently being implemented under the auspices of the DEFF as having an adverse impact on the environment. This predicament could be addressed through policy framework that will result in a perfect trade-off: Sustainable harvesting operations to create employment, skills development and entrepreneurial opportunities in the Green Business Value Chain (GBVC) must form part of the policy framework. Furthermore, the beneficiaries need to be made aware of the fact that clearing improves grazing capacity and water security as well as enhances carbon storage and improves the quality of the air they breathe.

1.3 Research questions

Even though extensive evaluations of human beings' dependence on ecosystems have been conducted, to date, most rural communities and communally owned areas largely remain unware of the value of these ES to their livelihood. To this end, the two main questions that guided this study were:

- What ecosystem services are available to the Fafung community?
- Which of the available services are currently being used or could potentially be used by the community?

1.4 Research aim and objectives

The overarching aim of this study is to establish the extent to which ES are used, enjoyed and valued by local people in Fafung Village. The first objective was to establish which ecosystem services are available to the Fafung community and to determine which of those ecosystem services are currently being used, enjoyed and valued by the local people in the area. Based on the resulting findings, the second objective was to make recommendations on how Fafung, and other communities in the area, can ensure that they utilise the ecosystem goods and services at their disposal in a sustainable manner so as to promote their socio-economic well-being whilst maintaining the integrity of the environment.

It is anticipated that all of the above will inform the recommendations stemming from this study since, in order to attain LDN, the intention with establishing a baseline assessment of ecosystem services available to the Fafung community is to encourage good land management practices and to create a context for future decisions regarding the implementation of restoration/rehabilitation program MEA in the area.

1.5 Dissertation outline

This dissertation is comprised of five chapters, following a logical progression from background to a conclusion and recommendations (Figure 1.2).

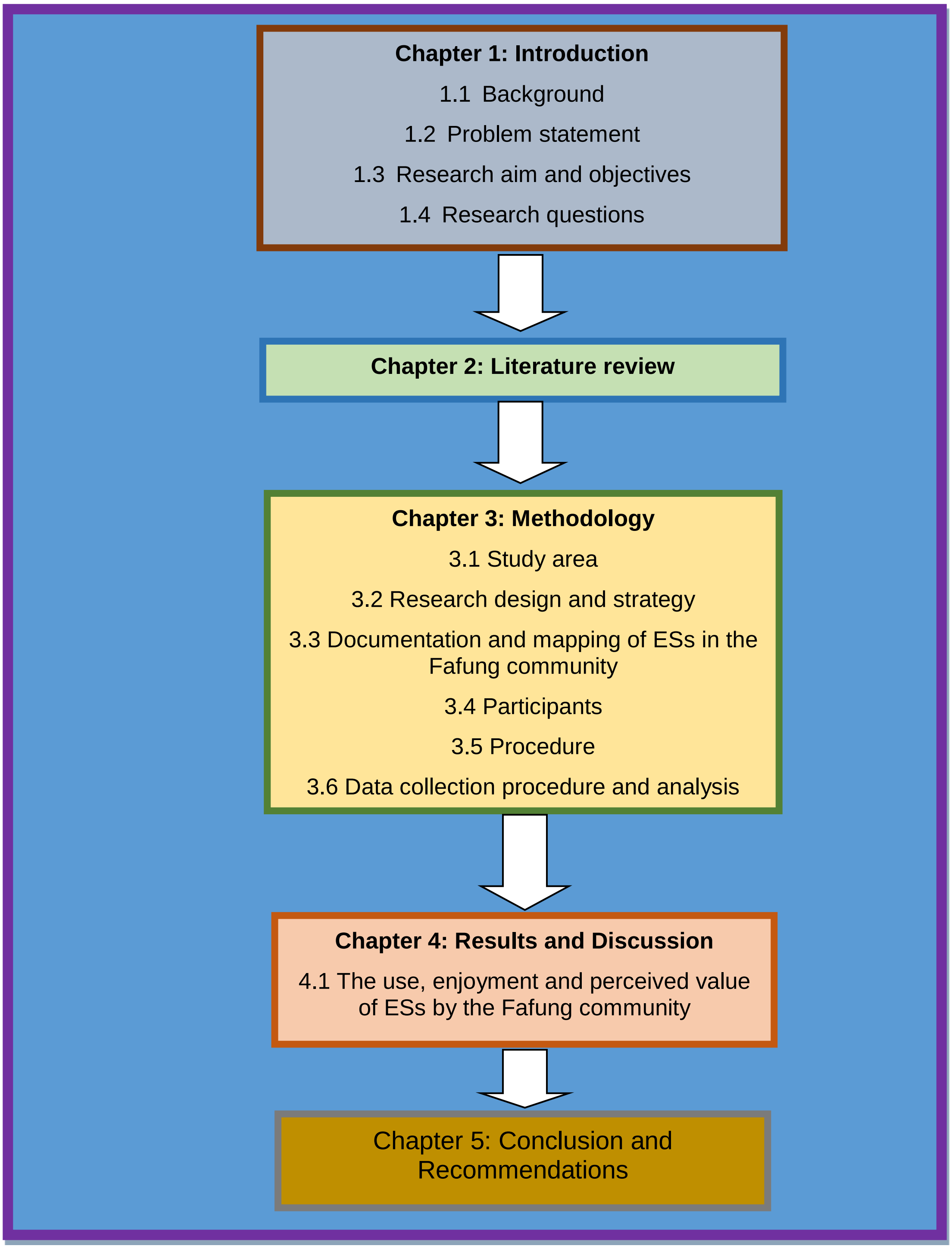

Figure 1.2: Chapter outline

Chapter 1 sketches the background to this study; states the research problem, aims and objectives, and sets the tone for how ecosystem services are used, enjoyed and valued by communities the likes of Fafung.

The literature review (Chapter 2) is organised in a hierarchical fashion, in other words it moves from studies looking at Africa as a continent, then to Southern Africa as a region, South Africa as a country and Fafung as a local community. As will be evident from this review, research regarding local communities' dependence on ecosystems services is sourly lacking, implying that these services' contribution to human well-being and socio-economic development may have been overlooked and that the value of these services has never been fully appraised (Le Maitre *et al*, 2007). Chapter 3 outlines the research methodology and provides a description of the study area and its spatial hierarchical order. This chapter also outlines the research design and procedures as well as the methodology followed to document and map ecosystem services in the Fafung community, sample participants and collect and analyse data.

The results are provided in Chapter 4, together with a detailed analysis of and discussion on the use, enjoyment and perceived value the Fafung community attaches to the 32 ecosystem services that were the focus of this study. Moreover, using land-use/-cover (Figure 3.3 and Table 3.1) as a frame, this chapter provides evidence of the availability of ecosystem services and analyses the results from the broader perspective of the research objectives as raised in the problem statement.

Chapter 5 presents the conclusions drawn from the results discussed in chapter 4 and makes certain recommendation based on the findings of this study which, in future, can inform decision making as well as strategic planning for the restoration/rehabilitation of natural resources and contribute to sound ecosystem management in support of the Integrated Development Plan developed at local government level.

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CHAPTER 2: LITERATURE REVIEW

2.1 The role of ecosystem services

The Millennium Ecosystem Assessment (MEA) conducted under the auspices of the United Nations Environment Programme in 2005 revealed the challenges affecting ecosystems around the world. This assessment had as its objective to assess the consequences of ecosystem changes for human well-being and to establish a scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being. Four working groups contributed to this assessment and focused, respectively, on conditions and trends, scenarios, responses and sub-global assessments (MEA, 2005). The intention here was to synthesise each group's findings in response to the following core questions: How did ecosystems and their services change? What caused these changes? How did these changes affect human well-being? How might ecosystems change in the future and what are the implications for human well-being? What options exist to enhance the conservation of ecosystems and their contribution to human well-being?

Stemming from the MEA, the United Nations Development Programme (UNDP) developed a set of Sustainable Development Goals (SDG) to provide the guiding framework for aligning global investments in social, economic and environmental development over the next 15 years (Wood *et al*., 2018). The identified goals resort under seventeen headings: (1) no poverty, (2) zero hunger, (3) good health and well-being, (4) quality education, (5) gender equality, (6) clean water and sanitation, (7) affordable and clean energy, (8):decent work and economic growth, (9) industry innovation and infrastructure, (10) reduced inequalities, (11) sustainable cities and communities, (12) responsible consumption and production, (13) climate action, (14) life below water, (G15) life on land, (16): peace, justice and strong institutions, and (17) partnerships for the goals (UNDP, 2015).

The MEA (2015) synthesis of the linkages between ecosystem services and human well-being, as illustrated in Figure 2.1, reveals that rather than regarding the environment as a constraining factor, it should be viewed as an enabling factor in any attempt to achieve sustainable development – especially in rural landscapes (Wood & De Clerck, 2016).

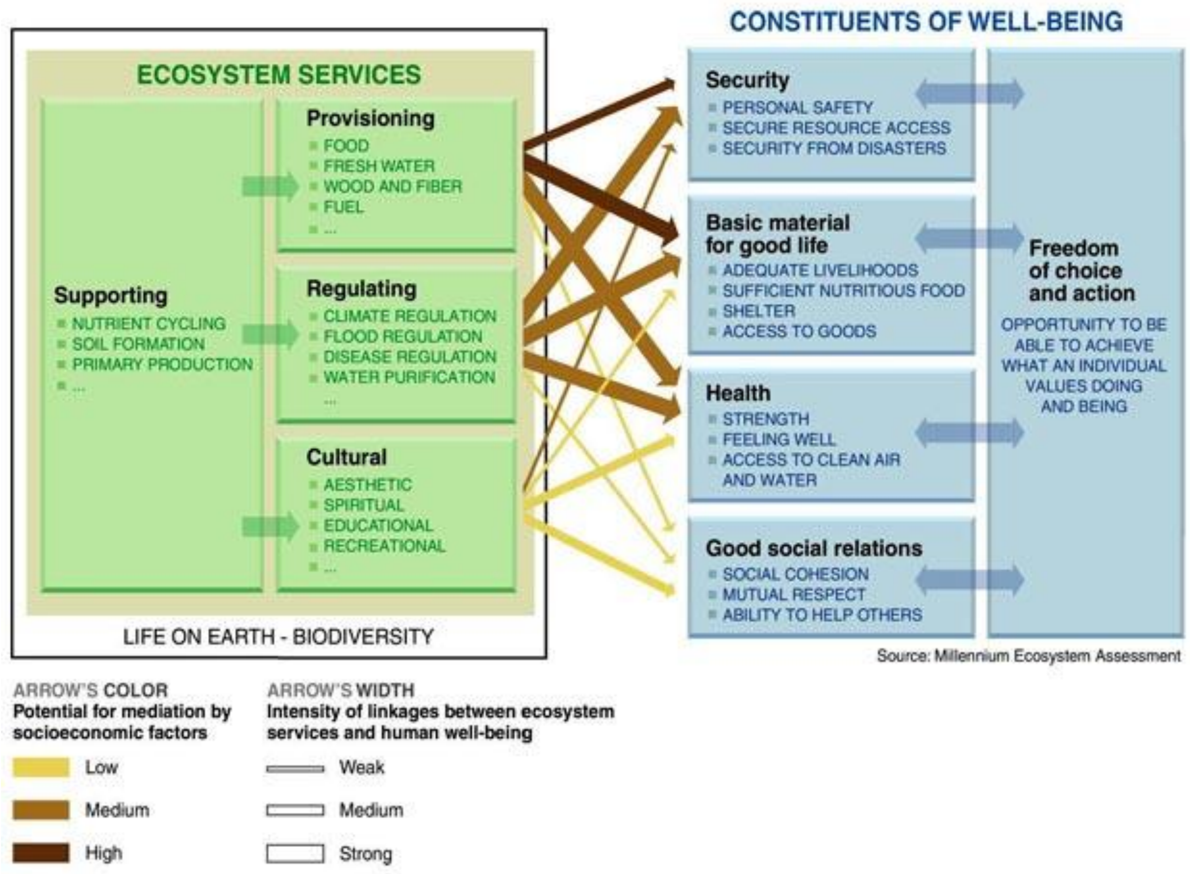

Figure 2.1: Linkages between ecosystem services and human well-being (MEA, 2005).

As illustrated in Figure 2.1, people the world over are dependent on ecosystems and the services they provide for their well-being. Clearly, there are strong linkages between certain categories of ecosystem services and their correspondent components of human well-being that can be mediated if certain socio-economic factors were attended to.

Obviously, the strength of the linkages and the potential for mediation (trade-offs) will differ from ecosystem to ecosystem and from region to region while economic, social, technological and cultural factors are also bound to have an impact on how ecosystem services influence human well-being, and how the usage thereof influences the environment. The downside is that as much as ecosystems have served humankind by contributing to a net gain in its well-being and economic development, the growing demand for food, fresh water, timber, fibre and fuel has resulted in a transformation of the planet, causing great harm to many organisms and ecosystems (Shackleton *et al.*, 2008).

In an attempt to contribute towards the sustainable management of ecosystems, the United Nations Convention to Combat Desertification developed a scientific conceptual framework aimed at attaining land degradation neutrality, which implies that losses should be balanced by gains so as to achieve a position of no net loss of healthy and productive land (UNCCD, 2016). The resultant policy brief defines land degradation neutrality (LDN) as “a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase with specific temporal and spatial scales and ecosystems” and proposes that a two-pronged approach (i.e. a combination of measures to avoid/reduce further land degradation and measures to reverse past degradation) be followed to attain LDN. On a global scale, attaining a state of land degradation neutrality will have a positive effect on poverty reduction (SDG 1), food security (SDG 2), clean water and sanitation (SDG 6), affordable and clean energy (SDG 7), responsible consumption and production (SDG 12) and climate action (SDG 13).

However, De Groot *et al*. (2018) cautions that the benefits of ecosystem services should be analysed and quantified in a standardised, transparent and certified manner. Only by following such an approach will ecosystems’ value and resultant return in the form of benefits be apparent and warrant an investment in nature conservation, land restoration and sustainable land management. This has led to some governments in the world expanding their national accounting systems to include a Natural Resource Account which reflects how the macro-economic benefits derived from natural resources, with the inclusion of ecosystem services, have been used to generate wealth (Le Maitre *et al.*, 2007).

On a sub-continental level, the literature review revealed that very few studies have been conducted to date that specifically focused on the linkage between natural resources/ecosystem services and the promotion of human well-being (poverty alleviation/economic advancement) in Southern Africa. Given the scope of the Fafung study, the findings of the following researchers were of particular interest, though: The study conducted by Wilkie and David (2020) regarding Namibia’s ‘bush business’ as supported by the findings of Laufs and Kashandula (2019) who conducted a study on behalf of Namibia’s de-bushing advisory services (Das Namibia); the study Shackleton *et al.* (2008) published under the auspices of the Consortium on Ecosystems and Poverty in Sub-Saharan Africa; and the RESLIM study published by Midgley *et al.* (2013) which focused on the Limpopo river basin in particular.

Namibia is one of the arid countries that form part of the Southern Africa Development Community where bush encroachment is a serious problem, especially in the savanna areas (Wilkie & David, 2020). Since bush encroachment has an adverse impact on ecosystem services, especially rangelands’ grazing capacity, many a country in this part of the world has adopted thinning as a management approach to address this issue in densely populated areas (Turpie *et al.*, 2019). In Namibia, though, government and other stakeholders in the biomass value chain have succeeded in turning this problem into an opportunity. Through beneficiation, the biomass generated by bush clearing is nowadays used as an energy source (charcoal, briquettes, fire wood) as well as to construct homes and kraals and as a component of sought-after, eco-friendly furniture, arts and crafts. To aid this trade-off, the country has established a de-bushing advisory service, Das Namibia, whose sole purpose is to advise farmers on bush control and to establish linkages between those who generate biomass and investors who are interested in bush biomass utilisation operations (Laufs & Kashandula, 2019).

Commissioned by the Consortium on Ecosystems and Poverty in Sub-Saharan Africa, Shackleton *et al.* (2008) conducted a situational analysis of six southern African countries, namely Botswana, Mozambique, Namibia, South Africa, Swaziland and Zimbabwe. These countries were selected because at least 50% of their land area had a ratio of mean annual precipitation to potential evaporation of less than 0.5. The intention with this analysis was to, firstly, investigate the links between ecosystem services and poverty alleviation in the arid and semi-arid countries of Southern Africa; secondly, to identify the factors influencing these linkages (such as drivers of ecosystem change and trade-offs); thirdly, to identify knowledge gaps that need to be addressed by means of long-term research and advocacy programmes to inform appropriate policy; and fourthly, to manage interventions as well as to identify strengths and weaknesses in the countries' capacity to manage ecosystem services.

As an extension of the above situational analysis, USAID commissioned a five-year programme aimed at improving the lives of communities and the sustainability of ecosystems in the Limpopo river basin. Commonly referred to as the RESLIM study (Resilience in the Limpopo River Basin), this trans-border project involves South Africa, Botswana, Mozambique and Zimbabwe where millions of people face water shortages and a decline in crop productivity interspersed with severe flooding that can largely be ascribed to the impact climate change has on this arid region (Midgely *et al.*, 2013). As was the case with the situational analysis, RESLIM is modelled on the spatial variability of biophysical, biological and socio-economic factors and is of critical importance for restoration and rehabilitation projects that are designed to enable ecosystems to function and produce services required for human well-being, including mechanisms to deal with extreme events such as droughts and floods. A combination of exposure and sensitivity was used to model this study resulting in the identification of eight hotspots in the Limpopo River basin. As an embedded community, Fafung and its associated ecosystems are spatially located within two of these hotspots, namely Pretoria North and Moretele (Midgley *et al.,* 2013).

According to Gordon-Cumming (2017), to date, only one other study looked at the Moretele area. This study set out to establish and assess the factors that affect the local community's attitudes towards conservation and protected areas through their association with the Borakalalo Nature Reserve across four domains: biodiversity conservation, protected areas with special reference to Borakalalo, participation and benefit sharing. The findings revealed that biodiversity is inextricably linked to ecosystem services and that the community regarded conservation as a primary step to prevent degradation and to minimise or avoid ecosystem dysfunction. Restoration and/or rehabilitation are secondary following failed efforts to conserve.

In addition to the global, continental and regional studies referred to above, papers and policies published by South Africa's national government pertaining to the conservation of natural resources and, by inference, ecosystems should by no means be discounted. In 2011, the National Planning Commission resorting under The Presidency published a National Development Plan in which an entire chapter is devoted to “ensuring environmental sustainability and an equitable transition to a low-carbon economy" (NPC, 2011).

Of note here is that this plan recognises that the country’s rich endowment of natural resources and mineral deposits can potentially aid the transition to a low-carbon future and a more diverse and inclusive economy. Furthermore, it acknowledges that environmental sustainability must be prioritised in an attempt to overcome developmental challenges and to build resilience against the effects of climate change, particularly in poor communities. For this reason, if a more sustainable society is to be developed and a low-carbon economy is to be realised, the plan purports that every effort should be made to invest in and to develop the necessary skills and technology that will capacitate South Africans to become a zero-waste society capable of developing environmentally sustainable green products, services and technologies that will contribute to the creation of jobs in niche markets where South Africa has or can develop a competitive advantage.

Stemming from the objectives outlined in the NDP referred to above, the then Department of Environmental Affairs published its targets for attaining land degradation neutrality (DEA, 2018) which, yet again, underscore key national development priorities, namely to reduce poverty, to ensure food security, to create jobs and to reduce inequality.

CHAPTER 3: METHODOLOGY

3.1 Study area

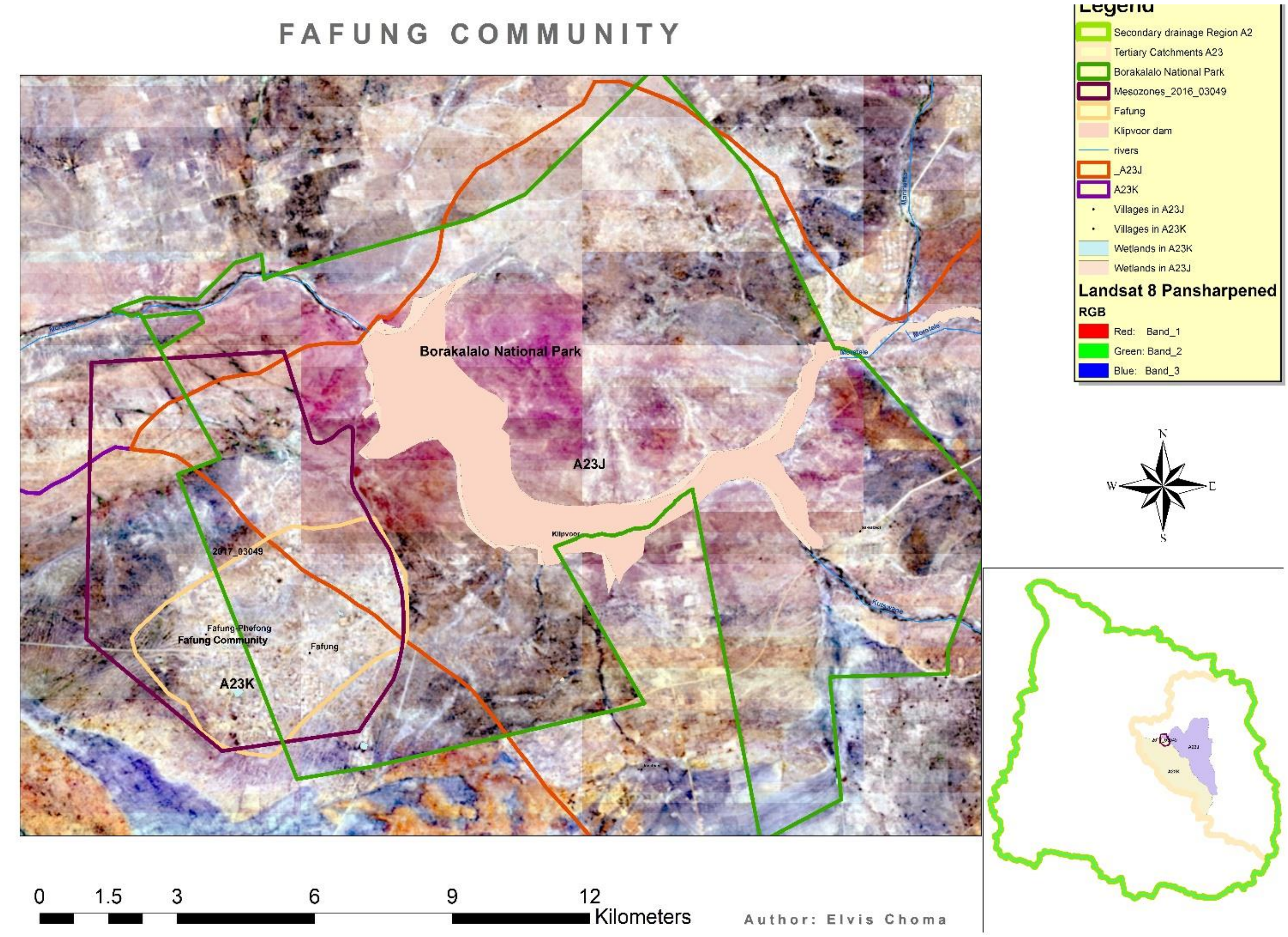

Figure 3.1: Locality map of the Fafung community in Water Management Area 1 (Limpopo) (created using ArcMap).

Fafung village is situated approximately 60.8 km to the north-west of Madibeng on the R387 within the Pienaarsrivier valley. A tributary of this river, commonly referred to as the Moretele River, drains into the Klipvoor Dam in Borakalalo Nature Reserve (Figure 3.1). According to the Department of Water and Sanitation's classification of significant water resources in this area (SA, 2012), Fafung resorts under Water Management Area 1 (Limpopo). The same classification indicates that sub-catchment A2 (i.e. Crocodile West) is comprised of a mountainous area with a moderately low variable seasonable rainfall of between 600 and 650 mm per annum. The altitude of the Fafung community ranges between 950 m and 1,200 m above sea level as shown in Figure 3.2 below.

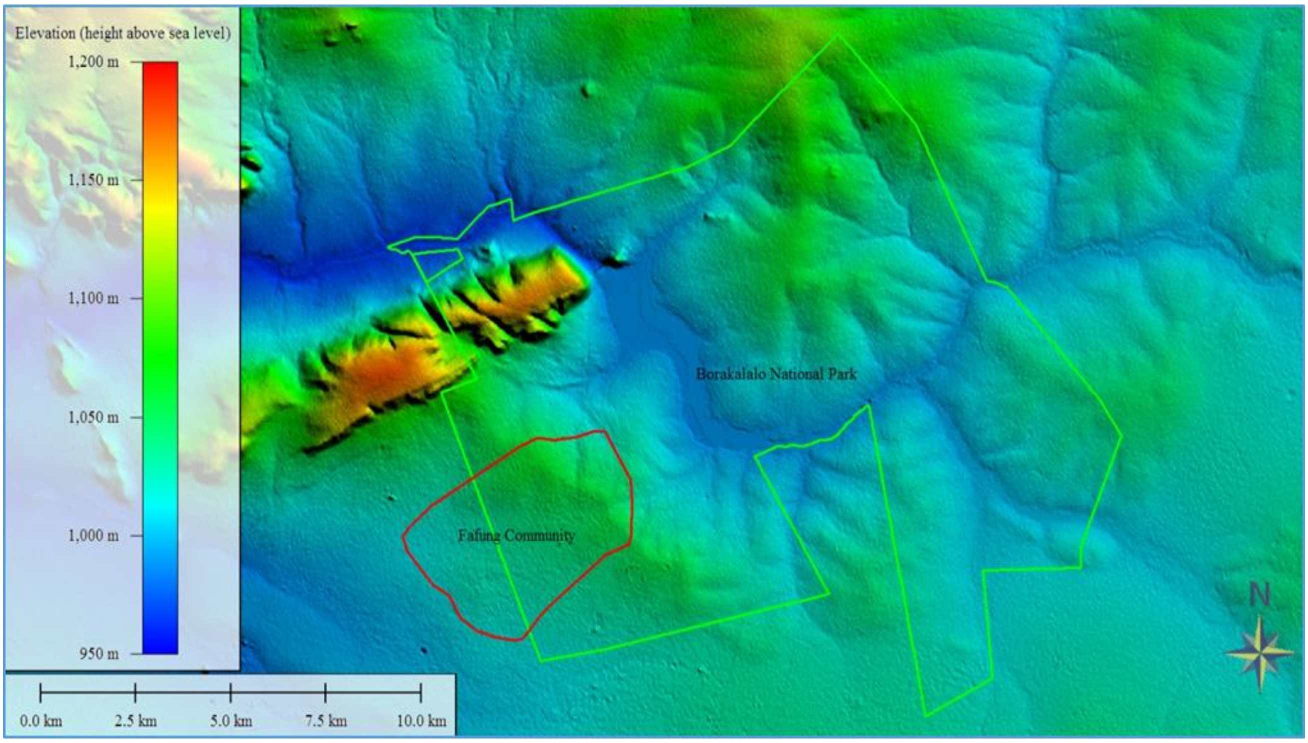

Figure 3.2: Elevation map for the Fafung community

The geographical coordinates of this village, which borders on the Borakalalo Nature Reserve to the west, are 25^{0}11'38'' and 27^{0}47'49' and resorts under the savanna biome within the central bushveld region (Mucina & Rutherford, 2006). As per the definition of Scholes and Archer (1997) quoted in Khavhagali and Bond (2008), "savannas are tropical seasonal ecosystems with a continuous grass layer, mixed with forbs and sedges with a variable cover of trees and shrubs". Of particular importance to the socio-economic well-being of tropical regions, savannas are associated with a distinct dry and wet season and are typified by C_3 trees and C_4 grasses that are highly shade-intolerant albeit tolerant to fires (Turpie *et al.,* 2019).

According to Claassen (2013), integrated water-resource management is important in as far as scaling of ecosystem services is concerned because this allows for the integrated management of the physical environment within a broader socio-economic and political framework. Here it ought to be noted, though, that these services may flow from one area to another and that they tend to follow the direction or the flow of water and air which does not have defined physical boundaries. In as far as municipal boundaries are concerned, Fafung straddles the boundaries shared by the Madibeng (NW372) and Moretele (NW371) local municipalities, both of which fall within the Bojanala Platinum District of the North West Province (DC37) (SDF, 2015). Despite the fact that the community is by and large embedded within NW372, the landscape and environment are the same as that found in

NW371 where the Moretele hot spot is situated (see the RESLIM study by Midgley *et al.,* 2013).

As indicated under the literature review, only one study regarding ecosystem services has thus far been conducted in communities adjacent to the Borakalalo Nature Reserve, namely that of Gordon-Cumming dated 2017. Given that Fafung is one of the communities that boarder on this reserve, the DEFF would like to address some of the related challenges by developing a process and methodology to evaluate the availability, use, enjoyment and value of ecosystems before initiating restoration/rehabilitation interventions in the area.

As a matter of fact, the Fafung community owns a specific portion of land inside the reserve (see Figure 3.1) which they manage in accordance with an agreement entered into between the reserve's board and the residents. A process to formalise this agreement by way of registering a Community Property Association is currently underway.

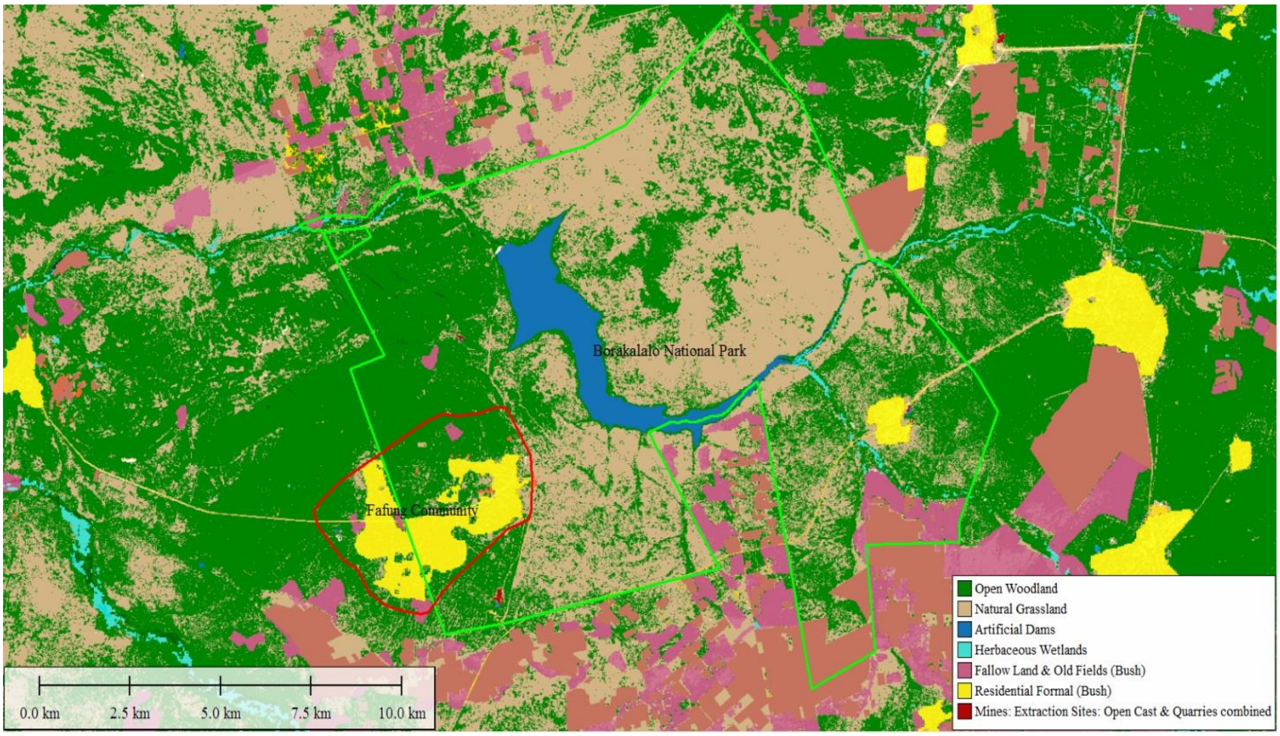

Figure 3.3: Latest Fafung land-cover/use map

As is evident from Figure 3.3, seven land-use/-cover classes are available to the Fafung community (circled in red) and other communities in their immediate vicinity: open woodland (class 4), natural grassland (class 13), artificial dams (class 19), herbaceous wetland (class 22 & 23), fallow land and old fields – bush (class 43), residential formal – bush (class 48), and mines comprising both open-cast extraction sites and quarries (class 69). Other features on the map include the national park's boundary, roads and the settlement's boundary.

A brief explication of the seven classes identified above is provided in Table 3.1 below. Note that these explications have been derived from SANLC 2018.

Table 3.1: Explication of seven classes of land-use/-cover available to the Fafung community

Class Number	**Class Name**	**Class Definition**
4	Open woodland	Naturally tall woody vegetation communities, with canopy cover ranging between 10-35% and canopy heights exceeding 2.5 metres. Typically represented by open bush and woodland communities.
13	Natural grassland	Natural and/or semi-natural indigenous grasslands, typically devoid of any significant tree or bush cover and where the grassland component is typically dominant over any adjacent bare ground exposure. Note this definition differs slightly from the equivalent gazetted class definition (i.e. total plant canopy cover ranges between (4-100%) in order to provide a more comparable context for the 1990 and 2013-14 South African National Land-cover (SANLC) datasets. Typically representative of low, grass-dominated vegetation communities in the grassland and savanna biome.
19	Artificial dams	Man-constructed artificial inland water bodies, ranging from farm dams to large reservoirs and, if image detectable, large irrigation canals. The spatial extent of the classification of water is the cumulative extent of all image-detectable water surfaces from all available images used in the production of the national land-cover (NLC) dataset, which is comparable to the annual maximum extent. Note that the accordance of rooted or flooding emergent aquatic vegetation that covers the water surface may influence the area of image-detected open water.
22 & 23	Herbaceous wetlands (currently mapped and previously mapped extent)	Natural or semi-natural wetlands covered in permanent or seasonal herbaceous vegetation. The mapped wetlands represent the surface wetlands detectable from image-detectable surface vegetation characteristics, which may differ from soil-profile-based wetland delineations. This specific wetland class represents wetlands identified in comparable archival land-cover datasets that have not been detected in the current national land-cover modelling (presumably as a result of seasonal characteristics), nor have been lost to other more recent land-uses or land-cover. The class represents primarily riparian wetland areas but can also include emergent aquatic vegetation in pans. Note that the full spatial extent of any pan landscape feature is often represented by a combination of both flooded pans, dry pans and/or herbaceous wetland vegetation classes, although this may not still represent the full extent of the physical pan depression, especially if the pan depression

		has been grass covered for a long time without flooding.
43	Fallow land and old fields (bush)	Long-term, non-active, previously cultivated lands that are now overgrown with bush-dominated woody vegetation. Typically the cultivated land unit is no longer image detectable. Historical field boundaries (supplied by SANBI) have been mapped from archival topographical 1:50,000 maps circa 1950s-70s. This class is only represented if it has not been modified to a more recent, alternative land-cover or land-use class.
48	Residential formal (bush)	Built-up areas primarily containing formally planned and constructed residential structures and associated utilities. In the case of Fafung, settlements are situated in and around highly bush-encroached areas where dwellings have been erected in fairly scattered sections buffered by woodlands.
69	Mines: Extraction sites: Open cast and quarries *combined* (magenta).	Non-vegetated, active and/or non-active extraction pits associated with surface-based mining activities, including open-cast mines, quarries and road-side borrow pits, etc. Road-side burrow pits and sand mines are quite prevalent in and around Fafung. These are the result of construction projects undertaken by the government to build houses, schools, roads and the like.

3.2 Research design and strategy

A cross-sectional design guided this study. According to Mann (2003) and Trochim (2006), a cross-sectional design can be viewed as a type of observational study that analyze data from a population, or a representative subset, at a specific point in time and may be used to measure the prevalence of specific phenomena. In this study, the research process consisted of three phases: The first phase, which included non-participant observations, was used to document ecosystem services with the aid of a spatial mapping programme called Global Mapper (2017). Given the proximity of Fafung to the Borakalalo National Park and the fact that a portion of this community's land falls within the reserve, the scaling of ecosystem services within the reserve as well was warranted. As Pelser *et al.* (2015) pointed out, ecosystem services flow from reserves to the benefit of adjacent communities and for this reason, rather than isolating them, reserves ought to be integrated into the economic and social context within which they are located.

In the second phase of the study an attempt was made to determine which of these ecosystem services are currently being used, enjoyed and valued by local communities in the area. In this regard, use was made of a structured questionnaire to collect 'social' data related to the current availability, use, enjoyment and value of ecosystem services, a practice which is in keeping with the recommendations made by Bryman (2006) regarding the integration of quantitative and qualitative research in a cross-sectional design.

The third and final phase of the study involved making recommendations on how local communities can benefit further from the ecosystem goods and services available in the area.

3.3 Documentation and mapping of ecosystem services in the Fafung community

Maps are essential for decision making regarding the current state (availability, use, enjoyment and value) of ecosystem services, their potential future and whether interventions such as restoration projects will be required to enhance their sustainability. The first phase of this study involved no human participants. To begin with, a list of all potential ecosystem services (ES) was developed from available literature. Based on the MEA (2015), these were broadly classified according to the following main categories: food, raw materials, fresh water, medicinal resources, local climate and air quality regulation, carbon sequestration and storage, moderation of extreme events, waste water treatment, erosion prevention and maintenance of soil fertility, pollination, biological control, habitats for species, maintenance of genetic diversity, recreation and mental and physical health, tourism, aesthetic appreciation and inspiration for culture, art and design, and spiritual experience and sense of place. The presence and availability of each ecosystem service were then documented in terms of being either “limited”, “common” or “abundant” (Brown *et al.*, 2007). Finally, the location of each good and service was documented with the aid of a colour-coding system.

As indicated in Figure 3.1 above, the Fafung community falls within quaternary catchment A23K while a small portion overlaps with A23J. Nested hierarchical catchments or hydrological areas, as adopted by the South African Department of Water and Sanitation, play a crucial role in as far as taking and implementing decisions about the planning and management of water resources are concerned. These catchment areas range from primary through to secondary and tertiary, with the smallest operational unit being the quaternary catchment (Maherry *et al.,* 2013). To determine the contribution of quaternary catchments to the risk and vulnerability of the Limpopo River basin, Farina (2007) advises that using nested hierarchical catchments would be the correct scale.

The Mesozone set demarcates South Africa as a grid comprised of 25,000 spatial units. Although not uniform in shape, these Mesozones are roughly the same size (˜50 km^2) and have been created in such a way that they fit completely within current municipal areas and other significant geo-economic and historic demarcations (Mans *et al.*, 2018). With the aid of computer software, these zones are then used as primary components to construct a geospatial analysis platform.

Given that spatial and temporally aligned socio-economic data is of critical importance to support a range of planning activities, including the prioritisation of infrastructure projects, the South African Department of Rural Development and Land Reform (2019b) confirmed that census data captured by StatsSA (2011) per mesozone formed the basis for the formulation of the draft National Spatial Development Framework.

Moreover, this scale also provides a perfect landscape size for monitoring disturbance regimes such as agricultural intensification, afforestation and fires using the chemical components of streams and underground and surface waters. Pollution, land management activities and environmental changes can also be studied and managed at this scale (Farina, 2007).

In as far as the Fafung community is concerned, Mesozone 03049 is the smallest unit and is helpful when socio-economic data sets at local and municipal level need to be taken into account given that Gross Value Add (GVA) in zones of this size is indicative of “how much is where” and helps to derive indicators such as demands on infrastructure and ecosystem services.

3.4 Participants in the Fafung ecosystem services study

The study design involved taking a representative sample (cross-section) from the population in order to generalise findings for the study population. In this regard, Omair (2019) emphasises the importance of randomly selecting the sample by using an appropriate probability sampling technique so that it is possible to identify the proportion of the population which, in this case, makes use of ecosystem services. To this end, a total of 100 households were systematically selected during the second phase of the study (Creswell, 2014).

Twenty fieldworkers were recruited in consultation with gatekeepers and trained on how to use the questionnaires. They were then divided into four groups and dispatched to administer questionnaires in four sections of the Fafung community.

Fieldworkers were instructed to randomly select an initial household in their section of the community, and thereafter to target every third household. Households that were unoccupied were to be replaced by the next nearest available household, up to a point where a predetermined sample size was reached.

Furthermore, all participants had to be members of the Fafung community and a representative of a household (i.e. a father or mother or child aged 18 or older who could speak on behalf of the household). All genders and all race or ethnic groups were to be included. In this way, the sampling frame aimed to ensure distributive justice (e.g. equal representation) and a fair selection of participants. These criteria are also in line with African traditional practices and community-based research in general.

The questionnaire, attached as Appendix B, consisted of two sections. Section A covered questions relating to the socio-demographic profile of the participants and section B covered questions regarding ecosystem service usage.

Section A: “Socio-demographic profile” included questions regarding:

iii Gender;
iiii Culture/ethnicity;
iiiii Nationality;
iiiv Home language;
iiv Level of education;
iivi Relationship status;
iivii Monthly household income; and
iiviii Number of dependants

Section B: “Ecosystem use” consisted of one question: “To what extent do you use, enjoy or value nature?” This question, though, was asked in relation to 32 ecosystem services classified in four main categories (namely provisional, regulating, cultural and supporting), and participants were asked to indicate their preferred score on a scale ranging from 1 to 5:

1. Not at all
2. To a small extent
3. To a moderate extent
4. To a fairly large extent
5. To a great extent

3.5 Procedure

The first part of the research process involved the documentation and mapping of existing ecosystem services as well as community engagement. At the time, gatekeepers and mediators were identified and their goodwill permission obtained.

The Fafung community falls in a proclaimed area with no street name or numbers. It was also a challenge to establish the exact number of households in the area (via the chief or available population statistics), and it was also not possible to use remote sensing because the area is heavily bush encroached. Consequently, a systematic method was used to identify potential participants for the second phase of the study whereby every x^{th} household was selected to take part in the research with a target sample of 100 households set as a minimum for the study. The intention with this method was to distribute any potential risks or benefits across the entire community and to ensure that no single section is overburdened.

The remaining phases of the study commenced as soon as ethical clearance had been obtained from the NWU's Human Research Ethics Committee (HREC reference number NWU-00108-18-51). To begin with, fieldworkers were trained in the process and procedure for collecting data and obtaining informed consent from the participants. At this point too, the questionnaire that was to be used to collect data was translated to the community's dominant languages (i.e. Setswana).

All participants could only be involved in the study after they have accepted and signed the informed consent form, thereby indicating that their participation was voluntary, free of undue influence, inducement, coercion or inappropriate incentives. As defined by Helsinki, cited by Greeff and Towers (2018), informed consent refers to a written, dated and signed decision to take part in a research project taken freely after being duly and adequately informed of its nature, significance, implications, aims, methods, sources of funding, conflict of interest, institutional affiliation of the researcher, anticipated benefits and potential risks by a competent fieldworker. Moreover, participants were also made aware of the risks associated with the study and of their right to withdraw from the study at any time.

In obtaining informed consent, fieldworkers ensured that the participants understood all aspects of the study. This they did by explaining all aspects of the research in participants' chosen language and at their level of education by using words that the participants are familiar with and, for example, by avoiding or carefully explaining the use of jargon, acronyms and abbreviations.

The final phase involved returning to the community to share with them what had been learnt and to explore with them how they could benefit further from the ecosystem services in their area.

As far as exclusion is concerned, adults who were not capable of providing informed consent were not included since it would be unethical to include people who are unable or unwilling to provide consent. Note, too, that only persons aged 18 or older were targeted in this study.

3.6 Data-collection procedure and analysis

Data was collected via a structured questionnaire and analysed using SPSS 23 (Field, 2005). As indicated, fieldworkers were trained on how to administer questionnaires and how to collect and capture data on tablets. The collected data was submitted to the NWU's Statistical Consultation Service to ascertain statistical justifiability based on the electronically generated results.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Gender distribution

Figure 4.1 (Gender profile of Fafung community) represents the outcome of the questionnaire administered by the fieldworkers. The findings show that more males (52%) than females (48%) took part in the study (mean = 50%).

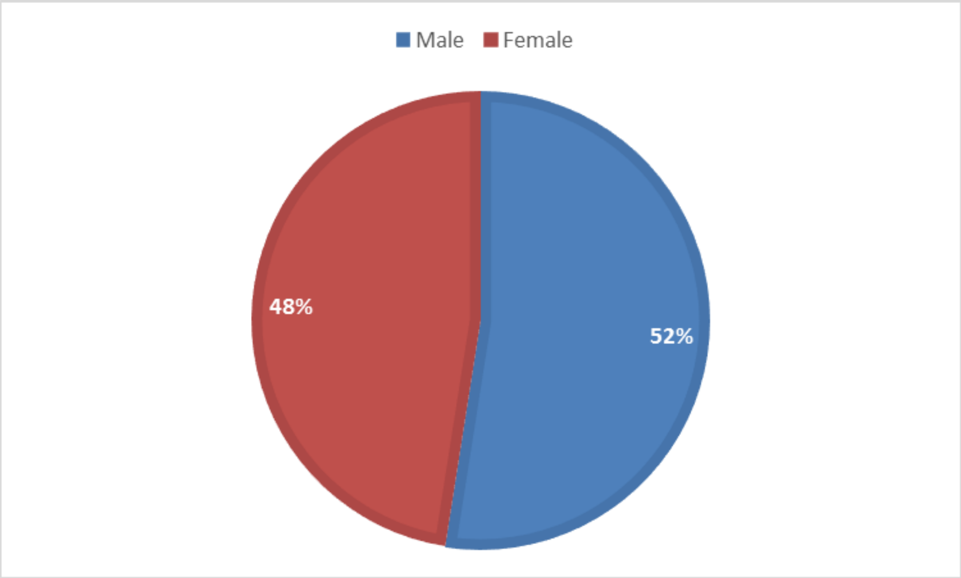

Figure 4.1: Gender profile of Fafung Community

Even though there were slightly more males than females, gender is representative enough to make an inference about the entire population of the Fafung community. The intention was to achieve a balance in gender representation, but this was not practical given that households were randomly selected and not selected based on gender. Moreover, since the ecosystem services study is not concerned with sexual attitudes, beliefs and behaviours (Dickinson *et al*., 2012), this marginal variance will not have a serious impact on the results. In 2011, census data indicated that there were more females (50.19%) than males (49.81%) in Fafung (StatsSA, 2011). However, significant shifts in population composition might have occurred during the seven-year gap between the last census and this study.

4.2 Nationality

Table 4.1 indicates that the majority of the participants are South African nationals (96%), followed by other nationalities (2%) and Lesotho and Mozambique nationals (1% each). The mean is 10%.

Table 4.1: Nationality of the Fafung Community

Nationality	Percentage
Lesotho	1%
Mozambique	1%
South Africa	96%
0ther	2%
Mean	25%

According to StatsSA (2011), the total population of Fafung is 2,086. Black Africans constitute 98.90%, whites 0.77%, coloureds 0.14%, others 0.14% and Indian or Asian 0.05% of the total population, which compares well with the observations made in this study. Indian or Asian and foreign nationals were classified under *other* in both the StatsSA (2011) and Mesozone data (See Fig. 3.1).

Furthermore, Le Maitre *et al.* (2007) indicated that cultural backgrounds influence how people view their environment and, thus, how they view and value ecosystem services. Furthermore, these authors hold that studies regarding ES should also address the diversity in the norms and values held by society. It is in the light of this argument that the inclusion of other nationalities in the assessment of ES should be considered, especially since South Africa’s rich natural diversity is viewed differently by people from African, European and Asian descent.

4.3 Language profile

Table 4.2 shows that the most frequently spoken language is Setswana (94%), followed by Sesotho (3%), other languages (2%) and, lastly, isiZulu (1%). These percentages differ from those reported by StatsSA (2011) where the census revealed that the dominant languages in the Fafung community were Setswana (90.08%), followed by Xitsonga (1.87%), English (1.73%), isiNdebele (1.39%), Afrikaans (1.20%), isiZulu (1.15%), Sesotho (1.10%), Sepedi (0.82%), other (0.24%), Sign Language (0.19%), Tshivenda (0.10%), SiSwati (0.05%) and isiXhosa (0.05%). The results obtained from this study could either mean that some of the frequently spoken languages were not included in the sample or that the population structure has changed since 2011.

Table 4.2: Languages of Fafung community

Zulu (isiZulu)	1%
Xhosa (isiXhosa)	0%
Afrikaans	0%
English	0%
Northern Sotho (Sesotho sa Leboa)	0%
Tswana (Setswana)	94%
Sesotho	3%
Tsonga (Xitsonga)	0%
Swati (siSwati)	0%
Venda (Tshivenda)	0%
Ndebele (isiNdebele)	0%
SA Sign Language	0%
Other languages	2%
Mean	8%

The variation in the study results as compared to StatsSA (2011) and Mesozone data (See Fig. 3.1) explains the degree of movement or migration of people from Fafung to cities or urban areas, a trend that is observed in many rural areas in South Africa (FAO, 2017).

4.4 Education

As indicated in Figure 4.1, 31.7% of participants have completed their secondary education, 26.7% have some secondary education, 15.8% have some primary education, 10.9% have post-school qualifications, 9.9% have completed their primary education, 3% have university degrees and 2% have no education. The mean is 13%.

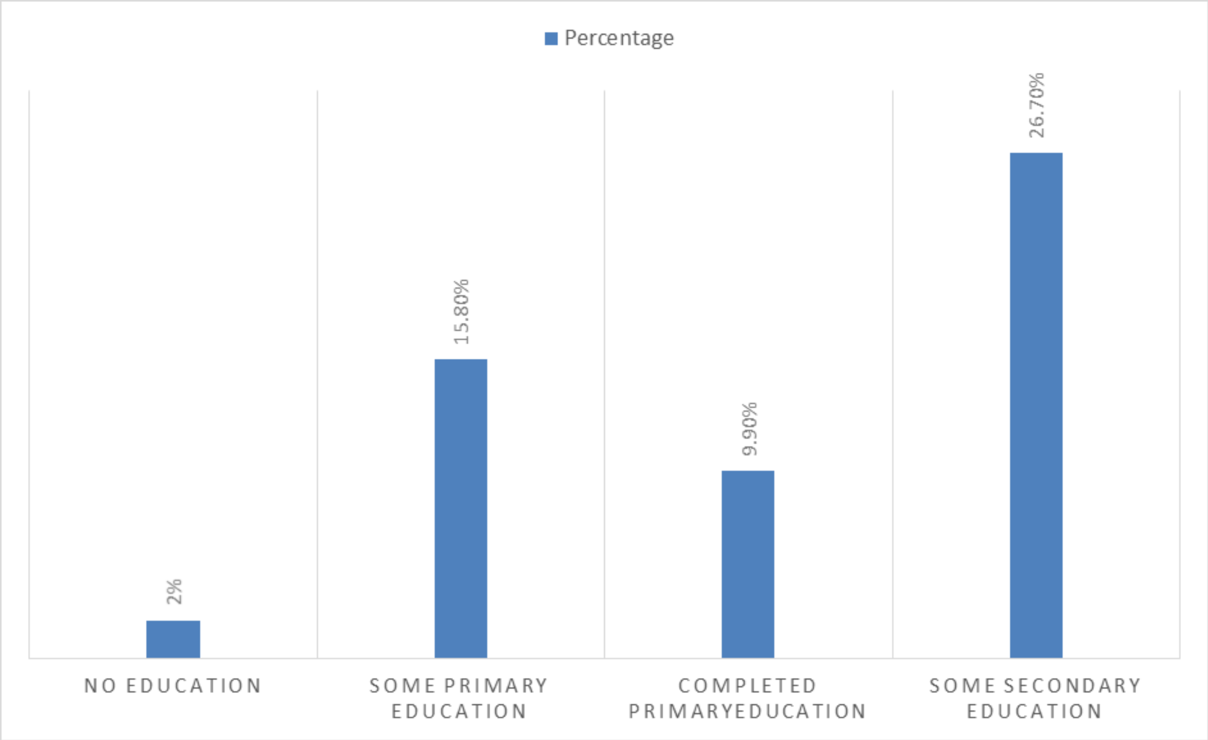

Figure 4.2: Level of education

The low levels of education in the Fafung community can be attributed to barriers such as distances to school which exacerbate both direct and indirect financial constraints on families from low-income groups and result in repetitions, drop-outs and unemployment. For example, institutions offering tertiary education are far removed from this remote rural community with the nearest being a college in Madibeng (some 30 km from Fafung) that offers technical and vocational education and training. Transportation to and from these centres of higher learning remains a challenge since learners have to rely on buses that only run according to a prescribed schedule. On top of that, as early as 2005, the Human Sciences Research Council found that both primary and secondary schools in the area are in a poor condition and understaffed.

4.5 Relationship status

The relationship status of the sampled group is reflected in Figure 4.3: Sixty-six percent are single, 22% married, 5% live with a partner (but are not formally married), 5% are widowed and 2% divorced. The mean is 20%.

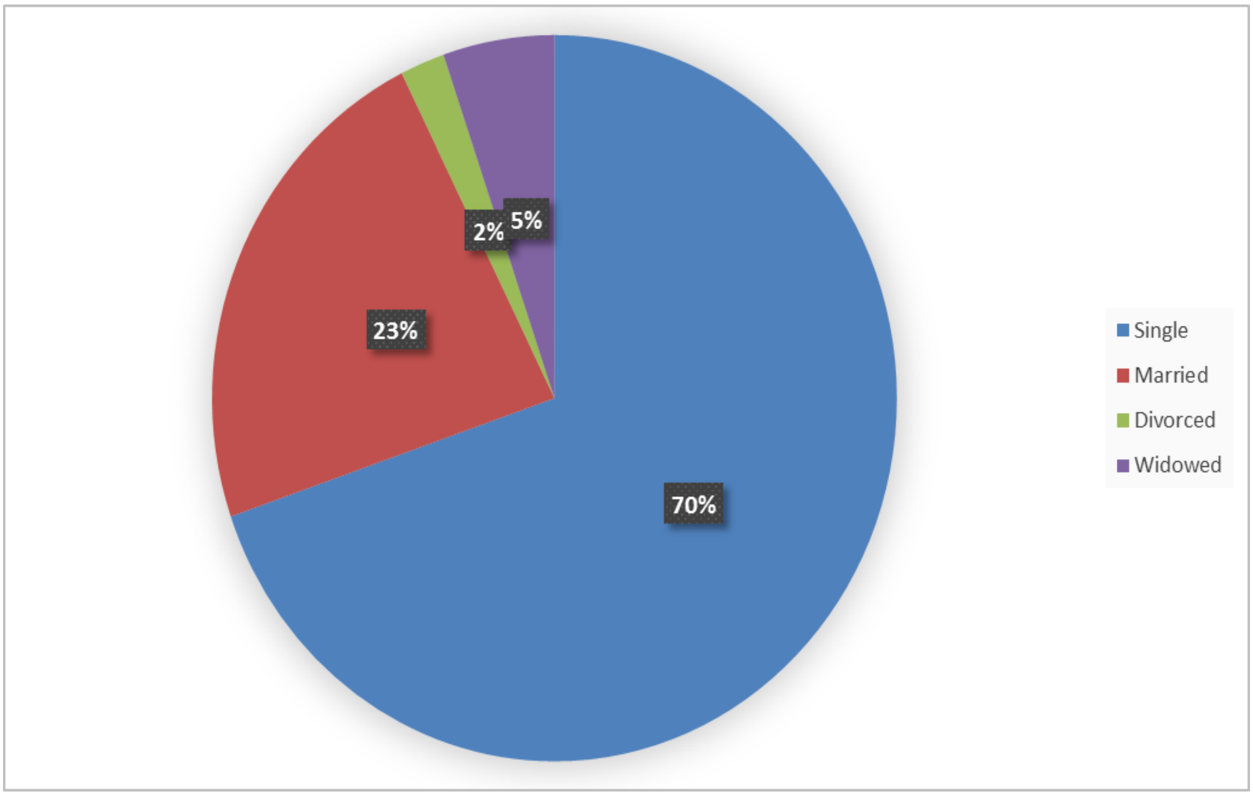

Figure 4.3: Relationship status of Fafung Community

Families in rural areas are affected by fragmentation because men normally migrate to cities in search of better opportunities which are often work-related. The distance between the partners and the time they spend apart is a major cause of the disintegration of relationships (HSRC, 2005). Where couples are not married, the tendency is that respondents will either classify themselves as “single” or, in a worst-case scenario, as “divorced”.

When interpreting the findings above, though, it ought to be kept in mind that Madibeng’s Spatial Development Framework dated 2015 estimated the highest population within the municipal area to be infants younger than four as well as young adults aged between 20 and 34. The latter is indicative of the large number of individuals of working age who are unemployed and who are simply biding their time in the community. This, too, can explain the high percentage of individuals who classified themselves as "single", especially among males.

4.6 Household income

Although nineteen income brackets were listed as options in the questionnaire, the results show that people in Fafung only resort under income brackets 1 to 4. As illustrated in Figure 4.4, the monthly household income of most respondents (87%) falls within income bracket 1 (between R0 and R2,000). This is followed by 10% of the population resorting under income bracket 2 (R2,001 – R4,000), 2% resorting under income bracket 3 (R8,001 – R10,000) and 1% resorting under income bracket 4 (R12,001 – R14,000). None of the respondents indicated that their household income resorts under any of the other income brackets.

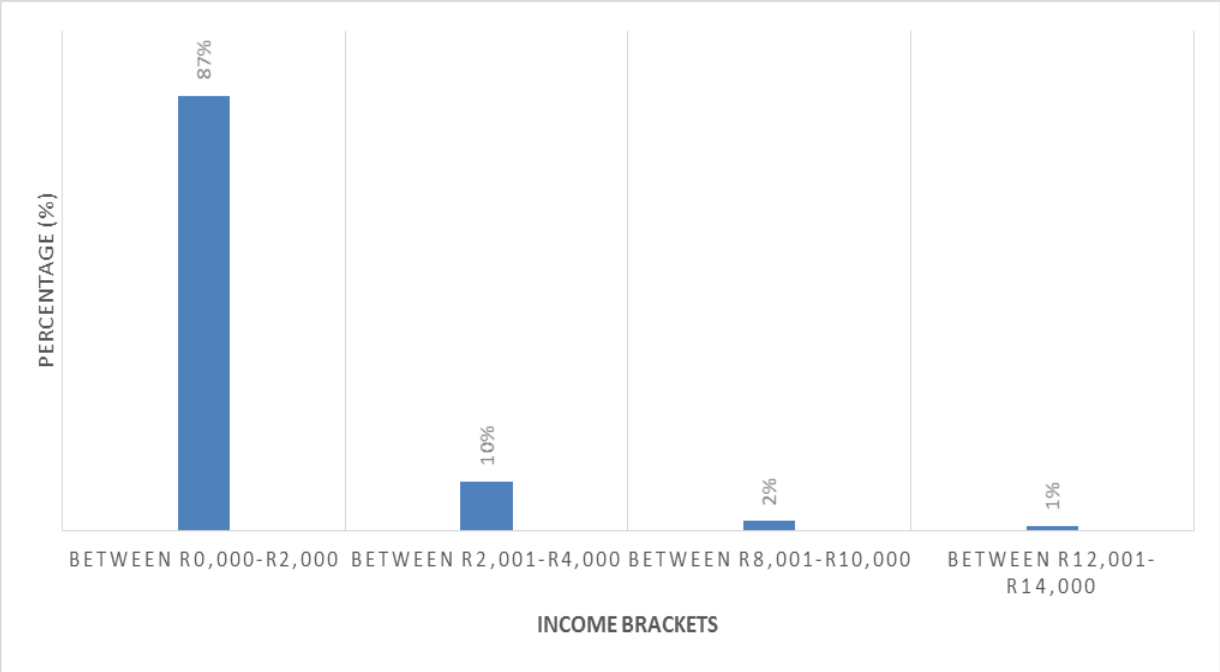

Figure 4.4: Monthly household income

Employment and income are directly related as people normally are engaged in a productive activity to earn an income. Midgely *et al.* (2013) cited high levels of unemployment, competition for informal trade opportunities, poverty and a weakened social fabric as contributing factors to low household income. According to the HSRC (2005), there is a high dependency on social grants and pensions in many rural parts of South Africa, which is linked to the high levels of unemployment. The declining employment opportunities in the mining industry have dire consequences for the Bojanala Platinum District Municipality within which Madibeng is located. Although poverty involves more than income, or the lack thereof, income is important since it provides access to resources. Seemingly, many people in Fafung derive their income from livestock and cultivation of land (subsistence farming); however, the income gained from these activities is not accounted for in the Standard Industrial Classification (SIC) because they are not formalised and should, according to the HSRC (2005), merely be viewed as a means of survival and a form of insurance against misfortune.

The low levels of employment in the Fafung community can directly be ascribed to poor infrastructure development. Due to rural municipalities' inability to generate revenue, the development of hard infrastructure goes astray which, ultimately, lead to low fiscal levels and no prospect of improved service delivery. Given that ecological infrastructure and ecosystem services are available at local level, they can potentially be harnessed to improve the livelihoods and household income of rural communities. To this end, several NRM projects have been deployed across the country with the intention to create a safety net that would simultaneously address the immediate challenges posed by unemployment and unlock ecosystem services' potential to address some of their most dire needs. In the process, the intention is to impart the necessary skills and knowledge so that the community will be capable of managing and sustaining restoration projects even when funding has run out.

A case in point is the restoration interventions currently undertaken in Fafung to counter the impacts of bush encroachment/thickening. Note, though, that in this regard, Cockburn *et al*. (2018) caution that restoration interventions of this nature should always aim to achieve a balance between social and ecological needs and should adhere to the so-called Social Ecological System (SES) approach.

4.7 Dependants

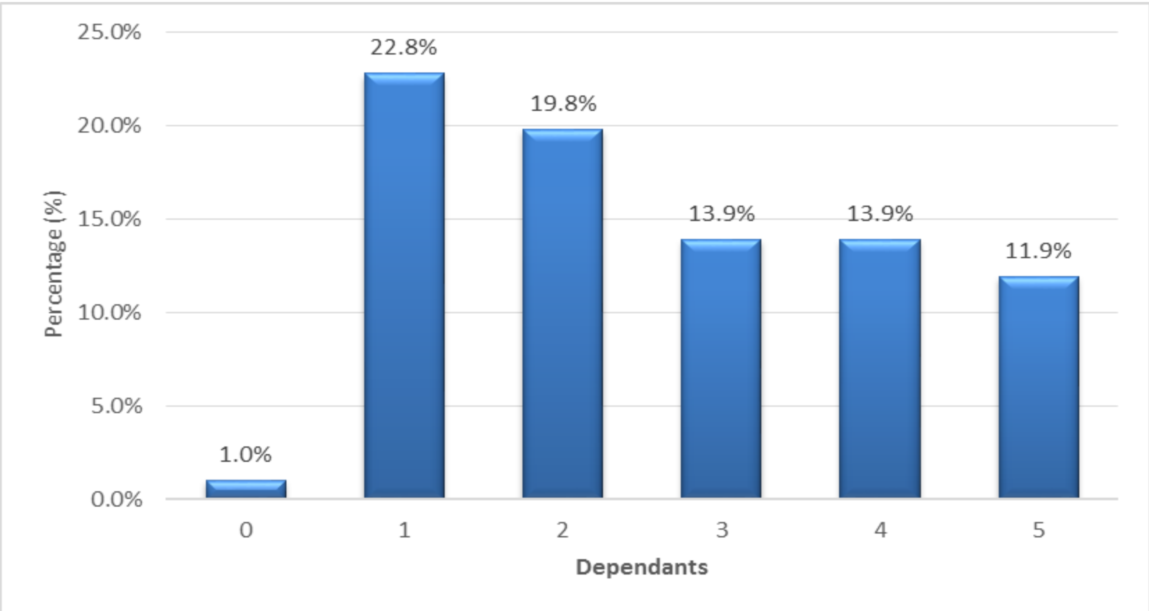

Figure 4.5: Dependants

As reflected in Figure 4.5, 22.8% of the respondents indicated that they have only one dependant, but then 11.9% of the population indicated that they have as many as five dependants.

As revealed in Section 4.3, which dealt with the relationship status of the Fafung community, Madibeng’s Spatial Development Framework (2015) estimates the highest population within the municipal area to be infants younger than four as well as young adults aged between 20 and 34. Adults who have migrated in search of better opportunities and a higher mortality rate could mean that other family members or relatives are now responsible for looking after toddlers and minors. Another contributing factor could be the high birth rate among teens, where the responsibility is transferred to adults in the family or even the whole community while the teens attend school or move out of the community in search of opportunities that will enable them to support themselves and their children.

4.8 The availability of ecosystem services in and around the community of Fafung

According to Montoya-Tangarife *et al.* (2017), there is a direct relationship between land-use/-cover and ecosystem services, where alterations to or changes in the former affect the delivery and flow of ES in the latter. This is clearly evident from Figure 3.3 which reflects the latest land-use/-cover in Fafung.

Moreover, Shackleton *et al.* (2008) regarded changes in land use as a critical driver with a high potential to cause direct changes to ecosystem services and concluded that changes in land-use/-cover in largely un-impacted ecosystems usually impact negatively on ecosystem services and can contribute to further degradation in already degraded ecosystems. Their findings are supported by Farina (2017) who also made use of a spatio-temporal approach to examine the impact of specific land-use/land-cover trajectories on eight ecosystem services over the past 150 years.

The latest land-use/-cover map of the Fafung community (Figure 3.3) was produced with the aid of Global Mapper (2017). To aid interpretation of this map, Table 3.1 describes the legends pertaining to the relevant classes of land-use/-cover. These descriptions have been derived from the land-cover legend and class definition as contained in Appendix 1 to the South African National Land-cover (SANLC) report (Thompson, 2018). This version of the SANLC, developed by GeoTerraImage (2015) and the Council for Scientific and Industrial Research (CSIR), commissioned by the DEA and the Department of Rural Development and Land Reform, is a 20 m-resolution, multi-seasonal Sentinel 2 satellite-imagery land-use/-cover dataset that has been generated from automated mapping modes (as opposed to the conventional image classification procedure used earlier). By way of explanation, Thompson (2018) holds that data collection should take place around May each year because this month represents the optimal, nationally applicable, single-window period for landscape interpretation across South Africa that enables the separation of natural vegetation covers from cultivation activities.

Compared to the LandSat imagery dating back to 1990 and 2013/14, SANLC 2018 clearly reveals an improved level of accuracy in terms of documenting true land-use-related changes compared to land-cover-related changes since land-use features are typically associated with easily (imageable) detectable boundaries and/or unique (image) spectral characteristics. Sentinels 2A and 2B provide much more accurate datasets given the resolution of 20 m, the frequency and quality of collected data (imagery containing 12 spectral bands provided every five days, anywhere across the globe), the spatial accuracy (90.14%) and the ability to delineate land use without any boundaries.

Clearly, Sentinel 2 imagery offers improvements in landscape interpretation and mapping as a result of improved spatial, spectral and temporal characteristics. Consequently, differences between the SANLC 2018 and the SANLC 1990 and 2013-14 datasets should not necessarily be ascribed to true landscape changes but may well be the result of improved interpretation and mapping quality (Thompson, 2018).

In many instances, the words 'land-cover' and 'land-use' are used synonymously and interchangeably. However, Dreber *et al.* (2014) is of the opinion that land-cover does not necessarily imply physical boundaries and should be delineated in terms of gradients because landscapes become continuous over time. Moreover, Sala and Maestre (2014) added that the expansion of landscapes depends mainly on drivers (e.g. climate). For example, the frequency and intensity of precipitation in conjunction with intensive grazing may enhance woody vegetation. On the other hand, a balanced climate or precipitation and less grazing may help to maintain the grass layer.

With regards to land use, as Thompson (2018) indicated, clearly defined boundaries do indeed exist. Land uses such as artificial dams, herbaceous wetlands, fallow land and old fields, mines and the likes have defined boundaries since their expansion is human induced. For instance, the extension of a mine or quarry depends on the availability of minerals, and only human beings can extend such land use.

Clearly, ecosystem services can flow from six of the land-cover/-use classes outlined in Figure 3.3 and Table 3.1:

- Class 4 (open woodlands) provides biomass for energy, bio-products and food (firewood, charcoal, briquettes, animal feeds, crafts, bush meat, building material and medicinal products). Areas such as these also have the potential to store carbon and to host a whole array of species. The Namibian case studies by Das Namibia, which is a national platform and focal point for questions relating to bush control and value-adding opportunities to combat bush-encroachment supported by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), provide classical examples where indigenous woody vegetation is converted into utilisable goods (Namibia, 2016). Woody plants also play an important part in the moderation of extreme events by reducing wind and water velocity as well as help to clean atmospheric air by way of photosynthesis.
- Class 13 (grasslands) provides grass for grazing, thereby enhancing food security (Kgosikoma & Mogotsi, 2013) as well as building materials for local people (Pelser *et al.*, 2015). These grasslands are high in species diversity and home to vertebrates (such as birds and snakes) and invertebrates (such as insects and flatworms) which are essential for carbon storage and soil fertility. They also provide a buffer against erosion and, in this way, regulate extreme events by reducing the severity of floods. Biological agents for pollination are also highly abundant in grasslands, while they also provide cultural services by adding to the area's aesthetic beauty.
- Class 19 (artificial dams) and classes 22 and 23 (herbaceous wetlands) provide water for drinking, cooking, irrigation and washing while wetlands also fulfil a wastewater-treatment role. Water as a source enhances the ability to use local fauna (including fish) and flora as food source, while wetlands, rivers and dams play a pivotal role in the moderation of extreme events by regulating droughts (Midgely *et al.*, 2013) and the cleansing of atmospheric air through evapotranspiration. Here it ought to be noted, though, that dams may worsen floods if not well managed or planned because they disrupt the natural flow of rivers. With reference to this study, note too that the Moretele/Pienaars River and its tributaries are not indicated as land uses on the legend even though one of the tributaries drains into the Klipvoor Dam. This could be due to the fact that this river has the largest wetland (floodplain) starting at the Kgomokgomo village near Makapanstad. This entire layer is, therefore, probably regarded as a wetland (floodplain) since the two (wetlands and rivers) have the same spatial extent.
- Class 43 (fallow land and old fields) provides agents for pollination (mainly wild). In terms of land use, this class should ideally provide food in the form of crops (Bonifazi *et al.*, 2017), but cultivation is practised on a minimal scale and mainly for

subsistence. In most instances, aridity and a greater interest in livestock farming contributed to the abandonment of the land. Less extensive cultivation in combination with mixed-crop and rotational farming that require fewer inorganic inputs will enhance biodiversity, keeping in mind that wild vegetation can act as a buffer to protect cultivated land and can enhance genetic diversity through heterogeneity (Reynold *et al.,* 2012).

Even though ecosystem services can flow from the land-cover classes available to the Fafung community, it ought to be noted that the landscape is primarily used for grazing. Given that Fafung is a drought-prone area where wetlands and riparian zones become substitute areas for grazing during dry periods, the area is being subjected to land transformation that can potentially affect the community's food security. In short, poor land management including over-grazing and over-stocking, trampling by herbivory and a lack of rotational grazing can result in soil erosion, siltation, bush thickening, loss of biodiversity and flooding, all of which can constrain the availability of one or more ecosystem service (De Klerk, 2004).

4.9 The use, enjoyment and perceived value of ecosystem services by the Fafung community

As indicated in Table 5.3, thirteen of the thirty-two identified ecosystem services available to the Fafung community were grouped under provisioning services, eight each as regulating services (Table 4.6) and cultural services (Table 4.7) and only three as supporting services (Table 4.8).

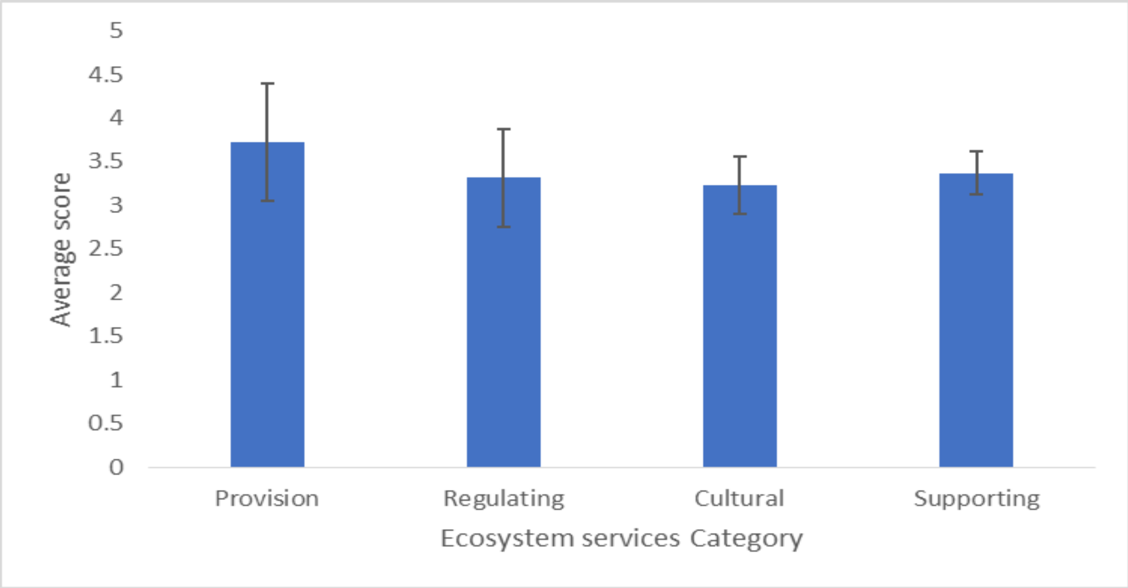

Figure 4.6: Error-Bar chart indicating ES value

According to Sykes *et al.* (2016) the mean (average) and median score represent the central tendency of the data, whereas standard deviation (SD) measures variability or the spread of the responses. As shown in Figure 4.6, provisioning ES has a mean of 3.72 with a median of 3.38 and SD of 0.67 in the score range. Supporting ES scored a mean of 3.37, median of 3.42 and SD of 0.5. Regulating ES has a mean score of 3.32 with a median of 3.34 and SD of 0.5. Cultural ES has a mean of 3.23 with a median of 3.1 and SD of 0.32. The standard deviations are reflected in Figure 4.7 below.

The variation line indicates the variation between the median and highest score as well as between the median and the lower score in the bar range. The SD is lower than the mean in all categories which, according to Sykes *et al.* (2016), indicates that the data points are close to the mean. This shows that the responses of individuals in a sampled group are very close to or concentrated around the mean because responses are not scattered. In other words, the views of the people in the Fafung community regarding the use, enjoyment and value of ES are not highly varied but closely related. In addition, the results displayed in Figure 4.7 also indicate that the respondents did not have reliability issues with the questions asked and are indicative of very strong or positive reliability or confidence.

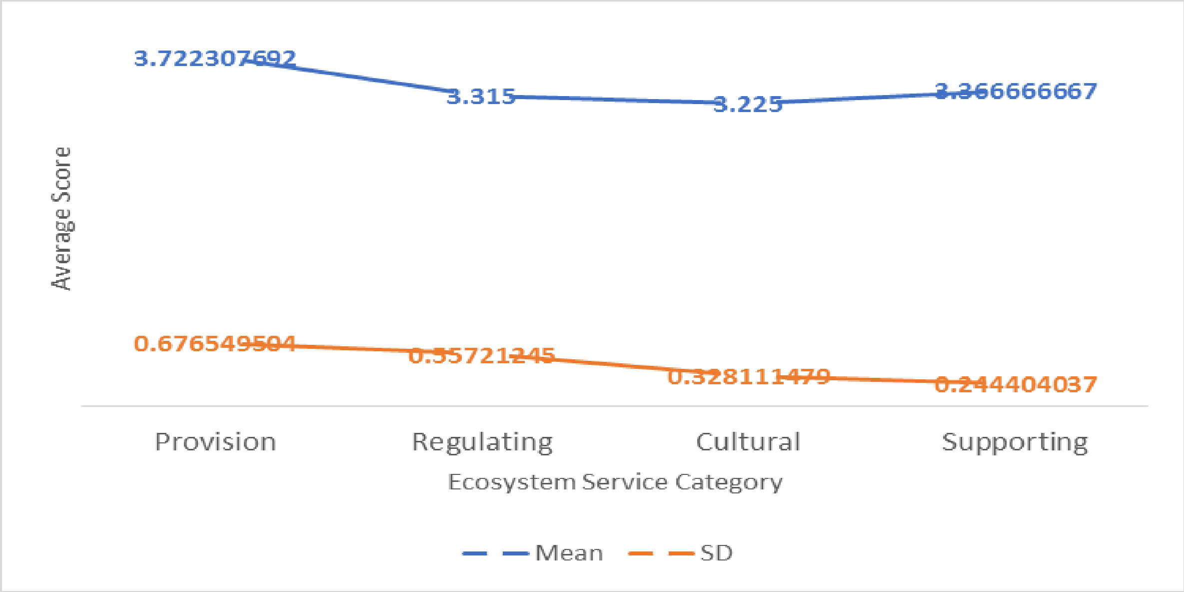

Figure 4.7: Correlation between the mean and SD

The summary in Figure 4.8 below confirms that provisional ecosystem services are being used to a fairly large extent. In this regard sand, water, grass (for grazing) and wood (for heating and cooking and for the building of houses, cattle pens, etc.) featured very strongly. Seven out of the 32 ecosystem services are being used to a fairly large extent, of which seven are provisional services and only one a regulating service.

Nineteen out of the 32 ecosystem services are being used to a moderate extent, of which six each are cultural services and regulating services, four provisional services and three supporting services. Respondents also indicated that they use six ecosystem services to a small extent, of which three are provisional services, two cultural services and one a regulating service.

This confirms the view held by Shackleton *et al.* (2008) namely that across the South African region, poor rural and, to a lesser extent, urban communities make use of a wide array of products gathered from natural resources and modified ecosystems to meet their everyday livelihood needs. These findings are also in line with the observations made in the course of the Millennium Ecosystem Assessment (2005), namely that ecosystem services resorting under four broad categories (provisional, regulating, cultural and supporting) tend to be dominant in one class but tend to cross-cut to other categories.

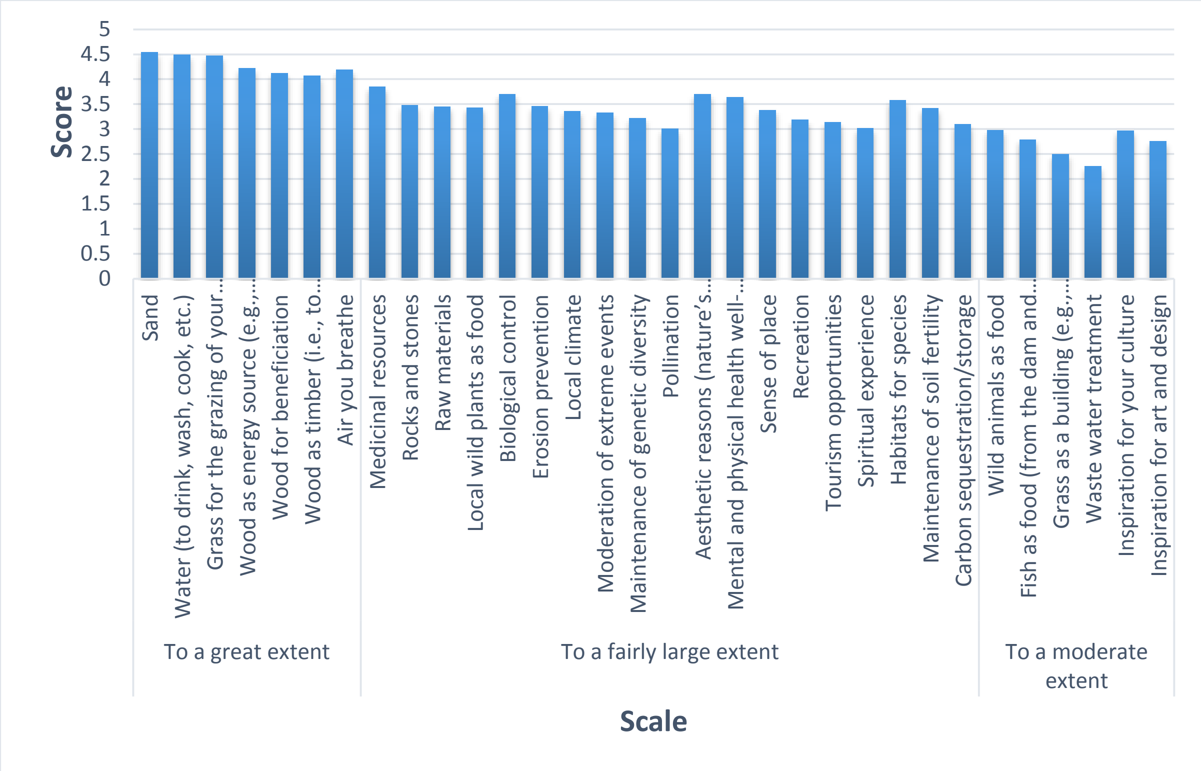

Figure 4.8: Overall findings regarding the 32 ecosystem services available to the Fafung community

In their analysis of the links between ecosystem services and poverty alleviation, Shackleton *et al.* (2008) found that the livelihood of people residing in Southern Africa's arid and semi-arid areas are dependent on utilising natural resource products as a source of food, nutrients and vitamins; as fuel for heating and cooking; as a means to manufacture agricultural implements and to construct shelters and vessels; and as a genetic resource. Their observations correspond with the findings of this study given that the four ecosystem services used, enjoyed and valued most by respondents all resort under the provisional category (i.e. sand, water, grass and wood).

4.9.1 Provisional services

Findings in this category generated a mean of 3.72, an SD of 0.67 and a median of 3.38. As per the details reflected in Table 5.3 below, six of the thirteen ecosystem services classified as provisional are used, valued and enjoyed to a fairly large extent, four to a moderate extent and three to a small extent.

Table 4.3: Provisioning ES used, enjoyed and valued by the Fafung community

Number	ES Classification	ES	Mean	Standard Deviation	Median	Highest range Score	Analysis
1		Sand				4.54	
2		Water (to drink, wash, cook, etc.)				4.49	
3		Grass for the grazing of your livestock				4.47	
4		Wood as energy source (e.g., fuel wood for cooking and heating)				4.22	
5		Wood for beneficiation				4.12	
6		Wood as timber (i.e., to construct houses and/or kraals)				4.07	
7	**Provisioning Ecosystem Services**	Medicinal resources	3.72	0.67	3.85	3.85	6 used to a fairly large extent, 4 to a moderate extent, 3 to a small extent.
8		Rocks and stones				3.48	
9		Raw materials				3.45	
10		Local wild plants as food				3.43	
11		Wild animals as food				2.98	
12		Fish as food (from the dam and other sources in the area)				2.79	
13		Grass as a building (e.g., thatching) and raw material (e.g., artefacts)				2.5	

i. Sand

As indicated in Figure 4.10, findings in Fafung strongly depicted a high reliance on sand as an ecosystem service with the highest score out of the 32 ecosystem services assessed. Of the respondents, 67.3% indicated that they value, enjoy and use this service to a great extent, a fairly large extent (22.8%), moderate extent (6.9%) and small extent (3%).

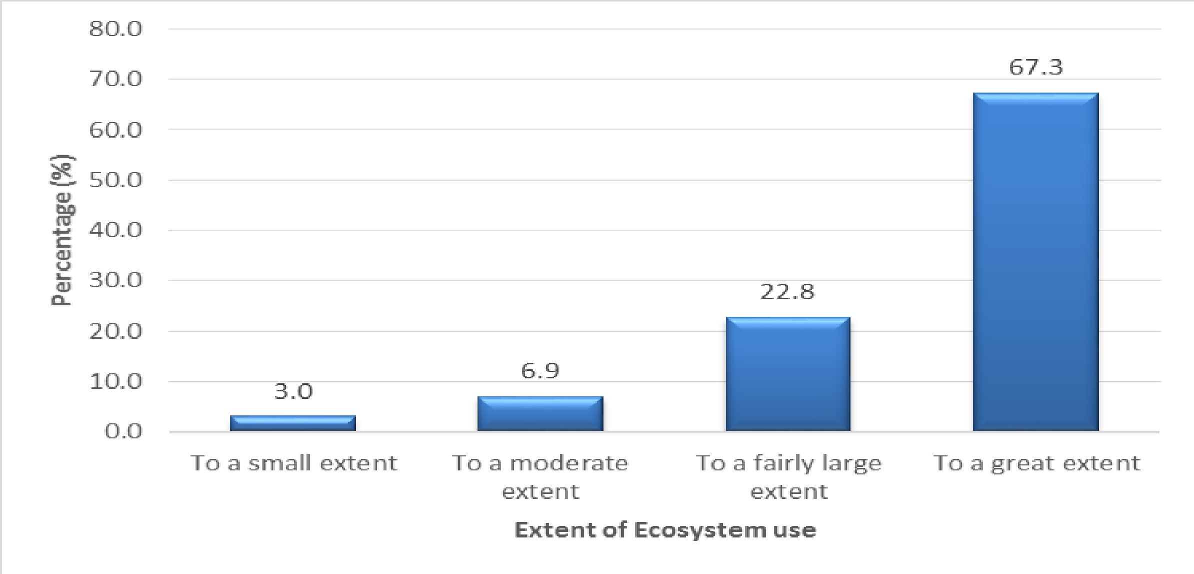

Figure 4.9: Sand

Amongst others, sand as an ecosystem service stores carbon and nutrients that help plants to grow. Although sand and gravel have a wide range of applications, the undeniable truth is that sand is highly over-extracted in all areas (rural and urban) as material for the construction of infrastructure such as roads, bridges, shopping centres, schools and clinics (Koehnken & Rintoul, 2018). This view is supported by Mngeni *et al.* (2016) who added that in rural areas, sand is mainly used as input material for the building of houses.

Although Fafung is a rural area, there is some evidence of development in the form of national government and municipal infrastructural projects given that roads and schools are being constructed and houses electrified. Consequently, many homes are improving or moving from old shack and mud houses into modern home.

As pointed out by Mngeni *et al.* (2016), few structures can exist in a permanent form without sand since it is the major constituent of any structure. Given the rising trend in sand use by both government institutions and private households (Nwachukwu *et al.*, 2017) and the alternating trend in population growth between 2011 and 2016 in Fafung (StatsSA, 2011), several sand mines and borrow pits have been established in and around the community. This raises a sustainability problem given that the formation of soil by way of weathering and the decomposition of dead matter is very sluggish compared to the current rate of usage (Earle *et al.*, 2012). As pointed out by Mngeni *et al*. (2016), the impacts of soil degradation are irreversible, unsustainable and destroy the environment and society, a state of affairs that is exacerbated since Nwachukwu *et al.* (2017) found that sand mining is mostly practised illegally and that rural areas are mostly targeted for this activity.

As is evident from Figure 3.3, sand mines and abandoned borrow pits are quite prevalent in and around Fafung and are a major cause of soil degradation due to the loss of topsoil which triggers the formation of gullies. Furthermore, Nwachukwu *et al.* (2017) found that abandoned pits are usually turned into ponds or waste dumping sites which increase pollution. Koehnken and Rintoul (2018) also warned that sand mining can potentially lead to ecological impacts such as the disturbance and/or removal of river habitats, the loss of or changes to the vegetation structure of riparian zones and increased or decreased downstream sedimentation that will affect habitat quality. Sand mining also interferes with a number of ecological processes such as the abundance, structure and movement of drift-feeding fish which impact food web dynamics.

Moreover, clearing of land for borrow pits leads to a loss of native species and an increase in alien invasive species that are renowned for their competitive advantage and ability to thrive in harsh environments by monopolising the use of limited resources. In short, sand mining can facilitate the colonisation of fertile ground by alien invasive species such as *Lantana camara,* resulting in a loss of grasslands' grazing and carbon-storage capacity (Mngeni *et al*., 2016).

Services flowing from soil as ecosystem service have both ecological and economic impacts; therefore, any proposed activity should be weighed carefully against both public and private interests. Since all ecosystems are dependent on soil (Koehnken & Rintoul, 2018), land earmarked for sand mining should be assessed thoroughly and selected to especially avoid impacting grass, the habitats of wild plants and animals and carbon sequestration.

Given that the use of soil for domestic purposes and large government projects is inevitable, especially against a backdrop of economic development, Le Maitre *et al*. (2017) advised that a trade-off approach need to be adopted when considering sites for sand-mining so as to prevent ecosystem disservices (Shackleton *et al*., 2008) that will impact negatively on the livelihood and well-being of the community. Rehabilitation interventions should also form part of sand-mining projects with measures to reverse past degradation and to avoid a net loss of healthy and productive land (UNCCD, 2016).

ii. Water (to drink, wash, cook, etc.)

Water is an important source of life. Hence, as indicated in Figure 4.10, it is highly valued in Fafung as an ecosystem service. In this regard, 66.3% of the respondents use, enjoy and value this service to a great extent, 21.8% to a fairly large extent and 5.9% to a moderate/small extent respectively.

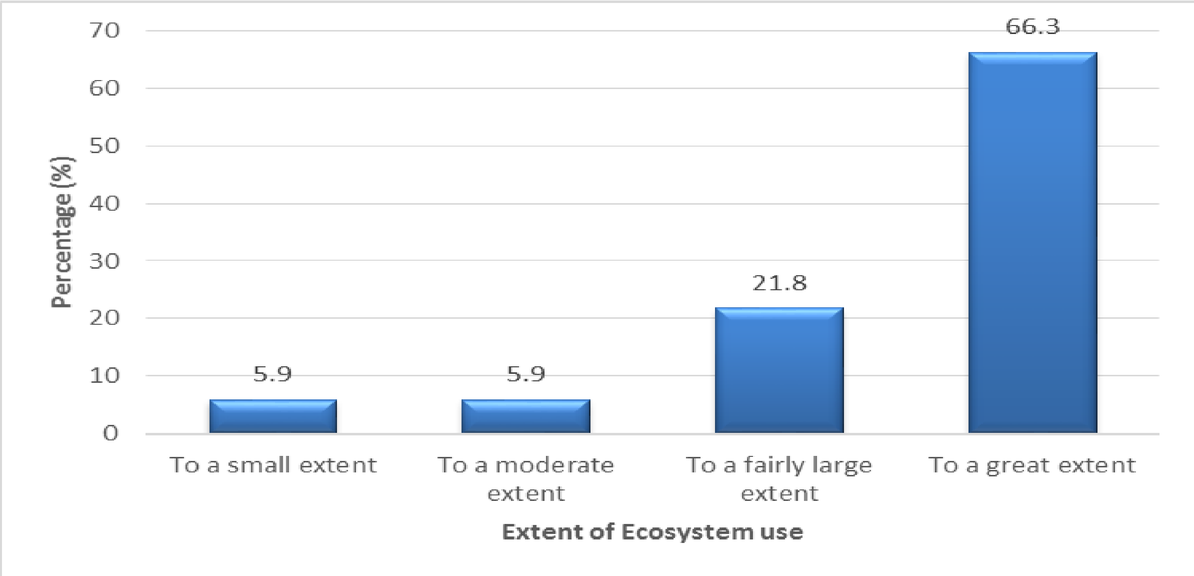

Figure 4.10: Water (To drink, wash, cook etc.)

By way of background, South Africa is a water-stressed country with an average rainfall of 450 mm per year, and most of the northern and western parts of the country are semi-arid and receive relatively low levels of rainfall (Maree *et al.*, 2016). According to Earle *et al.* (2012), Fafung's climate is similar to that of a semi-arid or desert region where rainfall patterns, and the subsequent run-off, are highly seasonal with short wet seasons and long dry seasons (Maree *et al.*, 2016). As a result of climate change, this part of the country is also subject to prolonged droughts during summer which also impact water sources.

The primary sources of water in Fafung are ground and surface water. In addition, precipitation (rainwater) is collected and stored in tanks provided by the government (SDF, 2015). Drinking water comes mainly from ground water and wetlands or wells, while water for activities such as washing and watering plants and livestock is derived from the Pienaars/ Moretele River and Klipvoor Dam. In this regard, do note that the South African Department of Water and Sanitation (2014) has classified surface water in this area as unfit for consumption due to eutrophication and pollution.

Supplying municipal water to the community is extremely costly, and the local authority seemingly also lacks the financial means and expertise to ensure that wastewater treatment plants are maintained in good working order. Even though some households classified as "indigent" are exempt from paying for certain municipal services, those who find themselves in the low-income group (see Figure 4.4) battle to settle their municipal accounts, resulting in a termination of services.

Water ecosystems do not only provide water but are sources of biodiversity. Poor water quality and a reduction in quantity will, therefore, have an adverse effect on biodiversity and may result in the destruction of aquatic habitats. According to Midgely *et al.,* (2013) as well as Issaka and Ashraf (2017), such a state of affairs can mostly be attributed to protracted droughts and occasional floods as well as siltation, all of which will result in soil erosion.

Another potential threat to the availability of water-related ecosystem services to the Fafung community is the invasion of alien plants. According to the DEA (2019), alien invasive plants can consume as much as 20% of South Africa's annual run-off if left uncontrolled. Hydrological studies conducted by Wilkie and David (2020) also suggested that bush encroachment has a negative impact on groundwater recharge since woody plants evaporate significantly more water than grass.

The Klipvoor Dam remains moderately pristine and clear from aquatic alien invasion; however, it is more vulnerable and susceptible to such given its linkage to the Roodeplaat Dam at the upper catchment (Midgely *et al*., 2013), which is densely invaded by *Eichhornia crassipes* (water hyacinth) and indigenous or cosmopolitan plants. Indigenous or cosmopolitan species flourish and become troublesome in disturbed aquatic habitats in response to various disturbances and are usually symptomatic of a problem, and not the problem itself (SAPIA, 2010). The increasing population of indigenous reeds on the verge of the Klipvoor Dam contributes to siltation and a reduction in storage capacity. Aquatic invasive alien plants are generally known to thrive in hypertrophic water systems with high levels of eutrophication, resulting in high water consumption and a threat to biodiversity.

The Pienaars/Moretele River has extensive wetlands along stream channels, partly as a result of substantial clay formations, which are prone to periodic flooding (Midgely *et al.*, 2013). Wetlands are important sources of water because they recharge rivers during droughts or dry periods. However, the high levels of degradation of the Moretele floodplains due to anthropogenic activities as alluded to by the Department of Water and Sanitation (DWS, 2012) is a worrying factor. These wetlands are also a source of palatable grass for cattle in the area, and the continued trend of degradation presents a serious challenge to cattle owners.

Figure 4.12 demonstrates the value of wetlands as grazing reserves during dry periods when upper landscapes fall short of grass due to a lack of rain and moisture. De Groot *et al*. (2018) argue that wetland ecosystems offer a high return on natural capital since they provide water as well as grass for grazing and simultaneously help to mitigate floods and droughts and to moderate the local climate.

"Water is life." This common expression most definitely applies to the health and well-being of people in Fafung since they are highly dependent on the availability of water and, most importantly, clean potable water. Here it ought to be kept in mind that water flowing through the Pretoria-North/Moretele hotspot is highly polluted as a result of urban and industrial effluent originating in Tshwane (Midgely *et al.*, 2013). Many diseases in the world, and Africa in particular, are water-borne (bilharzias, malaria, N_1H_1), and pollution of water systems increases humans' susceptibility to these diseases.

iii. Grass as grazing for livestock

As is evident from Figure 4.11, the majority of the villagers use grass as a resource to graze their livestock. Of the respondents, 66.3% indicated that they use grass for this purpose to a great extent, 20.8% use it to a fairly large extent, 5.9% to a moderate extent and 6.9% use it to a small extent.

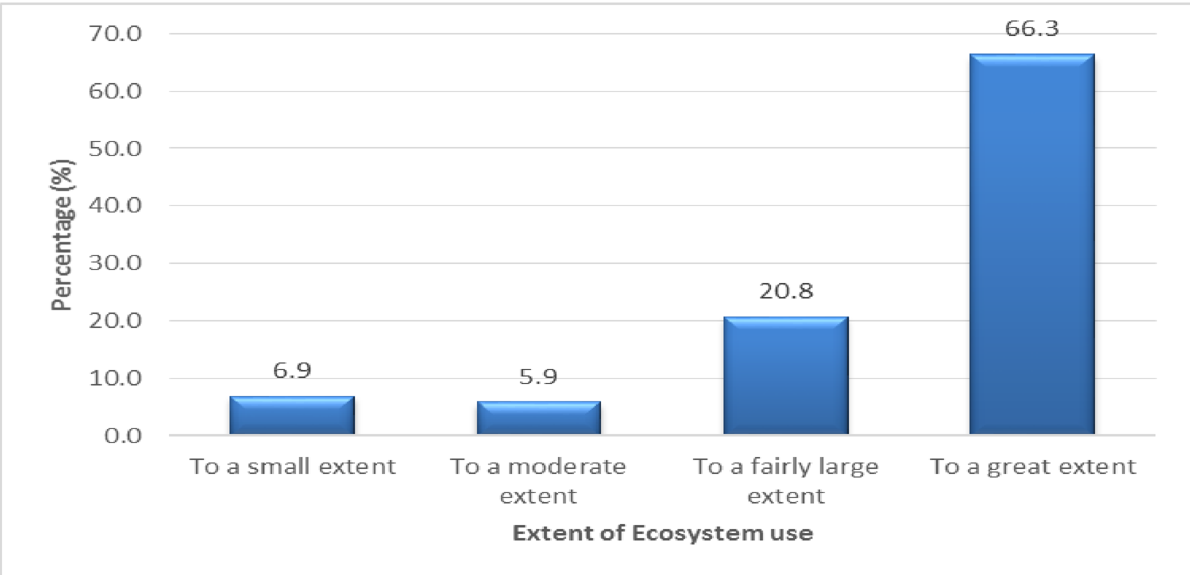

Figure 4.11: Grass for the grazing of your livestock

Grasslands and woodlands provide essential services to the people of Fafung as most of the services emanate from these ecosystems. However, these ecosystems are threatened by overgrazing and bush encroachment (Turpie *et al*., 2019). Where the growth and development of woody plants outcompete grasses (Mokgosi, 2018; Sala & Maestre, 2014), soil erosion, a loss of soil fertility and a reduction in soil's carbon storage capability inevitably follow. Thus, the objective of bush encroachment restoration (which is being implemented on a small scale in Fafung) is not only to reduce the densities of woody plants but also to enhance grass cover which will help to keep high surface water run-off in check, thereby reducing soil erosion. Once soil integrity has been achieved, the higher the chances of restoring carbon storage capabilities, ultimately resulting in improved soil fertility.

As indicated above, the Fafung community is highly dependent on the grassland ecosystem for their livelihoods and food security. As is the case with many rural villages in South Africa, cattle ownership is an integral part of Fafung's culture and way of life. In communities such as these, livestock ownership is associated with wealth. Since people prefer to keep their livestock rather than trade them for money, livestock is an end in itself and not a means to an end (e.g. money) (Dovie *et al.*, 2006).

Trampling and grazing are the most common disturbances caused by animals (herbivores), and such disturbances severely affect the distribution and structure of vegetation (grass, forbs and shrubs). Grazing prevents seed growth, while trampling modifies the composition of natural vegetation and reduces inter-specific competition, resulting in patches of high diversity (Farina, 2007). Midgley *et al.* (2013) also ascribed the high levels of land degradation in the Limpopo river-basin system to decades of high-density stocking which is bound to be exacerbated by deforestation and the impacts of climate change (e.g. prolonged droughts).

The land-cover map (Figure 3.3) illustrates the prevalence of vast stands of open woodland (class 4) and patches of natural grasslands (class 13). The dominance of the woody layer seems to be increasing exponentially, whereas the grass layer is dwindling. This observation is supported by Sala and Maestre (2014) who found that transitions from grassland to woodland implies that where savannas are typically characterised by a mixture of trees and grasses, trees now increase disproportionally to the extent where they form close-canopy forests.

Poor land management (i.e. heavy or overgrazing) is viewed by many who practise pastoral or rangeland science as the major cause of bush encroachment (Turpie *et al.,* 2019; Shackleton *et al.,* 2008). In Fafung, poor land management is influenced to a degree by land tenure policies and impaired governance. Regarded as an estate privately owned by a group of individuals who have bought the land in accordance with the South African Department of

Rural Development and Land Reform's national spatial development framework (2019b), landowners have formed a community committee with a chairperson and one committee member entrusted with environmental issues. Although it is unclear to what extent the committee truly pays attention to environmental issues, site visits confirm that rehabilitation interventions are mainly directed towards the Borakalalo Nature Reserve.

The lack of support from local government and other departments entrusted with environmental management is another serious cause of concern. Nevertheless, the Department of Environmental Affairs' final report on the targets set for attaining land degradation neutrality dated 2018 acknowledges that whereas the land productivity dynamics (LPD) of 63.0% of the country's shrub, grassland and sparsely vegetated areas have remained stable or are on the increase, the LPD of 35.9% are under stress or on the decline. This is one of the reasons why the department has prioritised grasslands as one of the biomes that will require serious attention if its minimum objectives for LDN are to be attained by 2030.

Given that cattle farming is the dominant agricultural activity in Fafung and has been the source of people's livelihood for many years, the dwindling grazing capacity in the area is of major concern. Nevertheless, an integrated approach must be followed when examining the coexistence of and inter-linkage between grasslands and woodlands because ecosystem services flowing from the two are mutually interdependent and their competition should be viewed against the backdrop of increasing climate change and land degradation in South Africa.

Even though some may perceive bush encroachment as beneficial due to heightened carbon capture and storage capabilities and the increase in the provision of woody biomass, this phenomenon alters the structure and functioning of ecosystems, and these changes will become increasingly irreversible as the fundamental nature of ecosystems changes (Turpie *et al.,* 2019). On the other hand, others can argue that cattle farming's contribution to the country's mainstream economy and gross domestic product has hitherto not been calculated (Le Maitre *et al*., 2007). Therefore, there is no factual base against which this activity can be compared to and judged against other ecosystem services in order to arrive at an informed decision on trade-offs.

This begs the question: Given the current state of grasslands in Fafung and the need to sustain the ecosystem services derived from this form of land-cover, what course of action would be most beneficial to the community? Given the high stocking rates typical of rural villages such as these, the DEFF has resolved that the conservation, restoration and rehabilitation of grasslands should be prioritised against other competing land uses such as settlements and cultivation. To this end, the department has launched a "Working for Ecosystems" project in Fafung and the Borakalalo Nature Reserve aimed at enhancing grass production by way of bush thinning.

It is envisaged that the trade-offs will result in the enhancement of grasslands' by-products (e.g. enhanced carbon sequestration, biodiversity conservation and erosion control) while the woody material harvested in the process will be utilised to generate business opportunities (i.e. traded for use as kindling or as timber/construction material).

Figure 4.12: Floodplain wetlands alongside the Pienaars/Moretele River in the Kgomokgomo (Makapanstad) community just above the Borakalalo National Park and Klipvoor Dam.

iv. Grass as building (e.g. thatching) and raw material (e.g. artefacts)

As indicated in Figure 4.13, the majority of the respondents attach little value to grass as building or raw material (small extent = 40.6%; not at all = 20.8%). On the other hand, an equal percentage (10.9%) indicated that they value it to a great or fairly large extent, with a further 16.8% indicating that they value it to a moderate extent.

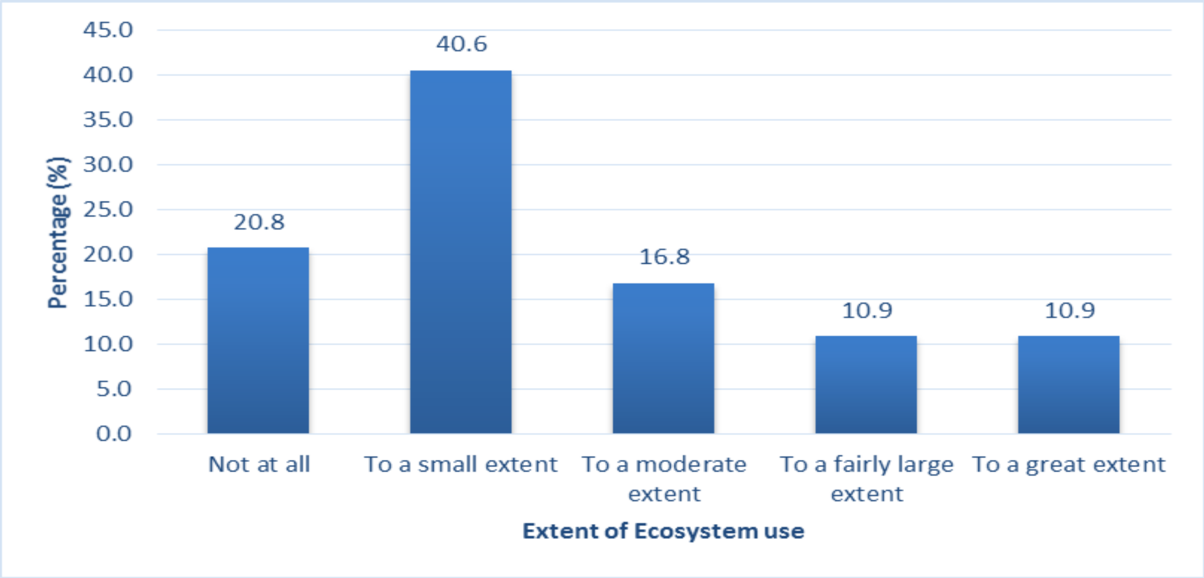

Figure 4.13: Grass as a building (e.g. thatching) and raw material (e.g. artefacts)

In addition to being used as thatching, grass is also used to manufacture a wide variety of artefacts such as brooms, hats, baskets, decorative articles and floor mats.

Given that the Borakalalo National Park has initiated a grass harvesting programme intended to improve the well-being of those living in the surrounds, it would be prudent to note that Pelser *et al.* (2015) cautioned that harvesting should be guided by a clearly defined spatio-temporal plan so as not to impede conservation efforts. They based their findings on an analysis of the impacts the People and Parks Programme, initiated by the DEFF, had on the communities neighbouring the Golden Gate Highlands National Park.

Initially, this programme was introduced as an interim measure to address several socio-economic issues that were ignored under apartheid rule in favour of conservation. To this end, the programme set out to ensure that the social and economic benefits stemming from biodiversity protection also benefit the community and to, simultaneously, guard against over-exploitation and to discourage illegal activities.

Even though the programme did not result in a significant reduction in poverty amongst affected households, it did foster a positive attitude towards the conservation and sustainable utilisation of ecosystem services.

v. **Wood as energy source (e.g. fuel wood for cooking and heating)**

Given that Fafung resembles an area where woodlands seem to be on the increase as a result of bush thickening/encroachment (Shackleton *et al.,* 2008), it is not surprising that almost 75% of respondents indicated that they use this provisioning ecosystem service to a great or fairly large extent. Noteworthy, too, is that none of the respondents indicated that they do not value, use or enjoy this ES at all (see Figure 4.14).

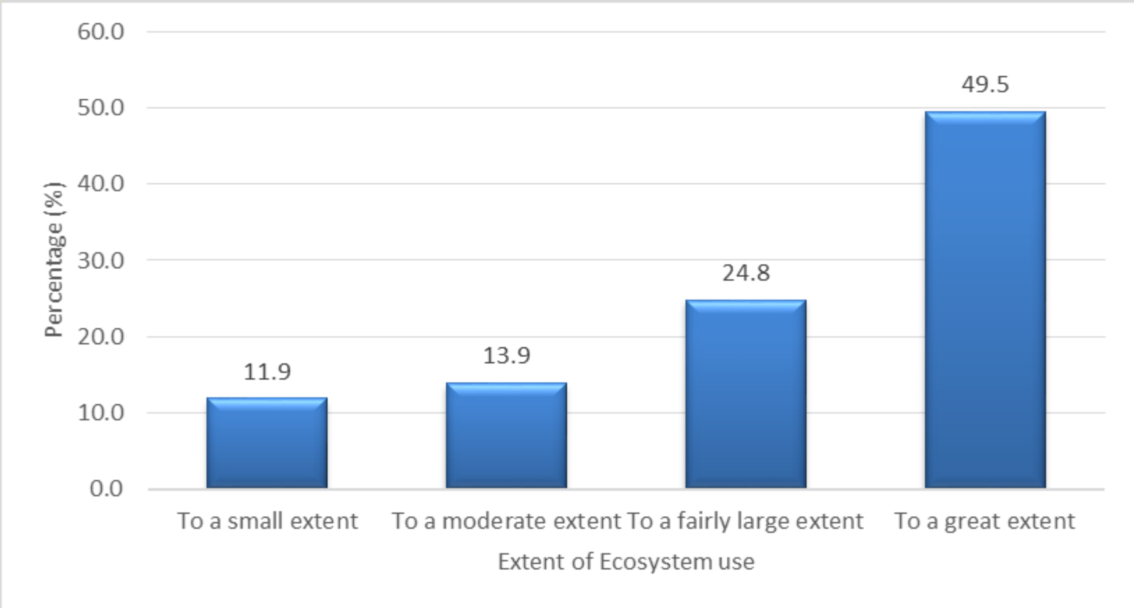

Figure 4.14: Wood as energy source

In this regard, it ought to be noted that Shackleton *et al.* (2008) found that households with the lowest income are bound to use wood as fuel most frequently to cook and to keep warm.

In South Africa, the national electricity grid has been under severe pressure in the recent past, a situation which is bound to worsen as a result of a growing demand that far exceeds supply. As part of the National Electrification Programme, the Department of Energy should address delivery issues in dispersed rural settlements by expanding the use of renewable energy in off-grid electrification (StatsSA, 2011).

Renewable energy such as solar and wood-biomass energy would be ideal for rural communities like Fafung where houses are scattered and where there is an abundance of wood reserves in the form of woody encroachers and AIPs. The utilisation of wood as an energy resource, either as firewood or as a by-product of bio-energy, could help to reduce the pressure on the national electricity grid.

vi. Wood as timber (i.e. to construct houses and/or kraals)

As is evident from Figure 4.15, close on 88% of respondents use, enjoy and value this ecosystem service. Here, though, it ought to be noted that wood as timber is mostly used to construct kraals and fences and to a far lesser extent as roofing or to build houses.

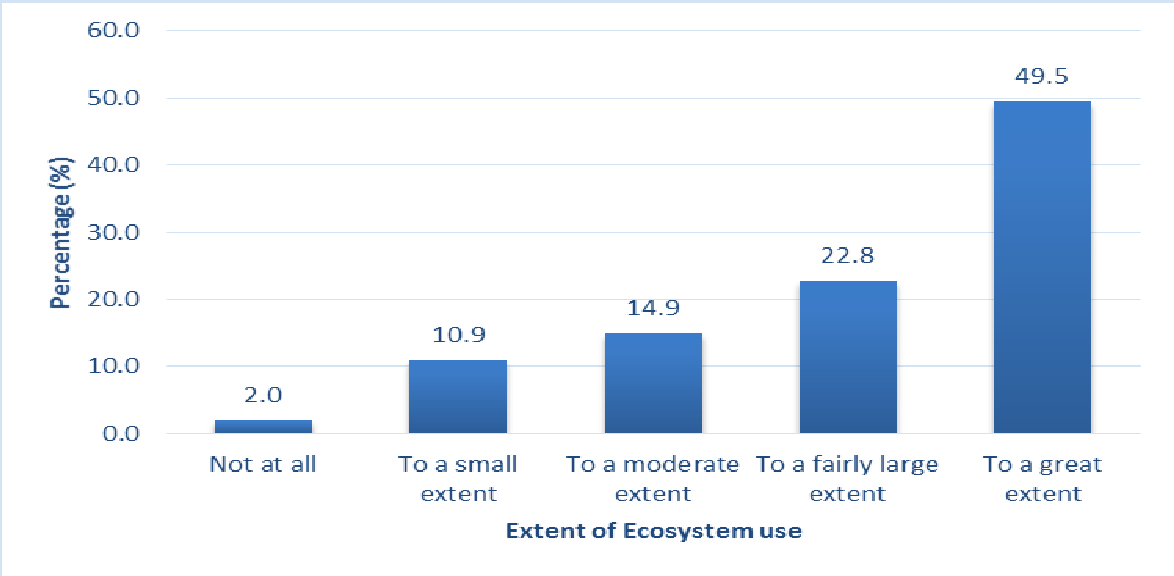

Figure 4.15: Wood as timber (i.e. to construct houses and/or kraals)

In as far as the choice of wood to use as poles and/or droppers is concerned, a study conducted in 2016 by the Namibian Ministry of Industrialisation, Trade and SME Development revealed that consumers prefer hardwood species (e.g. *Terminalia sericea* and *Colophospermum mopane*) that are not too knotted or distorted and that are pest-resistant. In this respect, the wood in the Fafung area is not suitable for timber production which is probably why there are no local industries that process wood for this purpose.

Wood as energy source and wood as timber are by-products of open woodlands (class 4) and are linked to raw materials (see Figure 4.15). In this regard, high-quality biomass harvested by means of bush clearing may well be turned into beneficiated products such as firewood, charcoal and briquettes, or even animal feed.

vii. Wood for beneficiation

Famers, entrepreneurs, innovators, financiers and academics the world over agree that the beneficiation of biomass can result in several positive economic spin-offs and contribute to rangeland restoration. To this end, the DEFF set out to develop a Green Business Value Chain Pyramid (see Figure 4.16) to illustrate how the major players (i.e. primary producers, distributors/suppliers and customers) can contribute towards enhancing rural communities' skill sets and entrepreneurial prospects. To measure the outcome of the GBVC, the skills and entrepreneurial expertise participants gained in the process are weighed against their exit or placement in other economic sectors (forestry, agriculture, water, tourism, energy, etc.) (DPW & DEA, 2014).

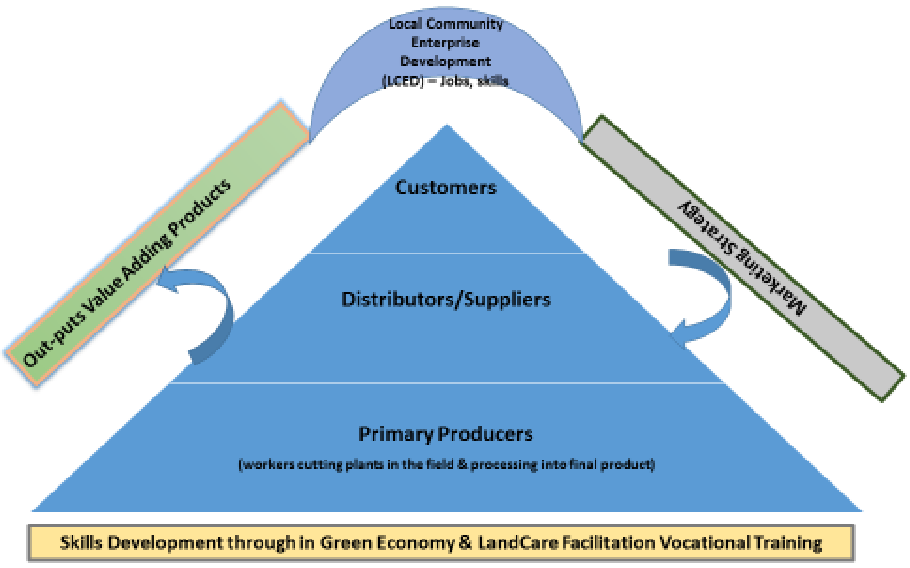

Figure 4.16: Green Business Value Chain

Given that the DEFF is already undertaking a three-year bush-thinning project in Fafung, the Borakalalo National Park and adjacent villages, investigating opportunities to beneficiate the resultant cleared biomass is warranted. As a matter of fact, the Eco-furniture Programme serves as proof that beneficiation of cleared woody material can create jobs and grow local economies.

A case in point may be the findings reported by the Namibian Ministry of Industrialisation, Trade and SME Development in 2016. Making use of simple affordable tools such as axes, pangas and saws, cleared woody biomass was manually transported to production sites within close proximity to sites where it was carbonised by means of manually transported kilns. Seemingly, the resultant charcoal is in huge demand in overseas markets.

Figure 4.17: Senegalia mellifera turned into charcoal

Although income generation through wood harvesting could make clearing a viable business option in itself, Turpie *et al.* (2019) caution that its economic viability is unknown and that encouraging opportunities such as these to address bush encroachment could result in the overharvesting of woody biomass and a decrease in soil fertility over the long term.

viii. **Local wild plants as food**

Only 6.9% of the respondents indicated that they do not use this commodity at all, while 24.8% use it to a great extent or fairly large extent respectively, 25.7% to a moderate extent and 17.8% to a small extent.

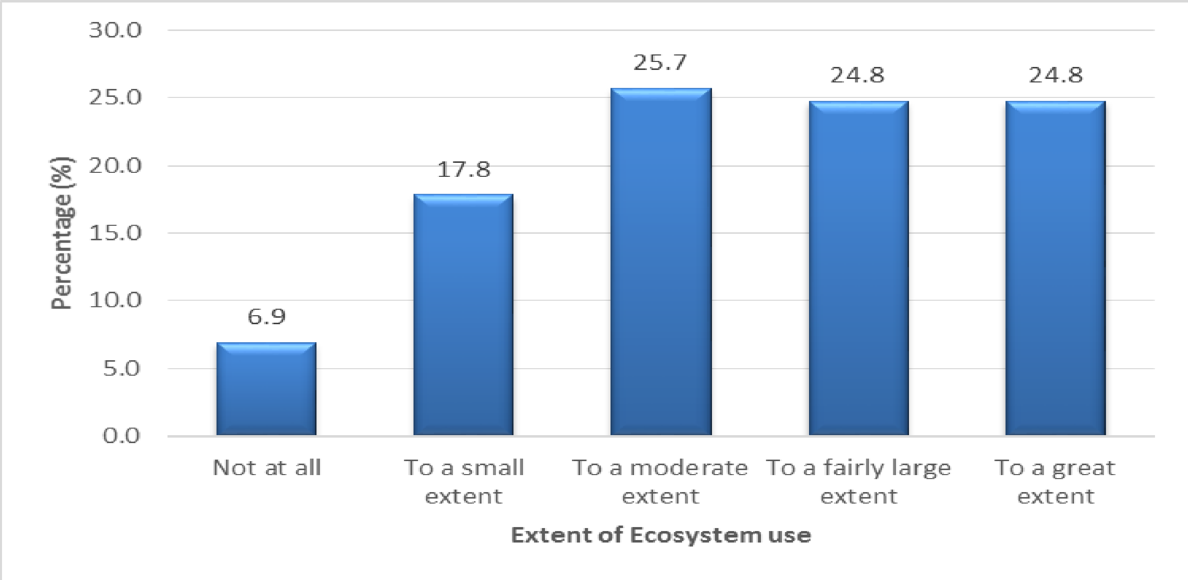

Figure 4.18: Local wild plants as food

Woodland/bush plants such as the prickly pear cactus (*Opuntia ficus indica*), marula (*Sclerocarya birrea*), wild medlar (*Vangueria infausta*), monkey orange (*Strychnos spinosa*), buffalo thorn (*Ziziphus mucronata*), mallow raisins/sand raisins (*Grewia villosa/microthyrsa*) and bluebush (*Diospyros lycioides*) are commonly used to counter nutritional deficiencies in poverty-stricken communities' diets.

Given that wild plants are not only used as food but also for other purposes (e.g. as medicine, dyes and cosmetics), Mokganya *et al.* (2017) hold that people in developing countries' subsistence and income are highly dependent on wild plants..

Clearly, the value of wild plants cuts across several ecosystem services and are also highly valued as a cultural service. As pointed out by Anthony and Bellinger (2007), the cultural and spiritual values of biodiversity as well as the links between these values and variables that affect them must inform environmental management schemes. More comprehensive and participatory local valuations to understand what species are used for what purposes can help to identify conservation targets for community-based initiatives and can inform planners about specific resource needs (Mokganya *et al*., 2017). In the long run, this will help to formulate marketing strategies for derivatives derived from wild plants.

ix. Wild animals as food

As illustrated in Figure 4.19, only 15.8% of the respondents indicated that they do not value wild animals (or bush meat) as food at all. In contrast, 33.7% indicated that they value it to a small extent, 21.8% to a great extent, 19.8% to a fairly large extent and 8.9% to a moderate extent.

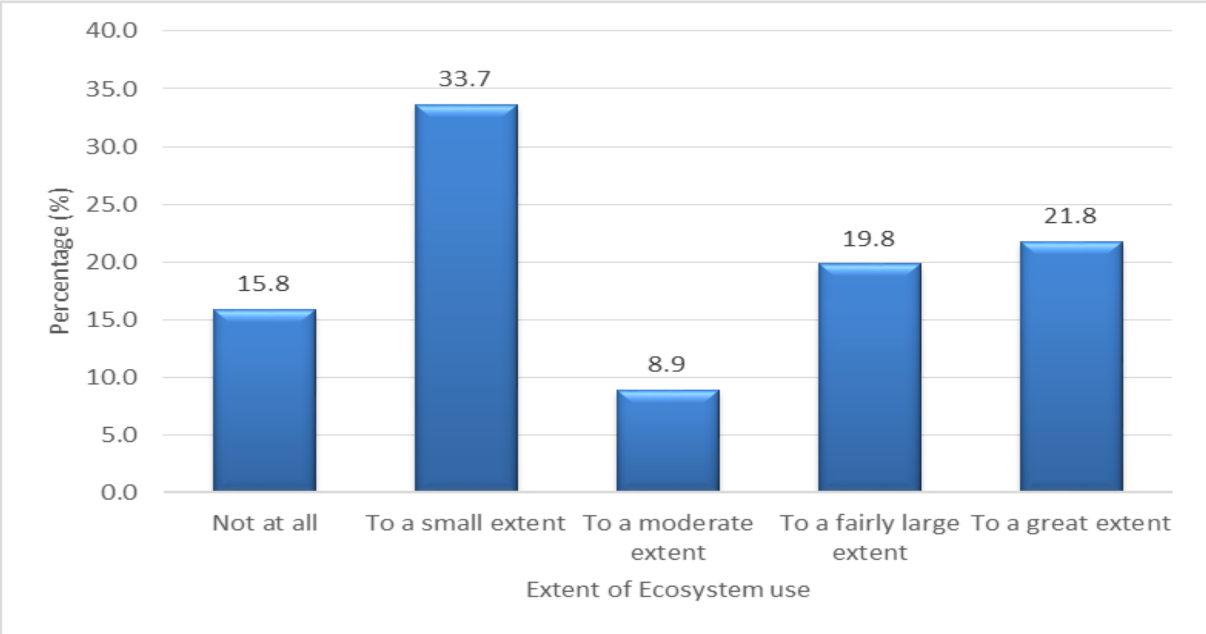

Figure 4.19: Wild animals as food

Kiffner *et al.* (2015) is of the opinion that the consumption of 'bush meat' stem from multiple factors such as socio-economic status, the availability of alternative sources of protein and ethnicity. One of the services derived from the widespread woodland in Fafung is bush meat and, in the course of this study, it has been observed that some residents are making use of snares and dogs to hunt wild animals. This kind of hunting is illegal; therefore, it is impossible to establish the extent to which wild animals are used for food and, likewise, the extent to which bio-diversity is lost as a result of this illegal practice and, in a similar vein, even though hunting has some economic and cultural value, this cannot be accounted for due to the illegal nature thereof (Daily *et al*., 1997). As Kiffner *et al.* (2015) observed, the actual magnitude of the availability and consumption of bush meat are underestimated because it is traded on informal markets that do not send price signals to warn of changes in supply or condition.

In 2017, Gordon-Cumming identified poaching by local residents as a serious issue, and this tendency has been confirmed by Anthony and Bellinger (2017) as well as Kiffner *et al.* (2015) who found that resource-dependent communities living next to protected areas tend to over-exploit resources resulting in a lack of integration in the conservation of biodiversity.

The widespread occurrence of bush meat consumption suggests that conservation interventions need to holistically address the hunting, trade and consumption of this ecosystem service. One of the methods utilised by the DEFF and SANParks is to make use of eco-guards. These workers ‘police’ the harvesting of flora and fauna, especially outside national parks, and in this way help to fight the scourge of biodiversity loss. Another strategy deployed in South Africa is to give people a stake in natural resource management, thereby creating access to greater economic opportunities. This follows on a report published by the DEA in 2019 on South Africa’s environmental programme which suggests that poor service delivery coupled with fewer economic opportunities make people susceptible to poaching. Nowadays, there are beneficiation scheme and programme that allow adjacent communities to benefit from national parks. One such programme, People and Parks, seeks to increase access to protected areas with a view to sharing the benefits derived from the use of indigenous resources while simultaneously countering biodiversity loss.

x. Fish as food

Figure 4.20 illustrates that only 18.8% of respondents indicated that they do not use fish as an ecosystem service at all. Of the remainder, 28.7% indicated that they use it to a small extent, 21.8% use it to a moderate extent, 15.8% use it to a fairly large extent and 14.9% use it to a great extent.

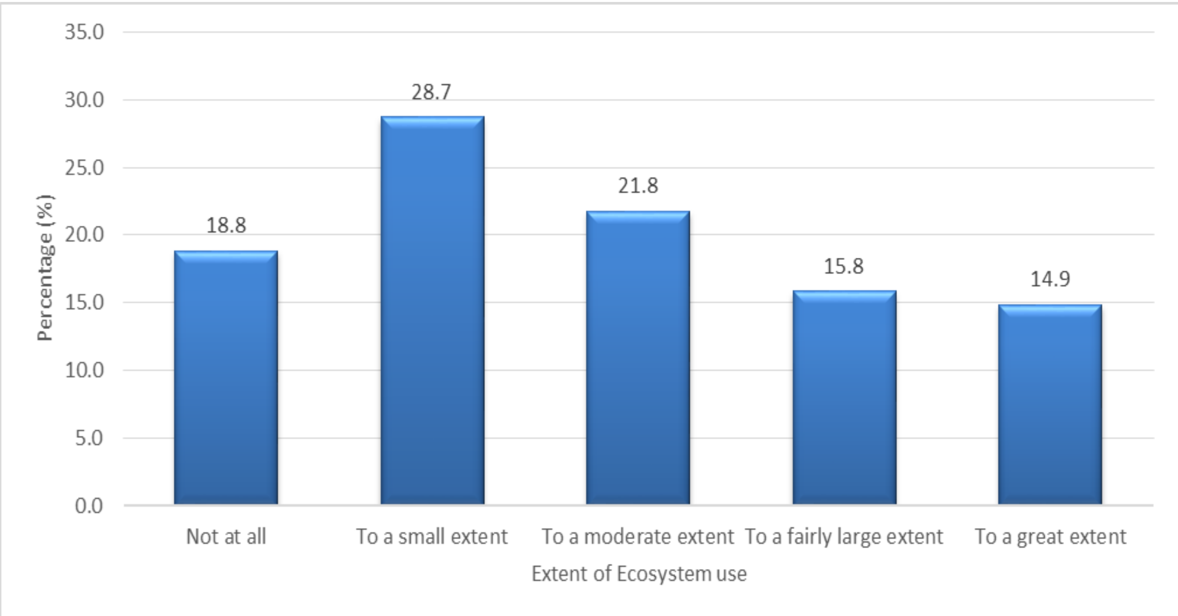

Figure 4.20: Fish as food

Of importance here is to note that fishing in and around Fafung can only be done from the Klipvoor Dam or from the Pienaars/Moretele River. Fishing from the former is illegal, while a permit must be obtained from the nature reserve to fish from certain parts of the Klipvoor

Dam. This dam is mainly used for irrigation purposes and to a lesser extent for recreational and game fishing purposes.

From observations, it is clear that fishing is the most valued and enjoyed activity in and around the Klipvoor Dam. Given that local people have to pay for daily fishing permits as a control measure, this too can result in the exclusion of rural people. Von Brown and Gatzwiler (2014) refer to this concept as “marginality” whereby local people are socially excluded as a result of formal and informal rules, regulations and institutions that govern access to land, water and biological resources fundamental to the operations of the livelihoods of their choice. This begs the question as to whether incentives are needed to discourage Fafung residents from illegal fishing.

However, as Holmlund and Hammer (1999) pointed out, ecosystem services generated by fish populations extend well beyond being a mere source of food. These services are derived from ecosystems with complex interactions, and for this reason both economically and non-economically valuable fish populations need to be sustained. This view is supported by the MEA (2005) which cautioned that fishing can only be sustainable if the surplus, not the resource base, is harvested and if the fish habitat is not degraded by human activities.

Given that fishing is mainly incentivised by the intimate contact people have with nature (i.e. a cultural and regulating service rather than a provisioning service), this ecosystem service should be used to stimulate human interest in nature and to provide aesthetic and recreational value (Holmlund & Hammer, 1999).

Since fishing in the Fafung community is mostly illegal and not accounted for, it is important that a holistic, ecosystem-based approach be followed to manage this resource and that the dynamics of this, often unpredictable ecosystem, be fully understood.

xi. Medicinal resources

As is evident from Figure 4.21 below, this ecosystem service is highly valued by the Fafung community since 42.6% of the respondents indicated that they value, enjoy and use it to a great extent, 20.8% to a fairly large extent and 19.8% to a moderate extent. Only 12.9% value, enjoy and use this ecosystem service to a small extent and as little as 4.0% indicated that they do not value, enjoy or use it at all.

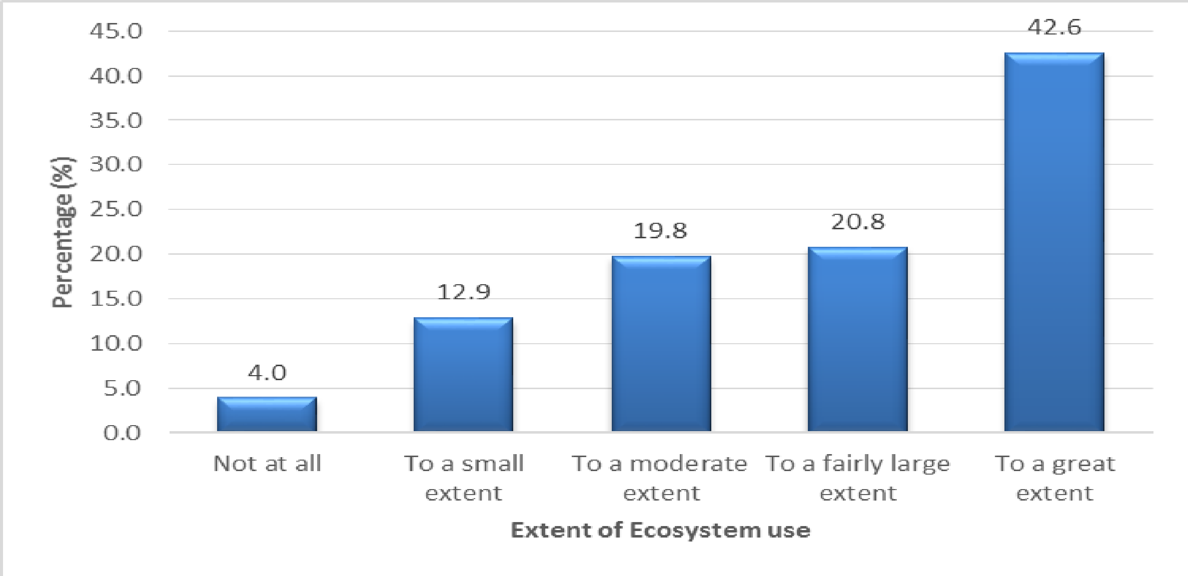

Figure 4.21: Medicinal resources

As has been pointed out earlier, Fafung is an impoverished community with low education levels and given the distance people have to travel to gain access to health centres and the fact that they cannot afford expensive pharmaceuticals, it is understandable that especially the elderly will resort to their indigenous knowledge and rely on traditional medicines (Mahomoodally, 2013). According to the latter, traditional medicine is the sum total of knowledge, skills and practices based on the theories, beliefs and experiences indigenous to different cultures that are used to maintain health, as well as to prevent, diagnose, improve or treat physical and mental illnesses.

Typically, plants harvested for medicinal purposes include *Agathosma betulina* (*Rutaceae*), *Aloe ferox* (*Asphodelaceae*), *Aspalathus linearis* (*Fabaceae*) and *Harpagophytum procumbens* (*Pedaliaceae*). According to Mahomoodally (2013), these plants consist mainly of secondary metabolites implying that they can stimulate digestion, reduce swellings and relieve pain. They also contain phenolic compounds that can act as antioxidants and venotoxins as well as antibacterial and antifungal tannins that act as natural antibiotics, diuretic substances that enhance the elimination of waste products and toxins and alkaloids that enhance mood swings and create a sense of euphoria. The lack of effective modern medical treatment for some ailments such as HIV/AIDS (Shackleton *et al.*, 2008) has also resulted in rural people resorting to traditional medicine.

The grassland and woodland ecosystems prevalent in and around Fafung are sources of medicinal plants and the presence of herbalists and traditional healers in the village correspondingly affirms the value, enjoyment and use of traditional medicine by this community. Zisenis *et al.* (2011) added that these plants can also be utilised commercially for the production of teas and oils, confirming that medicinal resources are a provisioning service which has close ties to cultural and economic benefits (Street & Prinsloo, 2012) and are, therefore, significant for human well-being (Shackleton *et al.*, 2008).

Although the use or harvesting of indigenous plants for medicinal use is highly important, it can at the same time pose a threat to biodiversity (Street & Prinsloo, 2012) since some protected plants and animals are targeted for medicinal use (Petersen *et al.*, 2017). In this regard, note that Daily *et al.* (1997) as well as Mahomoodally (2013) reported that approximately 80% of the emerging world population relies on traditional medicine for therapy. Furthermore, the commercialisation of medicinal plants in international trade (Shackleton *et al.,* 2008) makes overexploitation of indigenous plants worse. According to the National Research Council (1999), about 118 of the top 150 prescription drugs used in the United States are based on natural sources: 74% on plants, 18% on fungi, 5% on bacteria and 3% on one vertebrate (snake) species. According to Street and Prinsloo (2012), planting of medicinal plants on a large scale from which other benefits such as job creation and research may arise could be a possible solution. Currently, medicinal plants such as *Artemisa annua* (lengana in Tswana) are being considered as possible treatment for Covid-19 although they are still subject to testing for efficacy and possible adverse side effects (WHO, 2020).

Medicinal resources are also used to control events by supernatural means while others have symbolic value (Shackleton *et al.*, 2008), for example the ability to command respect when speaking and to make people accept one's viewpoint, especially in politics. In some instances, wild animals are also used for medicinal purposes including birds such as vultures, owls and eagles.

xii. Raw materials

Raw materials are used, enjoyed and valued in Fafung to a fairly large extent (27.7%), followed by a small extent (24.8%) and great and/or moderate extent (22.8% respectively). Only 2% of respondents indicated that they do not value this ecosystem service at all.

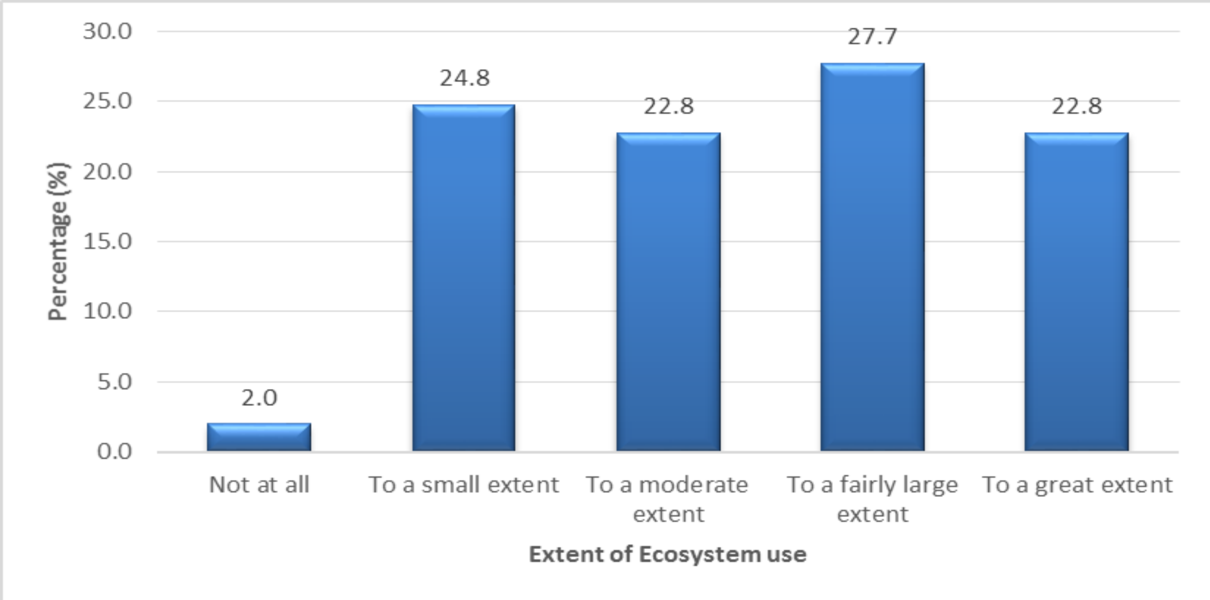

Figure 4.22: Raw materials

Raw materials are a general ES which encompasses other ES already discussed including medicinal resources, fish as food, wild animals as food, local wild plants as food, wood (as energy source and as timber), medicinal resources, grass as building and raw material and sand. Rocks and stones also resort under raw materials.

xiii. Rocks and stones

With regard to rocks and stones (Figure 4.24), out of the 100 respondents interviewed, the majority (32.7%) value, enjoy and use this ecosystem service to a great extent, while a further 20.8% indicated that they value, enjoy and use it to a fairly large extent and 11.9% to a moderate extent. On the other hand, 4% indicated that they do not use it all, while 30.7% value, enjoy and use this ES to a small extent only.

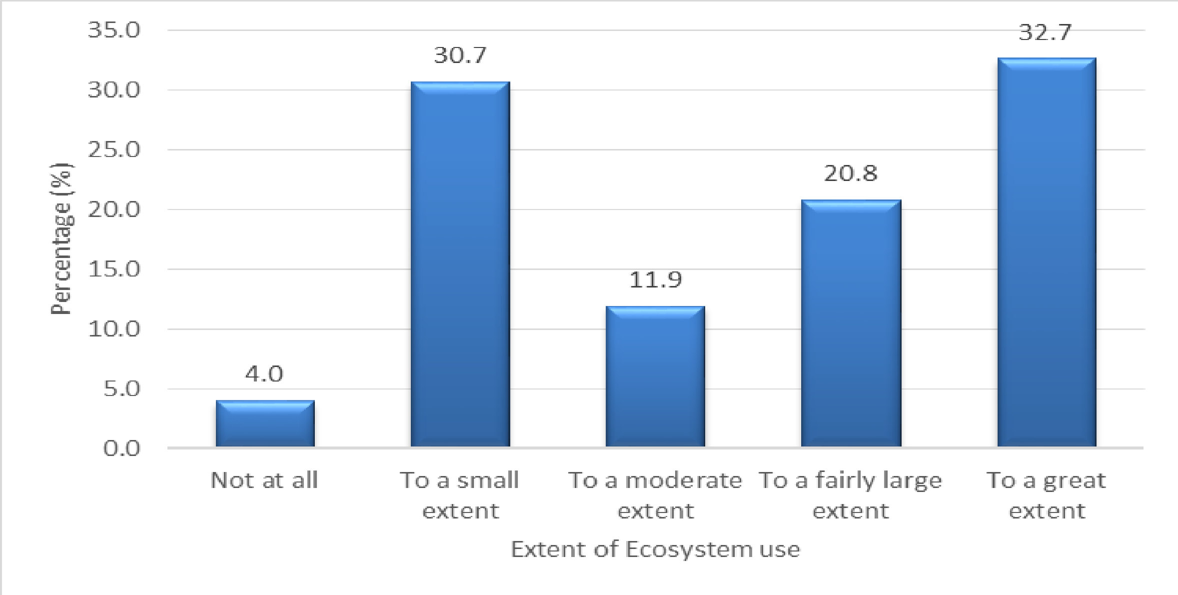

Figure 4.24: Rocks and stones

Rocks and stones are mainly used for building and construction. Building stones are naturally occurring rocks of igneous, sedimentary or metamorphic origin which are sufficiently consolidated so that they can be cut or shaped into blocks or slabs for use as walling, paving or roofing (UK, 2005). As a key component of ecological infrastructure such as mountains, rivers and wetlands, they are also appreciated for their aesthetic beauty and are the key to controlling soil erosion since they fulfil an essential role in trapping sediments and reducing high surface run-off (Lal, 2014).

4.9.2 Regulating services

The Millennium Ecosystem Assessment (2005) found that the condition of a service depends more on whether the ecosystem's capability to regulate a particular service has been enhanced or diminished. The results reflected in Table 4.4 below indicate a mean of 3.32, SD of 0.55 and median of 3.34, implying a normal distribution since values are dispersed evenly around one representative (mean) (Lee & Lee ., 2005).

Table 4.4: Regulating ES used, enjoyed and valued by the Fafung community

Number	ES classification	ES	Mean	Standard deviation	Median	Highest range score	Analysis
14	**Regulating Services**	Air to breathe	3.32	0.55	3.34	4.19	One ES used to a fairly large extent, six to a moderate extent and one to a small
15		Biological control				3.7	
16		Erosion prevention				3.46	
17		Local climate				3.36	
18		Moderation of				3.33	

		extreme events					extent
19		Maintenance of genetic diversity				3.22	
20		Pollination				3.01	
21		Wastewater treatment				2.25	

i. Air to breathe

As is to be expected, air to breathe is a highly used, enjoyed and valued regulating ES in Fafung with only 7.9% and 1% of the respondents indicating that they value it to a small extent or not at all (see Figure 4.24).

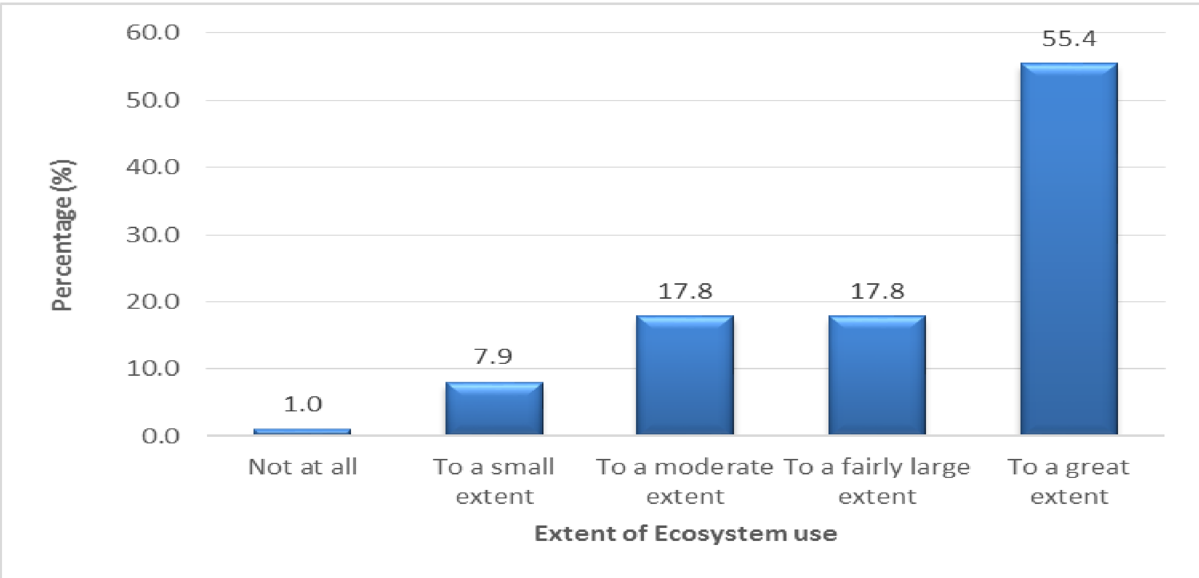

Figure 4.24: Air you breathe

According to Sekercioglu (2010), ecosystem services start at the most fundamental level: creation of the air we breathe and the supply and distribution of the water we drink. Ecosystems purify air and water, generate oxygen and stabilise the climate. Through photosynthesis by bacteria, algae, plankton and plants, atmospheric oxygen is mostly generated and maintained by ecosystems and their constituent species, allowing human and innumerable other oxygen-dependent organisms to survive.

According to Turpie *et al.* (2019), elevated atmospheric CO_2 acts as an enhancer of C_3 plants and constrains C_4 species from growing due to photosynthetic pathways. This argument has some relevance to the Fafung savanna where woody species, which use a C_3 photosynthetic pathway, have outcompeted grass species which use a C_4 process and this ultimately led to bush encroachment. The reduction of CO_2 emission in the atmosphere is critical to the grasslands of Fafung in so far as grazing capacity is concerned.

Furthermore, clean quality air is vital to reducing the severity of climate change in so far as extreme hot and cold temperatures are concerned. Gases such as CO_2, methane (CH_4), and nitrous oxide (N_2O) trap the sun's heat, especially the long-wave infrared radiation that is emitted by the warmed planet (Sekercioglu, 2010). According to the *South African Carbon Sinks Atlas* (DEA, 2017), the volatility of carbon in the soil means it will eventually find its way into the atmosphere and contribute to greenhouse gas (GHG) emissions if land degradation is not addressed.

Clearly, there is a strong linkage between air to breathe, carbon sequestration and soil fertility. The more soils are fertile and aid or support the growth of vegetation, the more they will be able to sequester carbon and this will lead to less carbon in the atmosphere and a reduction in GHG.

ii. Biological control

Biological control as an ecosystem service (Figure 4.25) is used, enjoyed and valued to a great extent by 34.7% of the respondents, followed by 29.7% to a moderate extent and 19.8% to a fairly large extent. A relatively small proportion of the respondents (12.9%) value, enjoy and use this ES to a small extent, while only 3.0% do not value, enjoy or use it at all.

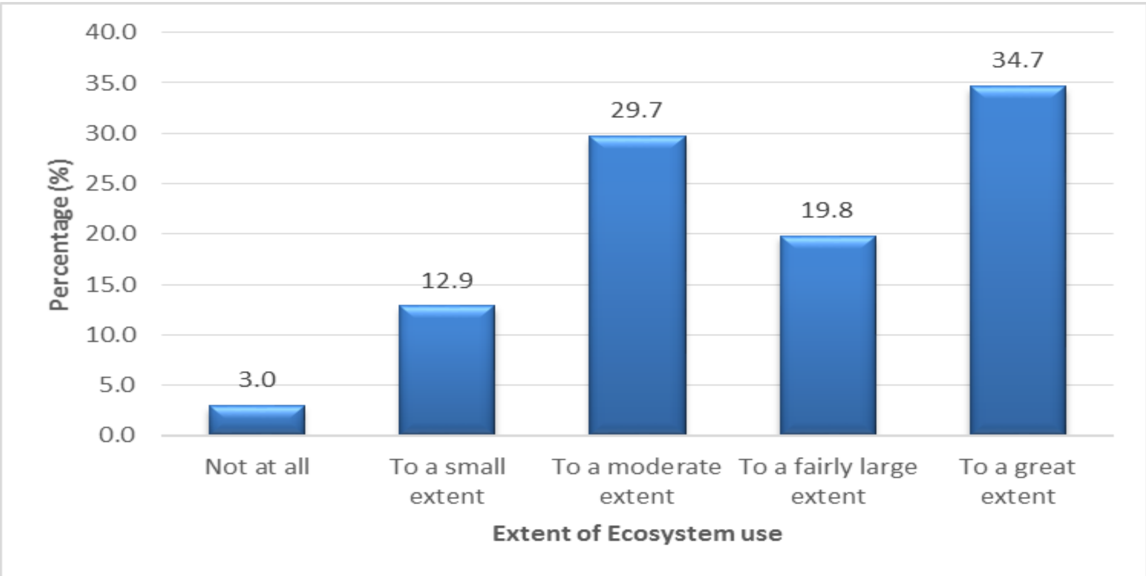

Figure 4.25: Biological control

Biological control is defined by Van Lenteren (2006) as the use of an organism to reduce the population density of another organism. It involves the use of introduced, highly selective natural enemies (usually herbivorous arthropods or pathogens) to control plants or pests (Zachariades *et al.*, 2017) and is regarded as an important ES in agriculture and forestry to enhance yield (Bengtsson, 2015).

Biological control is a sustainable, cheap and clean pest-management method compared to conventional synthetic pesticides (Van Lenteren, 2006). The most significant value of biological control in Fafung is the controlling of ticks as parasites on cattle (Richard *et al.*, 2006) and crops pests.

Furthermore, Zachariades *et al.* (2017) reported that biological agents released on alien invasive plants, especially *Cereus jamacaru* and *Opuntia ficus indica* species, have been highly effective in reducing their densities. Thus, if applied prudently, biological control can help to maintain the integrity of woodlands by protecting threatened indigenous species.

A hike in population growth necessitates agricultural intensification and the resultant increase in the use of conventional methods (i.e. fertilisers and pesticides) to expand croplands contributes to biodiversity loss and a decline in ecosystem services (Zhao *et al.*, 2014). In the case of Fafung, agricultural activities in the top catchment result in eutrophication and sedimentation that limit the community's enjoyment and use of ecosystem services. Nitrates, ammonia and other fertilisers are carried downstream (Botkin & Keller, 2007), resulting in a marked increase in non-communicable diseases known to be related to chronic exposure to pesticides including cancer, neurological diseases, cognitive and neuro-developmental disorders, reproductive disorders, cardiovascular diseases, diabetes and attention disorders and hyper-activity in children (TPRI, 2019). To counter eutrophication and sedimentation, integration of biological control can contribute towards developing mechanical, physical, genetic, pheromonal and semi-chemical measures to develop new cultivars that are resistant to pests and diseases (Van Lenteren, 2006).

Given that Fafung is hitherto lightly invested by alien invasive plants, utilising biological control to frustrate infestations by species such as agents of *Tecoma stans, Mada polluta/pseudonapomyza, Lantana camara* and *Puccinia lantanae* may well be highly cost-effective and serve as an alternative means to protect residents against the safety hazard posed by herbicides (Van Lenteren, 2006).

iii. Erosion prevention

With regards to erosion prevention (Figure 4.26), only 10.9% of the respondents value this ecosystem service to a small extent and only 3% indicated that they do not value it at all. In contrast, 41.6% of the respondents indicated that they value erosion prevention to a moderate extent, 26.7% to a fairly large extent and 17.8% to a great extent.

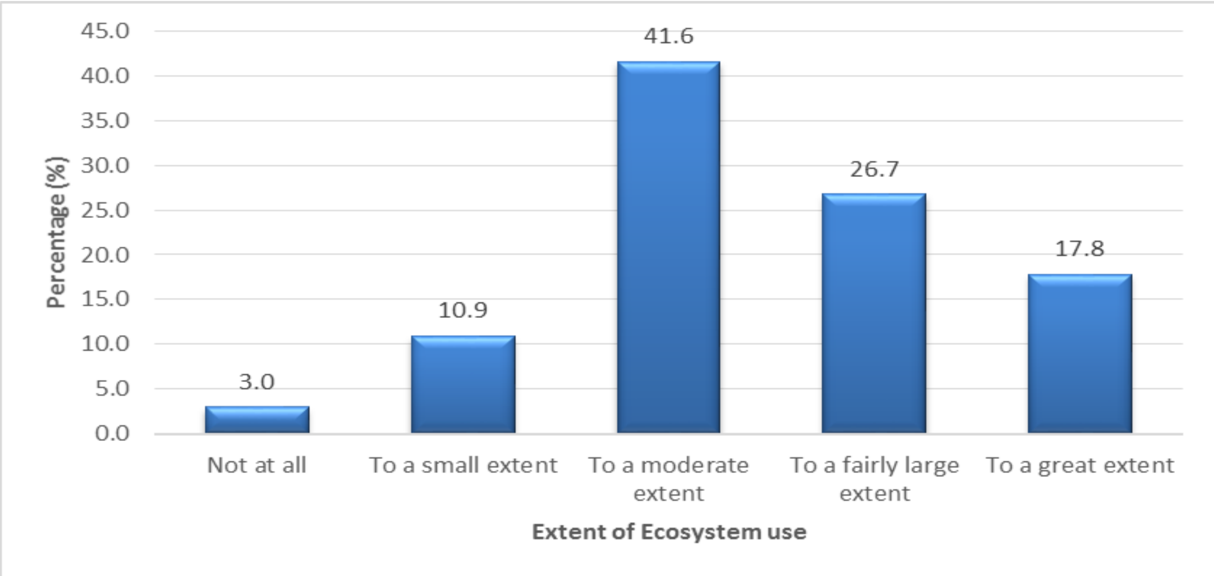

Figure 4.26: Erosion prevention

Sheet erosion is the most prevalent form of erosion in Fafung as a result of overgrazing and subsistence farming, followed by gully erosion due to sand mining. As Mngeni *et al.* (2016) and Lal (2014) pointed out, sand mining, soil erosion, water quality, carbon sequestration and biodiversity are intertwined: As gullies form due to sand mining, the water quality deteriorates and what remains of the bottom soils is left with poor carbon-storage capabilities (DEA, 2017) which is exacerbated by a lack of vegetation cover, resulting in habitat loss and a threat to biodiversity. Furthermore, eroded soils are a major cause of siltation in wetlands, rivers and dams, thereby contributing to the reduction of the carrying capacities of these water sources which could result in flooding. Off-site impacts that can also accelerate erosion include eutrophication and contamination, sedimentation of reservoirs and waterways and emissions of greenhouse gases (e.g. CO_2, CH_4 and N_2O). To a degree, the aforegoing can be observed along the Pienaars/Moretele River in Fafung where eroded soils are mostly topsoil rich in organic matter with high phosphorus levels that can be ascribed to *ex situ* activities.

Erosion prevention is an important regulating ecosystem service that could occur naturally where ecosystems are functional, in other words where vegetation is capable of trapping sediments and retarding surface run-off (Botkin & Keller, 2007). In some instances, though, severe soil erosion may require human intervention in the interest of advancing food and nutritional security.

The wetlands within the Borakalalo Nature Reserve are considered of high value despite being heavily degraded (DWS, 2012). These wetlands have been the focus of the DEFF's Working for Wetlands programme over the past few years. The purpose of this restoration work is to enhance the wetlands' functions in terms of removing excess nutrients, breaking down pollutants and, more importantly, helping to mitigate droughts and floods (Botkin & Keller, 2007). Another DEFF programme, Working for Ecosystems, currently focuses on controlling bush encroachment, but given the extent of erosion and soil degradation in Fafung, a soil restoration project extending beyond wetlands to dry landscapes may be necessary to curb the degree of soil loss which exacerbates the siltation of water courses. Combined, these two programmes can help to moderate extreme events and can contribute immensely to building resilience against climate change.

iv. Local climate

As depicted in Figure 4.27, ecosystem services flowing from local climate are valued, enjoyed and used at the higher extreme to a moderate extent (50.5%), to a fairly large extent (23.8%) and to a great extent (12.9%). At the lower extreme, this ES is used to a small extent by 11.9% of the respondents, whereas 1.0% of the respondents do not value it at all.

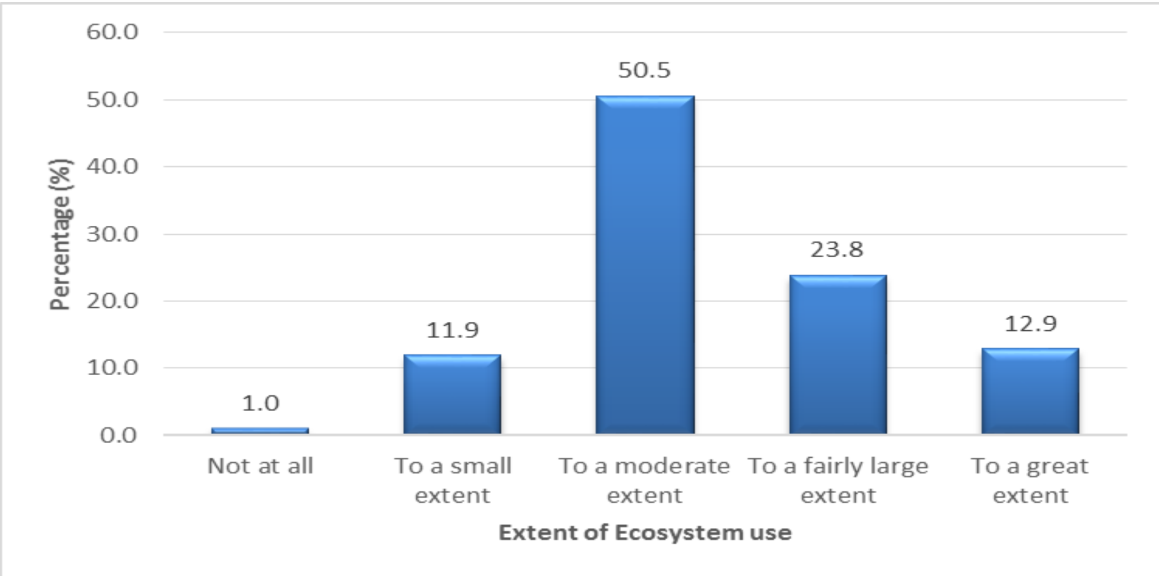

Figure 4.27: Local climate

According to Daily *et al.* (1997), climate plays a major role in the evolution and distribution of life. In fact, most scientists would agree that life itself is a principal factor in the regulation of global climate, helping to offset the effects of episodic climate oscillations by responding in ways that alter the greenhouse-gas concentrations in the atmosphere. By way of illustration, natural ecosystems could have helped to stabilise the climate and to prevent overheating by removing more of the greenhouse gas carbon dioxide from the atmosphere as the sun grew brighter over millions of years.

As has been pointed out by Midgley *et al.* (2013), Fafung resorts under hotspot 2 (Pretoria North/Moretele) where significant warming has been observed over the past couple of decades: Extremely hot days have increased significantly and extremely cold nights have become fewer. Given that this hotspot is in an elevated catchment area that can also be classified as semi-arid, it is understandable why, in terms of the global climate model, Midgley *et al.* (2013) would classify it as climatically stressed and prone to risks imposed by droughts, floods and wildfires The poor drainage systems of numerous rivers and wetlands, combined with a lack of spatial planning and building standards, create high risks for flooding and a loss of homes and assets after heavy rains in the upper catchment. This situation is aggravated by more intense downpours linked to climate change.

Even though intangible, indirect and less noticeable, global and regional climate regulation impact the local climate and is a threat to all human populations, with those most affected often having contributed least to the problem (Smith *et al.*, 2011). In the case of rural communities such as Fafung, local climate is more important since the services of ecosystems such as woodlands, grasslands, wetlands and rivers are beneficial to local people through the provision of shade and shelter and the regulation of humidity and temperature (Smith *et al.,* 2013). Ecosystems regulate global and regional climate in three different ways:

i. By providing sources or sinks of greenhouse gas (affecting global warming) and sources of aerosols (affecting temperature and cloud formation);
ii. By enhancing evapotranspiration and, thereby, cloud formation and rainfall; and
iii. By affecting surface albedo and, thereby, radiative forcing and temperature.

Local climate has linkages with carbon sequestration, air to breathe, soil erosion and maintenance of soil fertility. Ecosystem products such as timber and biomass crops can store carbon or replace other products with higher emission costs (Ashmore *et al.*, 2019). The emission of GHG as a result of anthropogenic activities such as agriculture, deforestation, wetland extraction and the production of ruminant livestock impact adversely on the quality of atmospheric air which people depend on for their survival. Some of these activities, specifically agriculture and deforestation, are major causes of soil erosion, which enhances carbon emission and contributes to loss of soil fertility.

v. Moderation of extreme events

With regard to the moderation of extreme events (Figure 4.28), 37% of the respondents value this service to a moderate extent, 27% to a fairly large extent, 16% to a great extent and 14% to a small extent while 6% do not value this service at all.

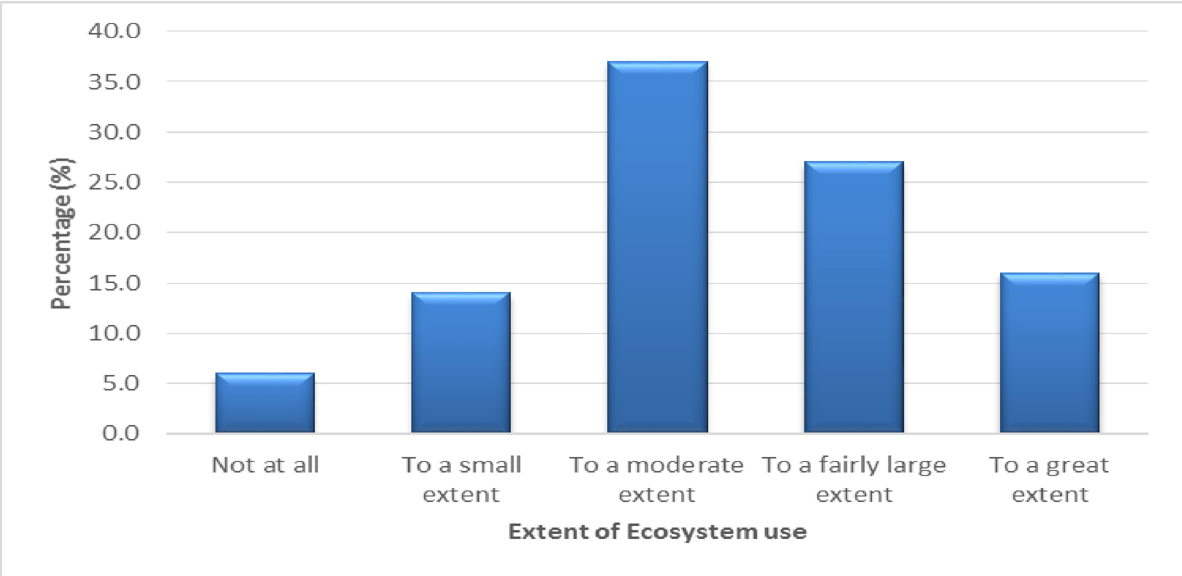

Figure 4.28: Moderation of extreme events

The ecosystem services related to moderating extreme events are indirect and intangible as opposed to provisional goods which are mainly direct and tangible in nature. The fact that only 16% of respondents attach great value to this ES could be attributed to a general lack of understanding regarding the importance of ecosystems in mitigating extreme events and the low levels of education indicated in Figure 4.2, which is a pre-condition for people to understand the indirect value of ecosystems. Despite the findings above, the fact of the matter is that the residents of Fafung, knowingly or unknowingly, are adapting to harsh climatic conditions even though they may not recognise their contributions in this regard.

Rural people tend to value ecosystems in relation to the tangible goods they derive from them, and this undermines a true appreciation of the real value of the ecosystem services provided by, for example, wetlands, namely an ability to attenuate floods, recharge ground water, store sediments, recycle nutrients and offer protection against erosion (Brotherton &

Joyce, 2015). Fafung village and the adjacent Borakalalo Nature Reserve are situated at the western end of the Moretele flood plain, which is the second largest flood plain in the Bushveld eco-region and represents the Southern most natural distribution of wild rice (*Oryza longistaminate*) in Africa (DWS, 2012). Wetlands and riparian habitats play a pivotal role in regulating flows and attenuating floods (Shackleton *et al.,* 2008) since they capture and store water during the rainy season, thereby moderating extreme events such as flooding in lower-level downstream landscapes, and release water during periods of drought when it is most needed. Thus it can be argued that wetlands are the balancing equation that ensures that neither floods nor droughts are too severe.

Shackleton *et al.* (2008) predict that climate change will result in an increase in the frequency of extreme events due to higher temperatures, higher evapotranspiration and an overall decrease in rainfall. Consequently, droughts interspersed with excessively wet periods are on the rise in South Africa, and these events are bound to have a devastating impact on the delivery of a range of ecosystem services and to cause havoc in people's lives.

Floods, in particular, have a severe impact on the environment since they destroy habitats, displace animals, affect the functioning of plants, alter river systems and destroy property. Along a similar vein, though, it ought to be noted that according to Marais (2012), siltation accounts for 718 million m^3 or a 4% loss in the storage capacity of South Africa's dams. There is a direct link between siltation and drought: Reduced storage capacity (quantity) and an increase in costs to treat water so that it is fit for human consumption has a direct impact on the livelihoods and well-being of rural communities such as Fafung where people rely on borehole and wetland water for drinking and water from dams and rivers for other uses (Tundu *et al.*, 2018).

Fluctuations in rainfall caused by climate change parallel fluctuations in other ecosystem services such as crop and forage production as well as water recharge and supply, often resulting in cyclical patterns of change. These alterations in climate patterns may create an environment that is conducive to infestation by alien invasive plants (Hoy *et al.*, 2016) and may worsen water shortages in semi-arid villages like Fafung.

Natural disasters such as floods and droughts in the rule increase the vulnerability of poor people to extreme poverty, displacement and health shocks or diseases. Most of the diseases and health shocks the world experiences, including HIV/AIDS, cancer, malaria, dengue, diabetes and pandemics the likes of Covid-19, have a clear climate-change signature (i.e. an increase in the frequency and strength of extreme weather events and the expanding range and spread of vector-borne diseases). Recently, the state of ecosystems and their capability and readiness to deliver healthy services or goods have become a key issue as the world battles to mitigate the Covid-19 health shock (World Health Organization, 2020). There is one thing, however, that almost all health shocks have in common: They hit the poorest and the most vulnerable the hardest. These health shocks act as poverty multipliers, forcing families into extreme poverty because they have to pay for their own healthcare since they do not even enjoy coverage for the most basic health services. When health disasters hit, and in a business-as-usual scenario they will do so increasingly, global inequality is sustained and reinforced and paid for with the lives of the poor and marginalised, the people of Fafung being no exception.

vi. Wastewater treatment

As illustrated in Figure 4.29, the majority of respondents' value, enjoy and use wastewater treatment as an ecosystem service only to a small extent (41.6%), while a further 26.7% indicated that they do not value this service at all. On the other hand, 15.8% of respondents indicated that they value, enjoy and use this service to a moderate extent, 11.9% to a fairly large extent and 4% to a great extent.

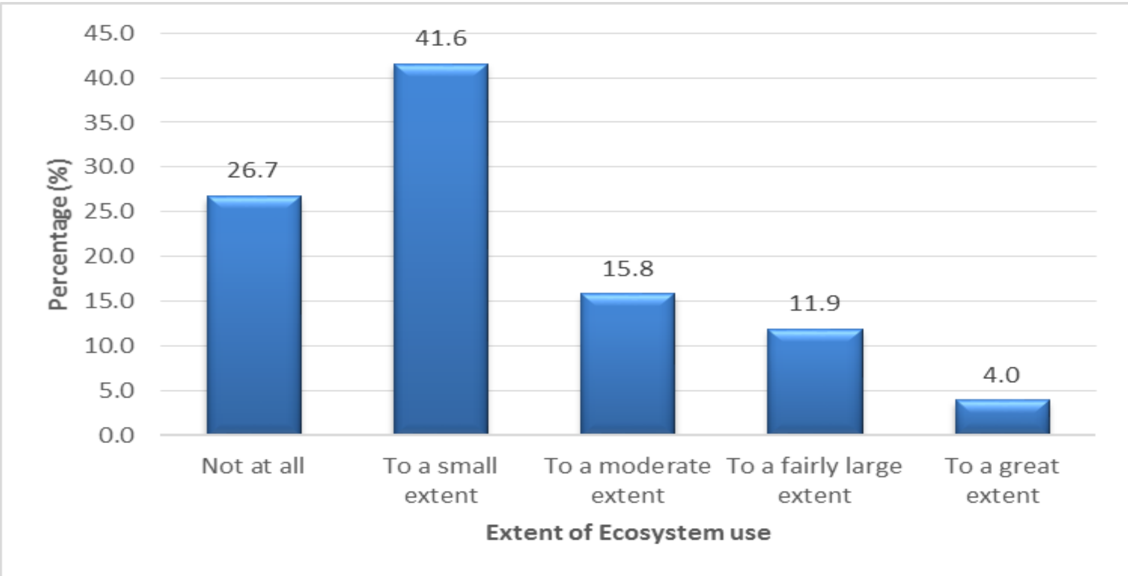

Figure 4.29: Wastewater treatment

The results reported above should be considered against the background of a village that has no running water and no wastewater treatment plant. The people of Fafung are dependent on water from boreholes drilled in their backyards or from the wetlands for drinking and must rely on water from the river and dam for all other purposes. The local

Madibeng Municipality has serious service delivery issues, including the supply of potable water, which has been the cause of major service delivery protests in the past.

As is evident from the demographics reported earlier, not everyone in Fafung can afford to drill in their backyard to access groundwater (SDF, 2015). Consequently, people will have no option but to collect water from potentially polluted neighbouring sources. As a result, vector-borne diseases such as malaria and dengue (World Health Organization, 2020) will continue to afflict the health and livelihoods of the people.

To offset the high cost of water treatment, the Madibeng Municipality could consider utilising natural ecosystems such as wetlands because, as Botkin and Keller (2007) pointed out, wetlands have the ability to remove pollutants or toxins and to trap sediments. This will, however, require investment in the restoration of ecosystems to enhance the delivery of clean water and improvement of land management practices and conservation.

vii. Maintenance of genetic diversity

As reflected in Figure 4.30, 36.6% of the respondents rely on ecosystems for the maintenance of genetic diversity to a moderate extent, followed by 24.8% who rely on it to a fairly large extent, 22.8% to a small extent and 12.9% to a great extent. Three percent of the respondents indicated that they do not value this ES at all.

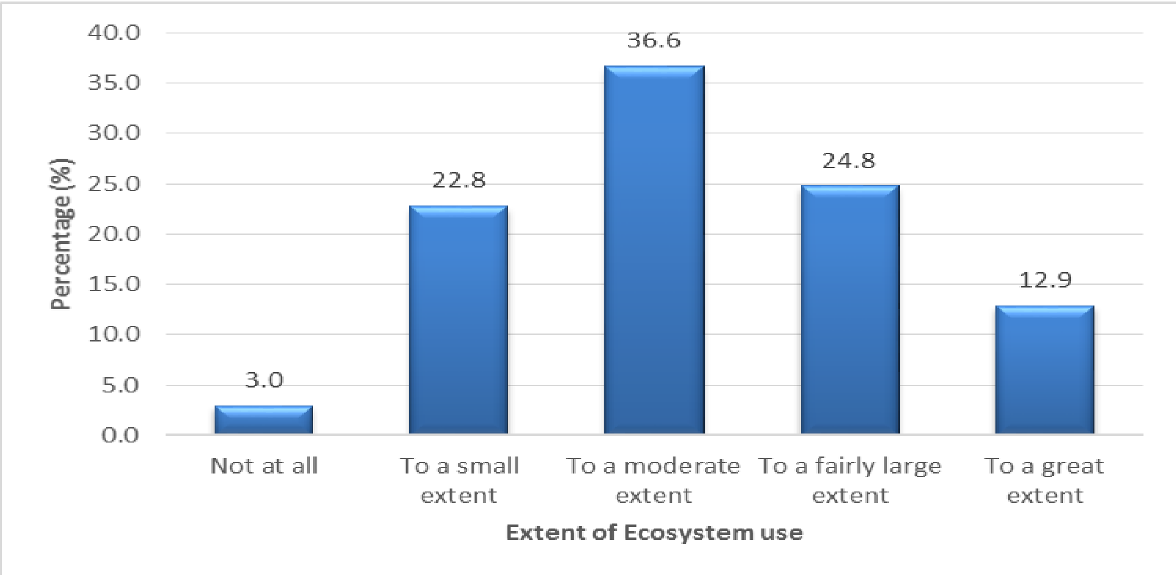

Figure 4.30: Maintenance of genetic diversity

Woodlands and grasslands are essential ecosystems with the ability to withstand and adapt to changing conditions and disturbance and to aid the development of genetic diversity.

Genetic diversity has to do with changes to inherited characteristics in response to changing environments and can occur through mutation with variations in deoxyribonucleic acid (DNA) and through natural selection (Botkin & Keller, 2007). In short, genetic diversity enhances the possibility of species to adapt to various degradation regimes or, to quote Bellamy *et al.* (2018): “Species with high levels of adaptive genetic diversity have a greater likelihood of containing individuals within their populations with the appropriate genetic make-up to survive and reproduce under altered conditions.”

Accordingly, Reynold *et al*. (2012) defined three measures of genetic diversity: Genotypic diversity or clonal diversity measures the number of unique individuals within populations; heterozygosity refers to diversity within an individual; and allelic diversity has to do with diversity at population level.

Effective maintenance of genetically diverse populations requires an understanding of the evolutionary process responsible for determining the gains or losses of genetic diversity. Therefore, management efforts to maintain or increase genetic diversity in populations should focus on maximising gene flow by maximising effective populations sizes (McKee, *et al.*, 2017). Likewise, maintaining genetic diversity as an ecosystem service depends on guarding against the fragmentation of habitats because, according to Reusch and Hughes (2006), habitat fragmentation is the main cause of a decrease in the genetic diversity of plant species. Fragmentation impacts on biodiversity not only at species level but also on genetic diversity since some smaller populations may be geographically isolated. According to Bellamy *et al.* (2018), loss of variation in some genes may lead to a decline in small, isolated populations as a result of genetic drift.

Genetic variation is directly related to population size and often decreases during the process of fragmentation. Since they are home to an exceptional diversity of plants, insects, and fungi, grasslands are probably one of the most diverse habitats and, therefore, extensive repositories of biodiversity and genetic materials but, as Zisenis *et al*., (2011) remarked, genetic diversity is generally negatively related to fragmentation of grasslands, especially against the backdrop of a growing human population

As has been observed in Fafung, overgrazing has the potential to convert grasslands to relatively sparse shrubland composed of less palatable herbaceous or woody species (Risser, 1998), the obvious consequence being a loss of grasslands’ native biodiversity. Furthermore, as a result of overgrazing caused by cattle, Fafung’s woodlands are in a state of neglect (Bellamy *et al.*, 2018) resulting in lowland broadleaf woodlands becoming increasingly shady and dense with fairly uniform stand structures, poor understory cover and reduced areas of open space. This change in woodland structure has contributed to a decline in many fauna species, such as birds, as well as specialist ground flora species.

To a degree, appreciating the need to maintain genetic diversity and appreciation of pollinators are intertwined. As argued below, pollinators enhance the reproduction and genetic diversity of plant species and, therefore, contribute to reproduction. Moreover, a variety of pollinators (wild and commercial) is a prerequisite for greater production.

viii. Pollination

As is evident from Figure 4.31 below, only 6.9% of the respondents indicated that they do not use, enjoy and value this ecosystem service at all. On the other hand, 31.7% indicated that they value it to a small extent, 27.7% to a moderate extent, 20.8% to a fairly large extent and 12.9% to a great extent.

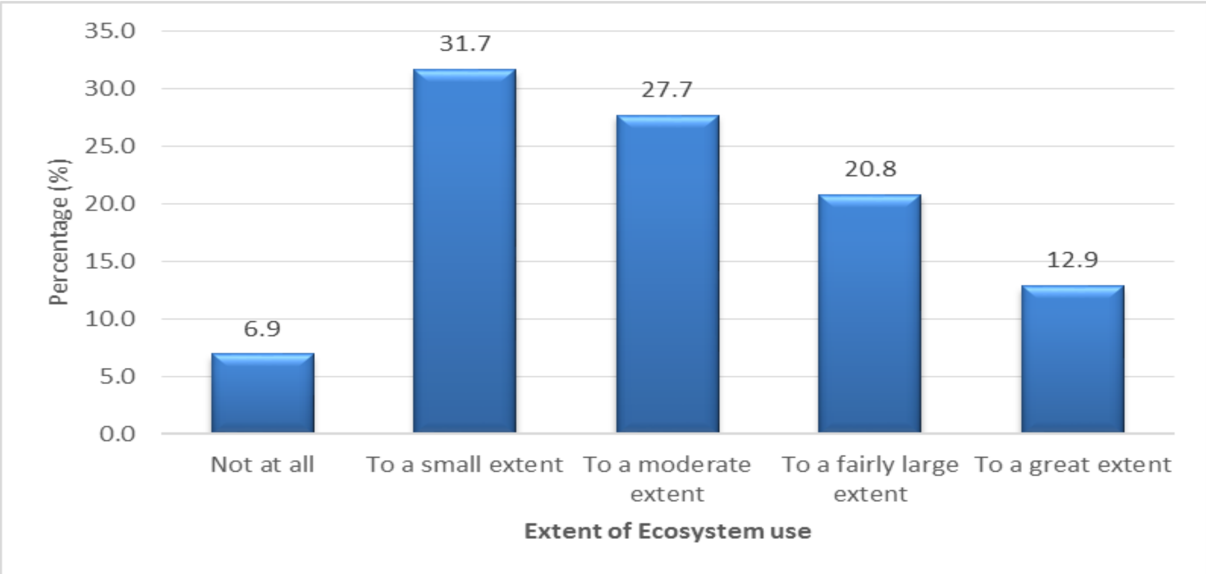

Figure 4.31: Pollination

As a regulating ecosystem service, pollination is the key to both food security and biodiversity conservation (Bonifazi *et al.*, 2017). It is especially true in rural areas where people derive fruits, firewood, dye, medicine and cosmetics from plants such as prickly pear cactus (*Opuntia ficus-indica*), marula (*Sclerocarya birrea*), wild medlar (*Vangueria infausta*), monkey orange (*Strychnos spinosa*), buffalo thorn (*Ziziphus mucronata*), mallow raisins/sand raisins (*Grewia villosa/microthyrsa*) and blue bush (*Diospyros lycioides*) (Mokganya *et al.,* 2017). Subsistence farmers benefit from wild pollinators' services and the conservation of these pollinators are important to maintain the production of the products referred to above. Therefore, the decline in wild bee populations is of great concern. This decline is mainly caused by environmental pressures including habitat transformation or fragmentation, loss of biodiversity and abundance of floral resources, inappropriate use of pesticides, spread of pests and diseases and climate change (Melin *et al.*, 2014).

Pollinators and pollination are not only relevant to agriculture and food production, but also to the conservation and sustainable use of biodiversity in all ecosystems since only a very small proportion of plant species produces seed entirely through autonomous self-fertilisation or through non-sexual processes such as apomixes. Around 80% of plant species are self-incompatible or dioecious and completely dependent on biotic pollination in the form of animal pollinators for the production of seeds and the maintenance of their populations. Animal-mediated pollination usually leads to some degree of out-crossing and thus promotes and maintains genetic variation in populations which, in turn, allow species to adapt to new and changing environments.

At the fourteenth Conference of Parties convened in accordance with the Convention on Biological Diversity (Convention on Biological Diversity – Conference of the Parties 14, 2018), a resolution was reached that these pollinators are critical for the continued functioning of ecosystems as they provide food from habitats and provide other resources for a wide range of species. Furthermore, Bonifazi *et al.* (2017) pointed out that indigenous people rely on pollinators and pollination for various reasons which include nourishment, traditional medicine, activities related to their spiritual and contemplative life and hand-crafting.

As indicated in Figure 4.11 (grass for grazing) and the latest land-cover/-use map (Figure 3.3), Fafung is prime grazing land. Melin *et al.* (2014) warned of the negative impacts of overgrazing on pollinators through the loss of host plants and trampling of nesting sites. Given that a small portion of land is being used for subsistence farming in the area, farmers may potentially increase their yields by practising less tillage or non-tillage as these methods will conserve the habitats of or nesting for pollinators while Bonifazi *et al.* (2017) hold that mixed-crop farming can also add value since this practice increases the variety of pollinators.

4.9.3 Cultural Services

Of the three categories, evaluating cultural ecosystem services (CES) is the most challenging. For instance, some anthropological studies address cultural services (i.e.

recreational fishing or hunting) from a provisioning point of view without really distinguishing between the two (Le Maitre *et al*., 2007). This makes it difficult to quantify, let alone value, these services. Consequently, literature mostly looks at CES of a recreational nature since these are easy to measure (Cooper *et al.*, 2016).

De Lacy and Shackleton (2017) concur that people tend to attach other forms of value to CES rather than a monetary value. For instance, sacred sites are typically high in species richness, biodiversity and biomass compared to surrounding land-uses and are, therefore, of conservation value. Le Maitre *et al*. (2007) argued that cultural services studies should be viewed broadly from the perspective of sustainability science where recognition is afforded to multiple and often divergent epistemologies stemming from different domains of science. In this way, studies such as these can address the diversity of norms and values held by society but will, nevertheless, require an understanding of non-scientific worldviews which may differ markedly from the objective knowledge scientists believe they offer. Le Maitre *et al*. (2007), described the characteristics that define sustainability science as “use-inspired basic research, located at the interface between society and its sustaining natural environment, focused on the resilience of complex social ecological systems, having a transdisciplinary approach to understanding the validity of multiple epistemologies, and emphasizing learning and adaptation”.

In total, eight cultural ecosystem services were assessed for the Fafung community, where six were used, enjoyed and valued to a moderate extent and two to a small extent. Aesthetic value and mental and physical well-being are the most used, enjoyed and valued CES. Conversely, inspiration for culture and inspiration for art and design are the least used, enjoyed and valued. The mean is 3.23 with a standard deviation of 0.32 and a median of 3.16.

Table 4.5: Cultural ES used, enjoyed and valued in the Fafung community

Number	**ES classification**	**ES**	**Mean**	**Standard deviation**		**Highest range score**	**Analysis**
22	**Cultural Services**	Aesthetic reasons (nature’s beauty)	3.23	0.32	3.16	3.7	Six ES used to a moderate extent, two to a small extent
23		Mental and physical well-being				3.64	
24		Sense of place				3.38	
25		Recreation				3.19	
26		Tourism opportunities				3.14	

27		Spiritual experience				3.02	
28		Inspiration for your culture				2.97	
29		Inspiration for art and design				2.76	

i. Aesthetic reasons (nature's beauty) and spiritual experience

Given that CES are intangible in nature and that rural people with high illiteracy levels may not understand the value thereof, the percentages reflected in Figure 4.32 are encouraging since very few respondents indicated that they attach little (5.9%) or no (6.9%) value to nature's beauty as a CES. In contrast, almost half of the respondents indicated that they attach little or no value to spiritual experience as a CES (Figure 4.33).

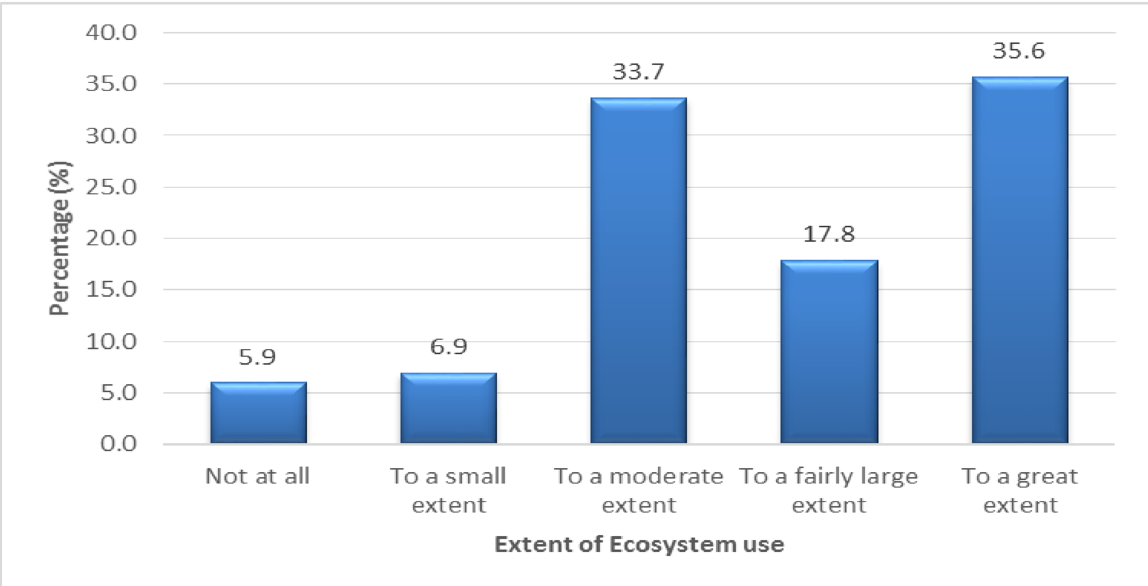

Figure 4.32: Aesthetic reasons

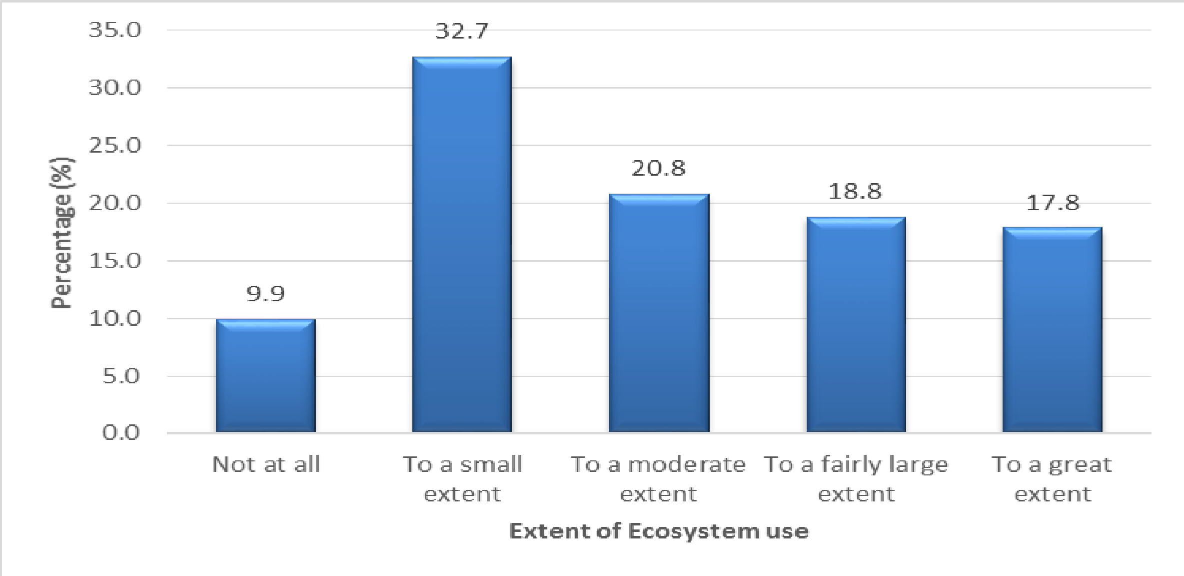

Figure 4.33: Spiritual experience

Cooper *et al.* (2016) define aesthetic value as the visual beauty, especially of landscapes, people enjoy and use for various reasons, some of them being spiritual. Rural people often find it difficult to assign aesthetic or spiritual value to an ecosystem service since these services are not discrete and, in studies of this nature, they inadvertently may have already assigned a value to these cultural ecosystem services under provisioning and/or regulating ecosystem services such as rivers, dams, wetlands, woodlands, grasslands, plants and wildlife.

Fafung is a deep rural African community characterised by poverty and underdevelopment where many people believe in an ancient culture, namely that they can connect with their ancestors. Given this community's proximity to the Borakalalo Nature Reserve, there are several hills and valleys as well as woodlands and wetlands that would qualify as "green infrastructure" as defined by De Lacy and Shackleton (2017) that is used by cattle headers, traditional healers and worshippers as well as locals to simply relax, exercise and socialise. In sum, it can thus be derived that green infrastructure contributes to the community's physical health and mental well-being since it reduces stress, creates a sense of place and increases social interaction and environmental knowledge.

Cooper *et al.* (2016) hold that spiritual and aesthetic services are closely associated with psychological benefit encounters with ecosystems and that the conservation value people attach to these places and ecosystems means that they will protect and defend them against anthropogenic destruction.

Aesthetic and spiritual understandings of the value of nature lead people to develop moral responsibilities towards nature (Cooper *et al*, 2016). For instance, sacred sites (churchyards, temple grounds, cemeteries and traditional spiritual spaces) heighten the value of ecosystems such as forests and groves since these sites are higher in species richness, biodiversity and biomass than the surrounding land. In this regard, De Lacy and Shackleton (2017) hold that natural green infrastructure in Fafung such as rivers, wetlands, hills and other places of scenic beauty is used by residents to connect with God or ancestors. Especially natural wells and wetlands are highly valued as sacred sites because people consider such areas to be closely associated with God or ancestors and normally go there to pray and to perform rituals such as baptisms.

ii. Recreation

According to Kulczyk *et al.* (2014), natural ecosystems are important since they provide people with recreational spaces where they can go to rest, relax and refresh. Vegetation, social, cultural and ecological factors define the recreational potential of an area which is further enhanced by recreational infrastructure and recreational activities (Krnacova *et al.*, 2018).

In Fafung, natural green ecological infrastructure takes the form of woodlands, grasslands and wetlands that can potentially satisfy mankind's need for leisure activities from which natural values can be derived (Kulczyk *et al.*, 2014). Furthermore, the Borakalalo Nature Reserve offers a whole array of recreational opportunities that make it possible for people to interact with the environment physically and intellectually. These recreational opportunities encompass fishing, game viewing and bird spotting as well as cultural visitations.

As is evident from Figure 4.34, just under 70% of the respondents indicated that they value, enjoy and use this CES to a fairly large or moderate extent with only 2% indicating that they do not value, enjoy and use it at all.

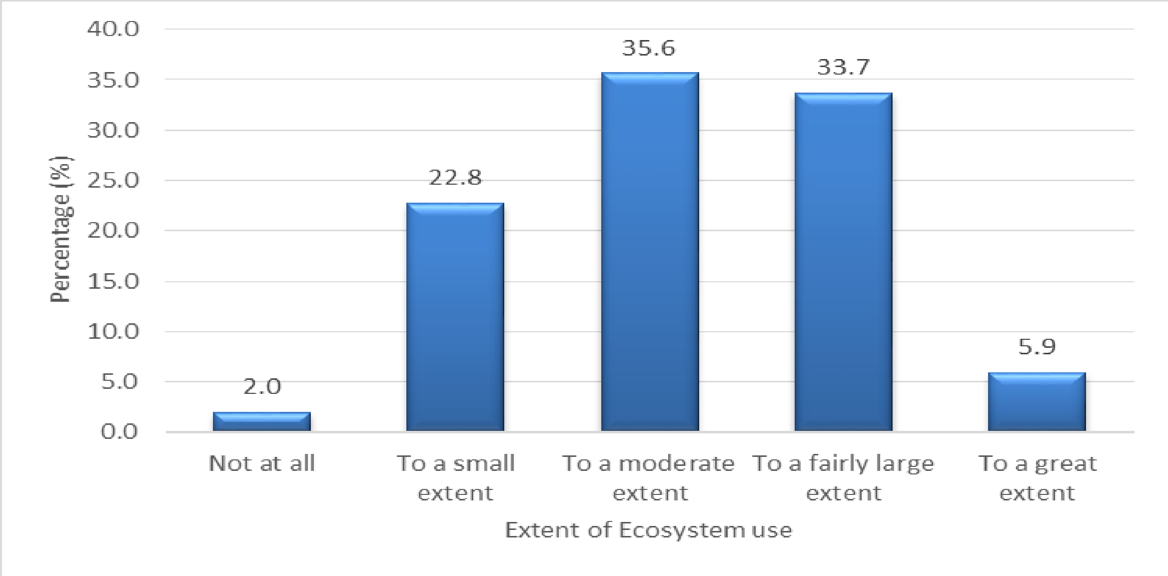

Figure 4.34: Recreation

iii. Mental and physical well-being

As has been indicated at the outset, it is often difficult to extract the value of cultural ecosystem services from that associated with other ES. This is particularly true for mental and physical well-being which is also dependent on provisioning services (e.g. food) and regulating services (e.g. moderation of extreme events and carbon sequestration) (Pueyo-Ros, 2018). According to Shackleton *et al.* (2008), the poor tend to be the most vulnerable in society because they face the widest array of risks and insecurities. They found that "for the very poor and vulnerable, a shock can send them on a downward spiral into deeper poverty that becomes difficult to escape".

Shackleton *et al.* (2018) hold that understanding what it means to be poor is crucial for interpreting and analysing ecosystem services' role in combating poverty. However, rather than referring to 'poverty relief' as an ecosystem service, human well-being is used as an alternative. Given that living nature contributes to people's quality of life through ecosystem services (Bratman *et al.*, 2019), human well-being is linked to the natural environment in a myriad of ways. The World Health Organization defines mental health as "a state of well-being in which an individual realises his or her own potential, can cope with the normal stress of life, can work productively and fruitfully, and is able to make a contribution to her or his community". In sum, human well-being is dependent on food, water, clean air, shelter and relative climatic constancy as well as the health benefits derived from a full complement of species, intact watershed, climatic regulation and genetic diversity (Corvalan *et al*., 2005).

According to the National Spatial Development Framework published by the Department of Rural Development and Land Reform in 2019, the Fafung community lacks many basic services (e.g. water and water infrastructure, shopping centres, schools and roads) that ought to be provided by government under normal circumstances (NSDF, 2019b). The resultant negative outlook affects the well-being of inhabitants and leads to stress, depression and a general low self-esteem.

Nevertheless, given that some of these services can be derived from nature at no cost or at lower costs (Shackleton *et al.*, 2008), it can be surmised that ecosystem services are indispensable for the health and well-being of people everywhere (Corvalan *et al*., 2005). For instance, people in Fafung are dependent on bore-hole water, wetlands and rivers for drinking, washing and watering their livestock (SDF, 2015). In many communities, especially peri-urban and urban communities, the unavailability of water will result in major service delivery protests. Equally, changes in the flow of ecosystem services have a direct impact on rural communities' livelihoods and income and can result in local migration and even political conflict (Corvalan *et al.*, 2005) since replacement of these services may have huge financial implications for the residents.

Against this background and given that ecosystem services enhance people's ability to counter environmental pressures and help to moderate extreme events such as floods and droughts, it is not surprising that just over 80% of respondents indicated that ecosystem services do, indeed, contribute to their mental and physical well-being (see Figure 4.35). Only 1% indicated that they do not value this CES at all.

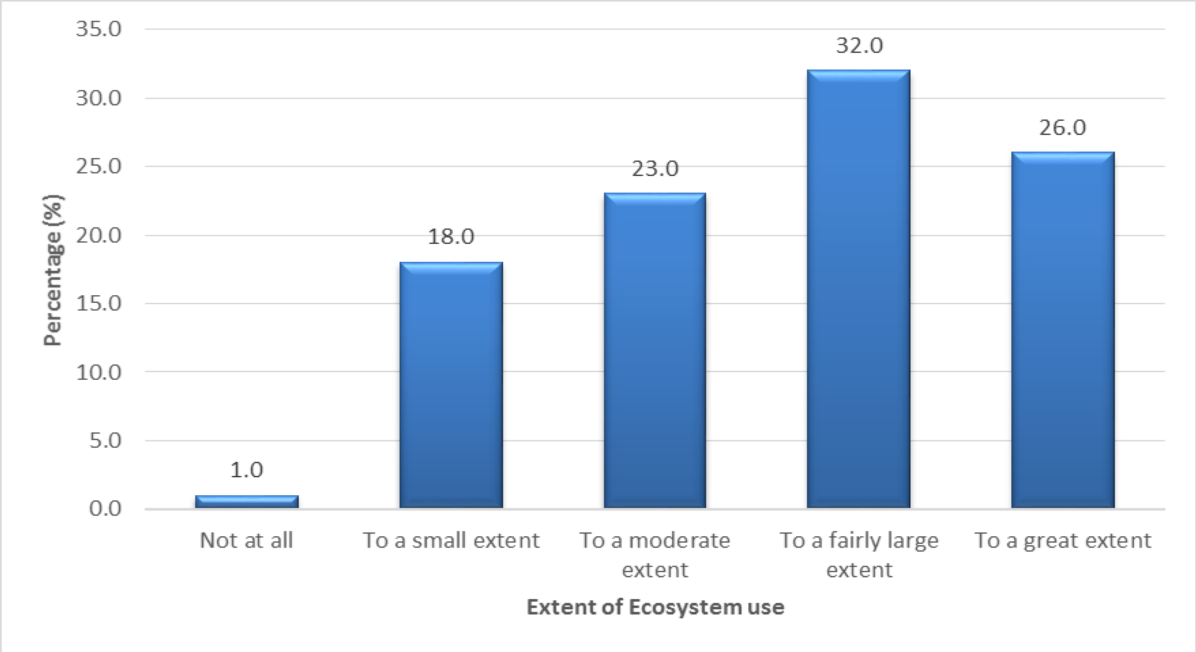

Figure 4.35: Mental and physical well-being

iv. Tourism opportunities

Yet again, tourism is a too broad and complicated phenomenon to be treated as a single ES itself (Kulczyk *et al.*, 2014). As Pueyo-Ros (2018) pointed out, there is a special connection between cultural and provisional services in that the “tourism industry needs provisioning services to provide tourists with food, water, or energy, among other things”. Furthermore, regulating services are important since tourists often choose a destination based on predictable weather conditions. Likewise, CES such as opportunities to interact physically, spiritually, symbolically and intellectually with sacred sites such as wetlands and valleys are an integral part of tourism and recreation (Kulczyk *et al.*, 2014) and ultimately contribute to mental and physical well-being (Shackleton *et al.*, 2008).

Biological diversity and preserved cultural heritage sites can enhance tourism opportunities (Krnacova *et al*., 2018) and this is indeed true in the case of the Fafung community where, especially, the Borakalalo Nature Reserve's cultural heritage and scenic beauty attract many a tourist. This reserve came into existence as a result of arrangements the former Bophuthatswana regime made with several surrounding villages, including Fafung, to consolidate land parcels held in trust by those communities. To this day, Fafung still owns part of the land constituting the park and co-manage the area in conjunction with the park’s board.

Sadly, though, despite the people of Fafung's cultural attachment to the reserve and the high biological diversity this landscape offers, tourists are seemingly deriving greater benefit from tourism as a CES than the local people themselves. Therefore, it should come as no surprise that almost 41.6% of the respondents indicated that they value tourism opportunities as an ecosystem service only to a small extent and 26.7% not at all (see Figure 4.36 below). Only 4% indicated that they value this ES to a great extent.

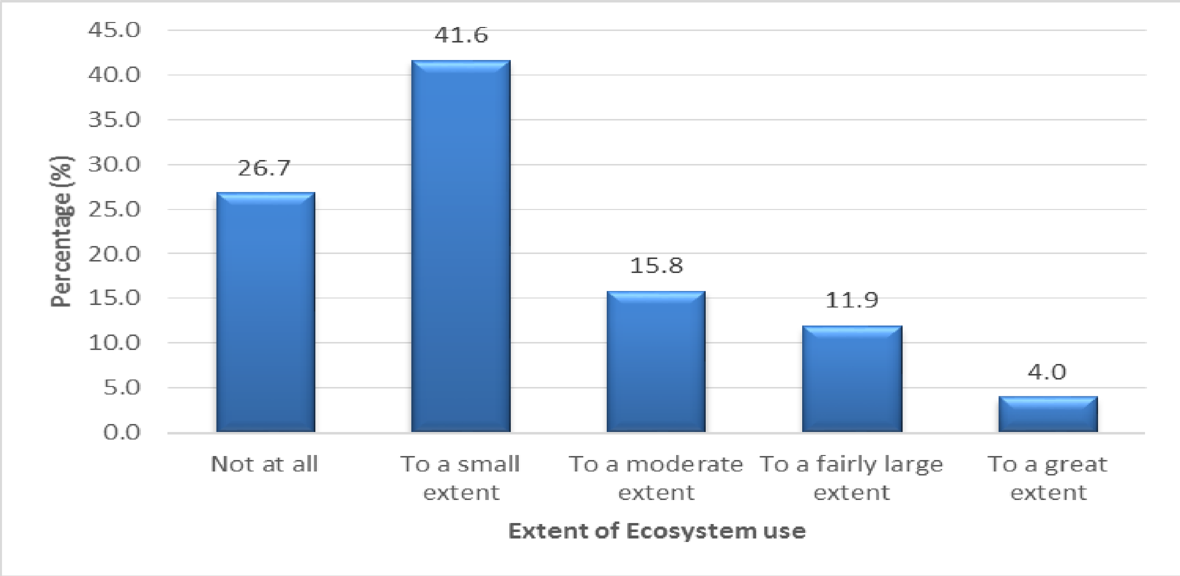

Figure 4.36: Tourism opportunities

Bioprospecting and the creation of tourism opportunities that will benefit local people are required if this CES is to be maximised given that tourism is comprised of a whole array of services involving commercial services such as food and accommodation establishments as well as cultural and social services (Krnacova *et al.,* 2018) Furthermore, bush encroachment and invasion by alien plants impact opportunities to explore tourism as an ecosystem service since phenomena such as these result in the creation of a monotonous landscape deprived of biodiversity where it is difficult to spot wildlife (Mokganya *et al.*, 2017).

v. Sense of place

As is evident from Figure 4.37, 78.3% of respondents indicated that they value, enjoy and use sense of place as a CES to a great, fairly large or moderate extent. Only 1% indicated that they do not value it at all.

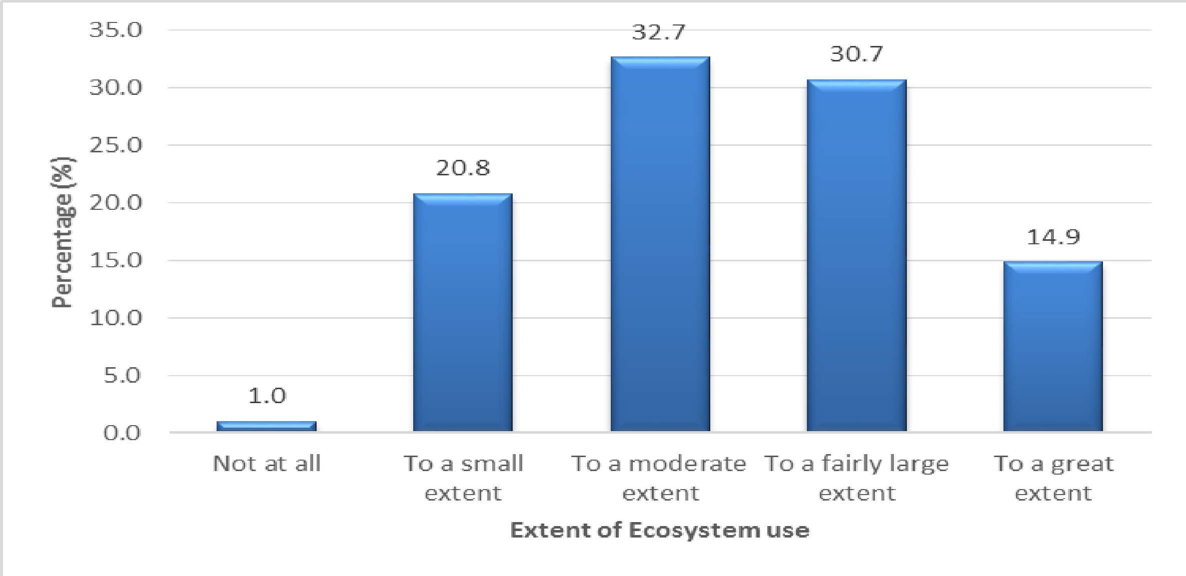

Figure 4.37: Sense of place

Sense of place gives meaning and purpose to landscapes (Farina, 2007) and can potentially link social and ecological issues since it embeds all dimensions of people's perception and interpretation of the environment (i.e. attachment, identity and symbolic meaning) (Hausmann *et al.*, 2015).

In short, sense of place offers psychological benefits since it reinforces the bond people have with specific natural features such as rivers and hills as well as sites where their ancestors are buried. According to Rayfield *et al.* (2019), sights, stories, feelings and concepts underpin sense of place. In rural communities, narratives are instrumental in relating cultural practices and telling stories about the sources and sites that are associated with these.

For example, in its Environmental Impact Assessment dated 2019, the Tshwane Metro found that in traditional rural settlements, rivers were and, in some cases, still are meaningful places that connect and inspire communities. They not only form boundaries but are also the social veins that activate life by enabling farming opportunities and creating a healthy environment for social interaction. These linear environments are important public spaces for expression of a shared common culture and for socialisation between community members. Furthermore, rivers are regarded as a place where one can come closer to and communicate with the spiritual world and for this reason is regarded by some religions as holy and fit for cleansing and baptism rituals or for rain-making ceremonies.

Even though cartographic representations of perceptions and preferences enable researchers nowadays to localise the most highly valued ecosystems in a landscape and, consequently, to identify critical focal areas, the information derived from cartography would make more sense when complemented by cultural sources that can reveal the "interior" knowledge of place (Rayfield *et al.*, 2019).

Furthermore, even though literature, film and music as cultural practices can help to investigate places as a central strand in contemporary human geography and beyond, it may be irrelevant in a rural community the likes of Fafung where there are high levels of illiteracy and where people rely on elders and cattle headers to tell them about sites that are of ecological and cultural importance.

vi. Inspiration for your culture and art and design

As pointed out in Table 4.7, inspiration for your culture and inspiration for art and design are the two cultural ecosystem services least valued, enjoyed and used by the Fafung community. However, as is evident from Figure 4.38 that 33.7% of the respondents value the service to a small extent, 30.7% to a moderate extent, 16.8% to a fairly large extent, 12.9% to a great extent and 5.9% do not value it at all. With regard to inspiration for art and design (see figure 4.39 below) the value attached by respondents to this service is 37.6% to a small extent, 21.8% to a fairly large extent, 16.8% to a moderate extent, 13.9% not at all and 9.9% to a great extent.

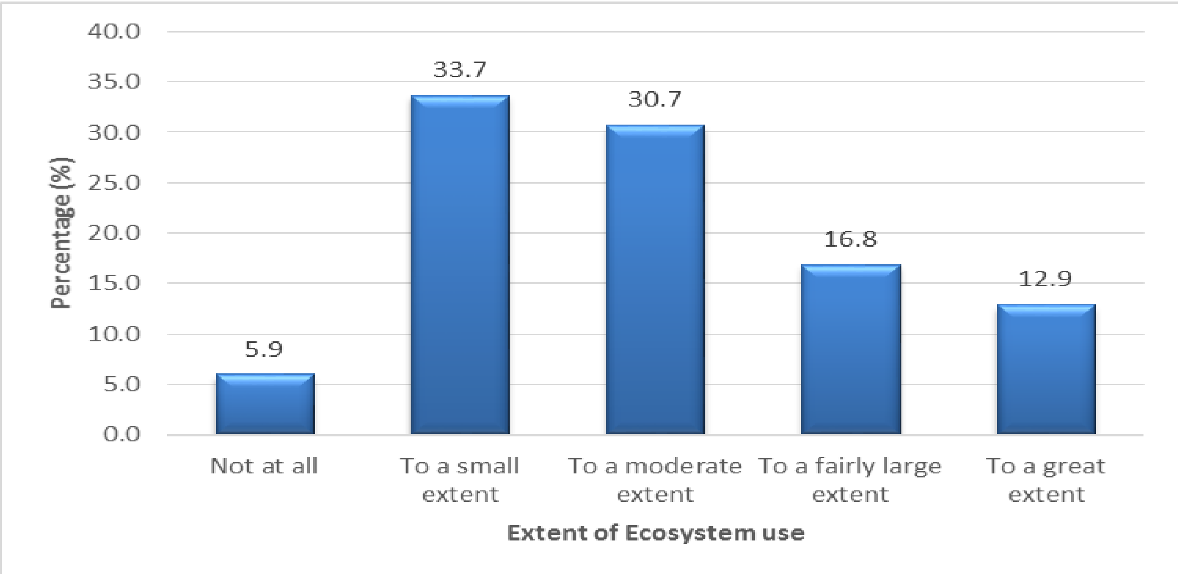

Figure 4.38: Inspiration for your culture

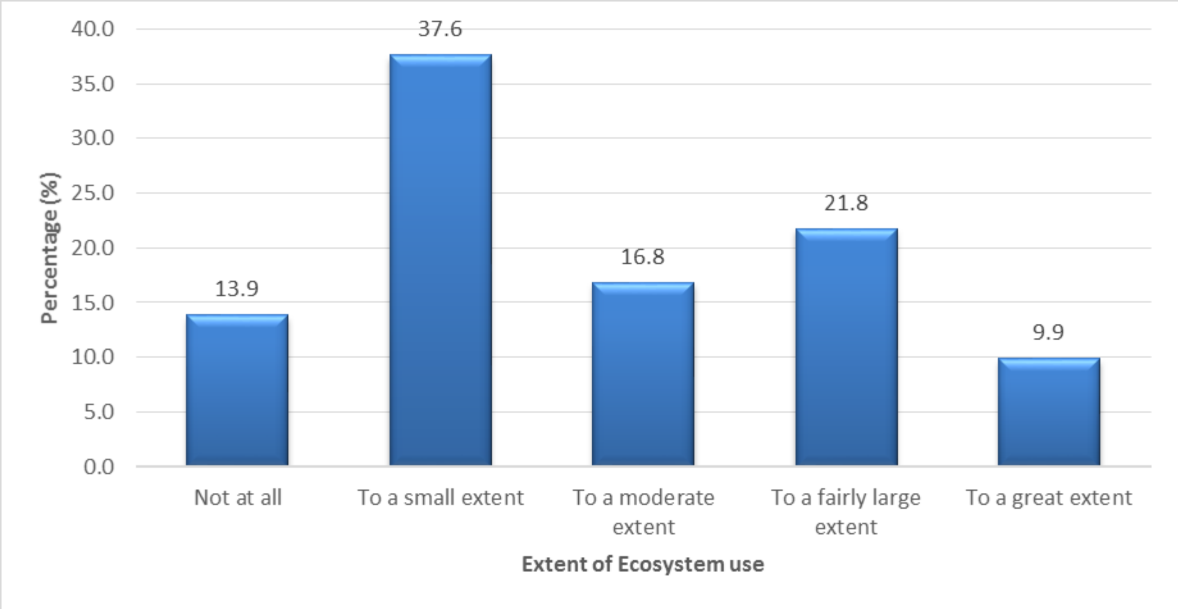

Figure 4.39: Inspiration for art and design

According to Coscieme (2015), inspiration refers to the process of being mentally stimulated to do or feel something, especially something creative. Due to their nonmaterial quality, it is difficult to value these CES, but they can result in inspirational and aesthetic goods that can be traded in the marketplace (e.g. music, creative writing and fine arts). However, as pointed out by Coscieme (2015), for inspiration as a CES to contribute to human well-being, three forms of capital need to be present: (1) Human capital in the form of knowledge, skills and creativity; (2) built capital in the form of infrastructure, tools and mechanisms that make it possible to turn creativity into something tangible; and (3) social capital in the form of a shared cultural background that facilitates cooperation and communication.

Through the years, interactions between nature and humans have proved to be a rich source of inspiration for art, folklore, national symbols, architecture and advertising. Moreover, humans are known to use ecosystems and have a long history of using ecosystems such as lakes, rivers, wetlands, grasslands and the sea metaphorically to express their feelings and, in so doing, contribute to creating a sense of place by capturing their audience’s imagination.

4.9.4 Support Services

Supporting ecosystem services maintain the condition of life on earth but may affect people only indirectly (e.g. soil formation supports the production of another ES namely food production) or only over an extended period of time (e.g. the role ecosystems fulfil in producing air to breath) (MEA, 2005).

Table 4.6: Supporting ES used, enjoyed and valued in Fafung community

Number	ES classification	ES	Mean	Standard deviation	Median	Highest range score	Analysis
30	**Supporting Services**	Habitats for species	3.37	0.24	3.42	3.58	Three ES used to a moderate extent
31		Maintenance of soil fertility				3.42	
32		Carbon sequestration/storage				3.1	

i. Habitat for species

Habitats contribute to ecosystem services in two ways: On the one hand, they themselves are service providers by, for instance, providing refuge for wildlife. On the other hand, habitats provide supporting services that underpin provisioning ES (e.g. food and water), cultural ES (e.g. recreation and aesthetic value) and regulating ES (e.g. climate and flood regulation) (MEA, 2005). Consequently, the concept 'habitat' and the concept 'biodiversity' are mutually dependent: An area's biodiversity is determined based on the condition of its habitats, whereas the state of a habitat is determined based on its condition and ability to sustain the continuous reproduction and existence of species (Ntshane & Gambiza, 2016).

Habitat loss is mainly the result of anthropogenic activities resulting in land transformation, fragmentation, degradation and climate change as well as the impact these have on biodiversity. In Fafung, habitat loss can mostly be ascribed to land degradation, particularly bush thickening, as a result of overgrazing that result in soil erosion and siltation. Furthermore, alien invasive species also contribute to habitat loss because of their ability to colonise areas and outcompete or displace indigenous flora due to a lack of pests, specialist herbivores and pathogens (Preston *et al.,* 2018). These species impact habitats due to high water consumption, monopolisation that reduces or constrains biodiversity and, inherent fuels that can exacerbate or intensify fires. Where these species occur in riparian zones, they can clog river systems and cause floods (DEA, 2019). Even though no intensive agriculture is practised in Fafung, intensive agriculture practices at the top of the catchment area impact the village's ecosystems through *ex situ* processes. In addition to high water consumption and a reduction in the diversity of organisms responsible for nutrient cycling, agricultural pesticides have the potential to kill non-targeted organisms while inorganic fertilisers cause the eutrophication of water systems and pollute the ground water (Ntshane & Gambiza, 2016).

Given that habitat for species as a supporting ES is strongly related to several of the provisioning, regulating and cultural ecosystem services covered thus far, it is understandable that most respondents indicated that they value, use and enjoy this ES to varying degrees with only 4% indicating that they do not value it at all (see Figure 4.40).

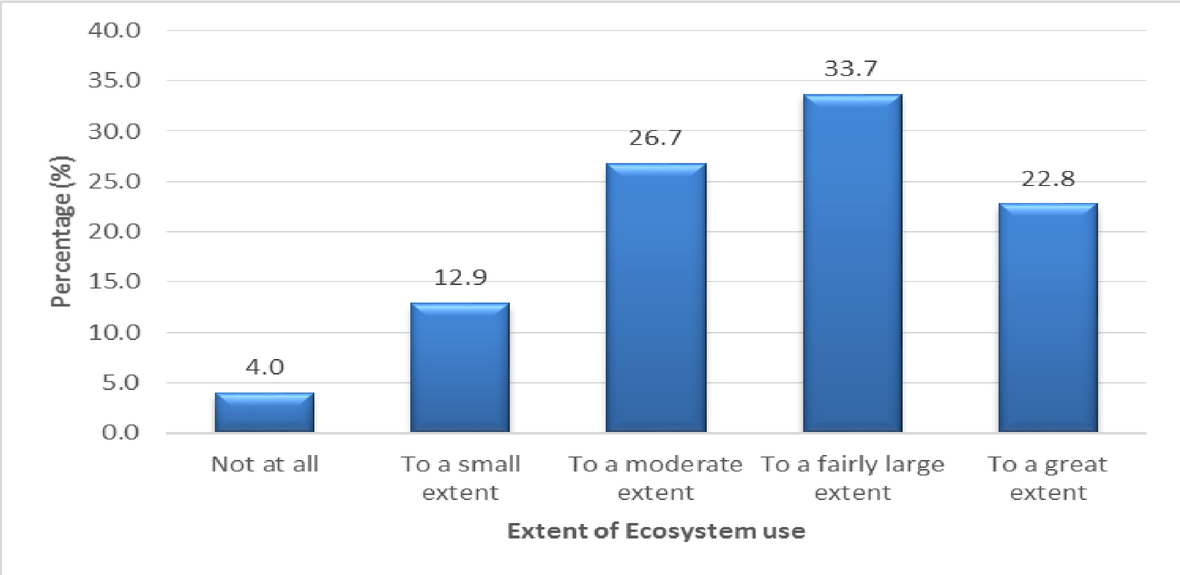

Figure 4.40: Habitat for species

Maintaining habitats for species is important since it preserves natural heritage and safeguards intrinsic human values while a loss of these habitats can have severe impacts on the flow of other important ecosystem services (Hatziiordanou *et al.,* 2019). Therefore, restoration of terrestrial and aquatic ecosystem to reverse degradation is essential to ensure that human well-being is fully realised (SER, 2004).

To regain habitat integrity, active restoration is required where the focus is on those species whose presence is regarded as essential and who may have specialist needs. To this end, habitats must be restored to the extent where they are adequate for any given species and encompass several aspects with the inclusion of resources (e.g. food, shelter, breeding sites) and access (e.g. movement for dispersal, breeding) and limiting threats (e.g. exotic grazers and predators) to tolerable levels (DEA, 2019).

ii. Maintenance of soil fertility

As is evident from Figure 4.41, respondents who indicated that they value the maintenance of soil fertility as a supporting ecosystem service to a great, fairly large, moderate or small extent are fairly equally distributed with only 3% of the respondents indicating that they do not value it at all.

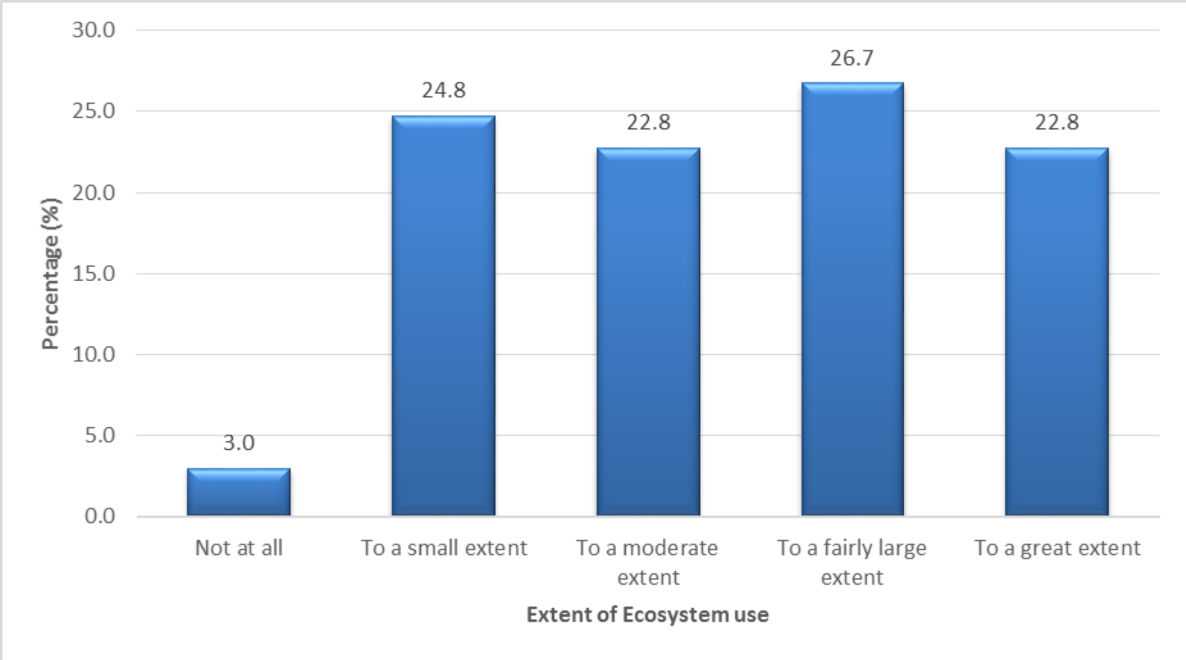

Figure 4.41: Maintenance of soil fertility

Fafung is prime grazing land and soil fertility is of vital importance for essential provisioning services such as food, forage, fibre, bio-energy and pharmaceuticals (Power, 2010) particularly in rural settlements such as Fafung where inorganic products are utilised less to enhance soil fertility. Cattle headers and small-holder crop farmers in rural settlements mostly rely on cattle manure, which is either deposited in the veld by cattle or harvested from kraals and applied to crops or gardens. According to Mosebi *et al.* (2015), this practice can enhance soil fertility and plant growth effectively, while Palm and Swift (2002) also favour the use of a biological approach to boost ecosystem functions such as net primary production, nutrient cycling and nutrient use and pest control.

Bush thickening, especially by woody shrubs, is seen as an enhancer of soil fertility and this view contributes to the replacement of grasslands by shrub lands. Even though enhanced carbon capture and storage capabilities can be perceived as a benefit of bush encroachment, Turpie *et al.* (2019) caution that this phenomenon will be damaging to the structure and functioning of ecosystems in the long run. Competition between shrubs and grass is highly prevalent in Fafung and is further exacerbated by over-stocking and overgrazing. Soil nutrients and characteristics of the landscape can influence patterns of bush encroachment which, in turn, influences disturbance factors such as fire and grazing. The alteration of soil nutrient status, whether through human intervention or positive feedback loops created by pioneer encroaching trees, may be an important determinant of landscapes' vulnerability to encroachment (Turpie *et al.*, 2019).

Soil erosion also has negative impacts on soil fertility (Mngeni *et al.*, 2016) and in this regard, Eldridge *et al*. (2011) found that bare interspaces experience higher temperatures and evapotranspiration, retarded organic incorporation, denitrification, ammonia volatilisation and increased erosion.

iii. Carbon sequestration/storage

Even though only 10% of respondents indicated that they value, enjoy and use carbon sequestration as a supporting ecosystem service to a great extent, 86% indicated that they value it to a fairly large, moderate or small extent with only 4% indicating that they do not value it at all (See Figure 4.42).

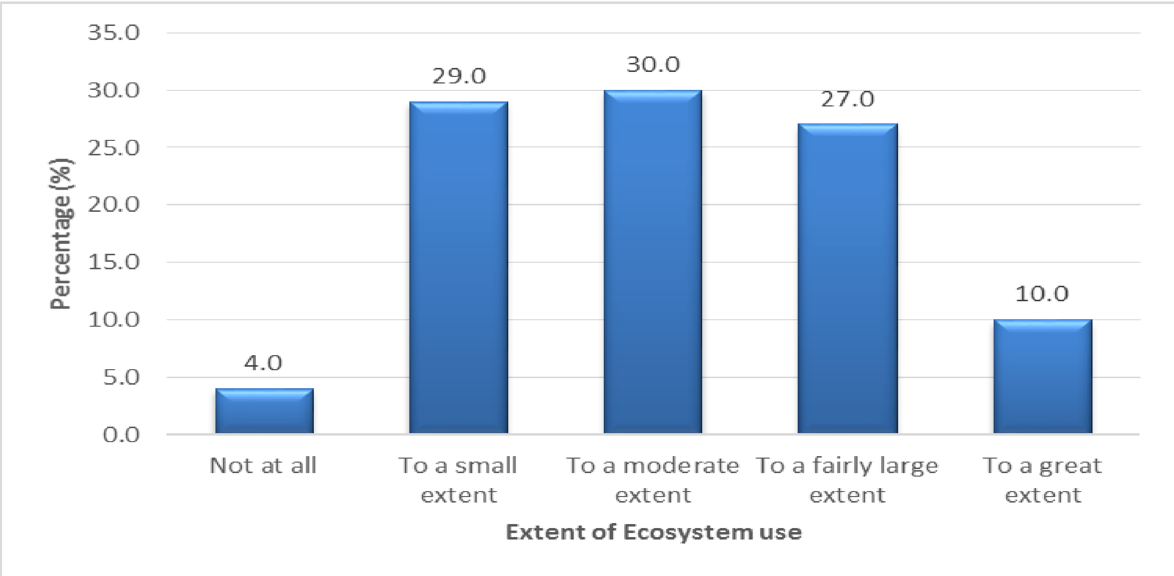

Figure 4.42: Carbon sequestration/storage

According to the *South African Carbon Sinks Atlas* (DEA, 2017), carbon stores in any given land area consist of biomass and soil carbon pools. Biomass pools encompass above-ground and below-ground living biomass, litter and dead wood. Terrestrial ecosystems with high carbon sequestration increase biomass production (Turpie *et al.*, 2019); therefore, the value the Fafung community attaches to carbon sequestering as a supporting ES can be attributed to its potential to aid grass production, which is highly needed for cattle grazing. Carbon sequestration is also important for the growth and development of woodlands, which are sources of biodiversity, fuel and pharmaceutical products (Mokganya *et al.*, 2017), as well as places of aesthetic and spiritual value, which inspire artistic design and culture (De Lacy & Shackleton, 2017).

Terrestrial carbon stocks are determined by the moisture available in plants, temperature, soil conditions and vegetation cover (DEA, 2017). Savannas and grasslands, the main biomes in Fafung, are the two ecosystems in South Africa with the highest carbon storage capabilities, where grasslands store 2,392 and savannas 2,091 gC/m^2 (DEA, 2017). Aridity, high temperatures and infrequent precipitation in Fafung impact carbon storage, which is exacerbated by degradation in the form of bush thickening and soil erosion as well as the *ex situ* impacts of agricultural activities that are dominant in the top catchment landscape (see Figure 3.3).

Given that bush thickening suppresses grass productivity, the Department of Environment, Forestry and Fisheries' NRM programme aims to selectively thin indigenous bush through its Working for Ecosystems initiative. Being selective here is the key since supporting ES such as carbon sequestration overlaps with other services of great importance to the land-use and livelihood of communities and, for this reason, trade-offs (i.e. replacing one service with another) must be considered (Power, 2010). Nevertheless, enhancing grass productivity has the potential to yield more carbon storage and for this reason, restoring Fafung's savannas to the point where they mimic the prehistoric range of ecosystem services would be the perfect trade-off and should not be viewed as deforestation and ought to be prioritised.

Furthermore, sand mining necessitating the removal of vegetation has been pointed out as being highly detrimental to the capability of soil and biomass to sequester carbon. In addition, the extensive crop farming practised in the upper catchment area can potentially reduce the carbon sequestration capabilities of natural grasslands and savannas by as much as 40-60%. Given that more and more land is bound to be cleared in order to cater proportionally for the demands of a growing population (Cias *et al.,* 2011), best agricultural practices such as non-tillage ought to be favoured to mitigate carbon loss (DEA, 2017). Furthermore, excessive use of pesticides must be dissuaded since it can result in soil sterility and contribute to the eutrophication of water sources (Botkin & Keller, 2017).

Soils' carbon content is volatile and has the potential to end up in the atmosphere unless current trends in land use are reversed or managed in such a way as to significantly reduce greenhouse gas emissions. The need to implement and upscale projects to restore and manage these biomes as well as to improve agricultural practices (principally non-tillage or low-tillage) cannot be ignored.

Nationally, the promulgation of the Carbon Tax Act in 2019, based on the carbon-offset paper published by the National Treasury in 2014 (SA, 2014), attests to the fact that the

South African government is committed to mitigating and reducing impacts caused by carbon emissions. Given that degradation of grassland and savannah biomes as a result of overgrazing and deforestation, veld fires and the burning of fossil fuel contribute to CO_2 emissions (Cias *et al.*, 2011), some of the mechanisms proposed by the Act to reduce, avoid or sequester carbon emissions involve projects to re-vegetate certain areas in an attempt to add biomass and to counter soil erosion. It is estimated that land management projects of this nature can boost the carbon sequestration potential of targeted areas by around 2.0 – 3.5 million tCO_2e per year (SA Carbon Tax Act, 2019).

As is evident from the background sketched thus far, the Fafung community is clearly in need of land management projects that will help to offset carbon emissions. If the DEFF is to deploy projects of this nature in the vicinity of Fafung under the auspices of its Natural Resource Management Programme, it will not only make a considerable contribution towards restoring landscapes, reducing land degradation and protecting biodiversity but will also help to create sustainable job opportunities whilst encouraging energy efficiency and low carbon growth.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The aims and objectives as set out under section 1.3 “research aims and objectives” were achieved. Ecosystem services available in Fafung community were determined through the non-participant phase of the study were observations regarding the use of ecosystem by local people were documented. The land cover/use map as shown on Figure 3.3 designed with the aid of Global Mapper v18 using datasets from the SANLC of 2018 clearly indicates the ES predominant in Fafung community. The survey data statistically analysed by means of the SPSS-23 explicitly shows that ES are used, enjoyed and valued by local people in Fafung. It is established through the mean (average) score that provisional services (3.72) are used to a fairly large extent, supporting services (3.37), regulating services (3.32) and cultural services (3.23) are used, enjoyed and valued to a moderate extent respectively.

It was found that sand, water, grass and wood as provisional ecosystem services were valued to a fairly large extent, while four where valued to a moderate extent and three to a small extent. The supporting ES category encompassing three ecosystem services (habitat for species, maintenance of soil fertility and carbon sequestration), were found to be the second most valued. Regulating ES, comprising eight ecosystem services, were found to be the third most valued. One ES (air to breathe) was valued to a fairly large extent, six (biological control, erosion prevention, local climate, moderation of extreme events, maintenance of genetic diversity and pollination) to a moderate extent and one (wastewater treatment) to a small extent. Cultural services comprised eight ecosystem services and were the least valued, where six (aesthetic reasons, mental and physical well-being, sense of place, recreation, tourism opportunities and spiritual experience) were valued to a moderate extent and two (inspiration for your culture and inspiration for art and design) to a small extent.

5.2 Recommendations

Based on the resulting findings, the second objective was to make recommendations on how Fafung, and other communities in the area, can ensure that they utilise the ecosystem goods and services at their disposal in a sustainable manner so as to promote their socio-economic well-being whilst maintaining the integrity of the environment.

It is anticipated that the findings and recommendations stemming from this study will inform decision making and policy development with regard to ecosystem restoration and promote the need to consider ecosystem services in local municipalities' integrated development plans. In the case of Fafung, residents' involvement in ecosystem restoration projects will contribute towards attaining the Sustainable Development Goals as espoused in the National Development Plan, especially against the backdrop of climate change and the health shocks experienced worldwide. Clearly, a business-as-usual approach is no longer viable. Rather, every effort should be made to heighten awareness of and to encourage best ecosystem management practices among stakeholders.

As is the case with manufactured goods, the provisioning of ecological goods such as food, wood and fibre depends on "flow" and "stock" (MEA, 2005). However, due to the pressure exerted on the flow of provisioning services, it is not always possible to ascertain their condition and sustainability (i.e. their ability to deliver goods). To cite an example, harvesting wood to counter bush encroachment may be necessary over the short term to sustain the grass-woody balance but may destroy woodlands in the long run. Thus, unless practised in a sustainable manner, rehabilitation interventions might help to maintain the integrity of one ecosystem in the short term but could result in a decline of another in the long run.

In as far as deciding to choose one ecosystem service above another, Le Maitre *et al*. (2007) hold that such decisions are largely informed by return on investment and trade-offs. Accordingly, services that yield more meaningful and valuable services are prioritised. De Groot *et al*. (2018) concur with this view, adding that money spent on ecosystem restoration should be viewed as an investment rather than an expense and ought to be weighed against resultant economic and financial gains. In the final analysis, future decisions regarding Fafung residents' sustainable use of ecosystems services ought to be viewed given this context (Fisher *et al.*, 2009).

The environmental challenges of the Fafung community have been alluded to in Figure 3.3 (land-use/-cover) and include, *inter alia*, bush thickening and a reduction in grass production (grazing capacity) as a result of overstocking and overgrazing, soil erosion, siltation, wetland degradation and poor water quality as a result of *in situ* and *ex situ* activities. This situation necessitates appropriate land management interventions to reverse the state of degradation in the interest of residents' well-being and to bolster their resilience against the harsh realities of a changing environment.

Restoration of degraded ecosystems is highly recommended and is common practice in many countries in a bid to re-establish ecosystems to such an extent that they reflect the same features as those that were present in the historic range where ES flowed unencumbered and contributed maximally to the improvement of people's livelihoods. Comparatively, the cost of restoration is generally extremely high compared to the cost of preventing the degradation of ecosystems. Moreover, not all services can be restored, and heavily degraded services may require a considerable input in as far as time and resources are concerned.

To this end, every attempt should be made to strengthen specific ES-related services that will contribute to poverty reduction, food security, human well-being and water safety (Wood & De Clerck, 2016). Accordingly, restoration interventions and conservation approaches will have to be intensified in Fafung to enhance ecosystem services where degradation has already taken place so that those ES can be returned to a pristine condition and maintained as such.

Even though restoration projects aimed at bush thinning, eradicating alien invasive plants and rehabilitating wetlands have been instituted in Fafung, these projects have a duration of only three years. Given the state of degradation, long-term restoration plans will have to be developed if land degradation neutrality is to be attained by 2030. In planning long-term restoration projects of this nature, the objective should be to halt and/or reverse land degradation and to restore degraded lands by any means possible. Given that anthropogenic usage has resulted in a severe alteration of ecosystems near Fafung Village, the recommendation would be to follow the guidelines for an ecosystem services partnership as proposed by the Foundation for Sustainable Development (De Groot *et al*., 2018) to restore and/or rehabilitate the landscape to such an extent that it can, once again, deliver services to the benefit of the people. Partnerships such as these are founded on a long-term approach (20 years) to landscape restoration in three zones (i.e. the natural zone, combined zone and economic zone) with reaping four returns as the objective: A return on natural capital, a return on social capital, a return on financial capital and a return on inspiration.

Furthermore, every effort should be made to explore the Green Business Value Chain so as to afford members of the impoverished Fafung community an opportunity to develop their skills and to explore entrepreneurial opportunities stemming from the ecosystem services at their disposal. To cite an example, the bush thinning project currently being conducted under the auspices of the DEFF offers several opportunities for the beneficiation of cleared woody material (see Namibia, 2016). Left to rot, cleared woody material can result in the emission of methane whereas the establishment of a bio-industry will help to sequester carbon and stimulate economic growth in the area.

The poverty stricken Fafung village suffers from the impacts of regional and global warming even though its contribution to greenhouse gasses is minimal since there are virtually no industries in the area. It is recommended that ecosystems should be conserved maximally so that they remain intact and be rehabilitated or restored where degraded. Ecological infrastructure is a vital natural structure that serves as a buffer against unwanted gases in the atmosphere. Resources should be allocated and redirected for restoration interventions in an effort to mitigate climate change and to sustain the livelihood of the local people and surroundings. A comprehensive green economy based on the needs of the community with the potential to create jobs and to transfer skills is necessary. NRM programmes (Working for Ecosystems, Working for Water, Working for Wetlands, Working on Fire) and value adding industries are important players in the green economy value chain (SA, 2019a) and must be implemented at full scale in areas of concern and must be prioritised for the purpose of earning carbon tax rebates (SA, 2014). A mechanism to recover the cost of emissions should be implemented practically to help the residents of Fafung to mitigate, adapt to or avoid the impacts of climate change which may render the community's ecosystems dysfunctional in the near future. The carbon-pricing mechanism that targets specific mitigation opportunities would be the ideal approach to follow in this regard (SA, 2011).

Furthermore, the nine-step approach to integrated ES assessment suggested by De Groot *et al*. (2018) can play an essential role in ensuring that appropriate land interventions are adhered to. These steps include scoping, analysing the direct environmental impacts of a given intervention, analysing the impact on ecosystem services, assessing the benefits and beneficiaries, conducting a monetary valuation and economic analysis, capturing the value, communicating the value, building capacity and affecting institutional change.

The resilience of the people of Fafung to weather extreme events, especially droughts, can be boosted by NRM interventions that seek to alleviate hydrological challenges and enhance water security by way of clearing alien invasive plants, thinning bush encroachment and rehabilitating ecosystems. In accordance with the National Development Plan (SA, 2011), the National Disaster Management Centre should incorporate climate change risks in its national disaster management plan and communication strategy. In this regard, an early-warning approach that relies on degradation and climate change projections ought to be followed to prevent and mitigate or respond to disastrous events. Furthermore, the approach should be people-centric and encompass community-based science and technology since moderating extreme events has a direct bearing on ecosystem services. In an attempt to profile the impacts of natural disasters and health shocks and to devise appropriate mitigation and adaptation interventions, there is indeed a need for cross-science pollination, especially between environmentalists and health and social scientists.

In the recent past, the DEFF as an implementer of ecosystem rehabilitation projects has received funding from the DWS for drought mitigation projects. Fafung as a semi-arid and drought-prone area should be considered for drought relief funding. The suite of water supply and conservation mechanisms can include eradicating alien invasive plants, bush thinning and harvesting rainwater. Furthermore, the community should be encouraged to be less reliant on coal-fired energy and to use a mixture of energy sources including solar, hydro- and wind energy as well as woody biomass since an over-dependence on coal-fired power stations results in overexploitation of mineral resources and further degradation of the natural environment (SA, 2011). To this end, the people of Fafung ought to be made aware of the vital role ecosystem services fulfil in moderating extreme events in an attempt to change their perceptions and attitude so that they attach greater value to the ES at their disposal.

In Fafung, the eutrophication and pollution of water sources can be ascribed to *ex situ* agricultural practices at the top catchment, especially the use of synthetic fertilizers and pesticides (Botkin & Keller, 2007). These chemicals are deposited downstream as a result of soil erosion and, ultimately, result in the siltation of water sources (Marais, 2012). Given the extent of sheet and gully erosion, a project to restore Fafung's drylands and riparian zones is definitely warranted. Restoration interventions of this nature should involve soft options such as the use of local rocks, eco logs, erosion blankets and re-vegetation as recommended by Russell (2009).

Bioprospecting, which involves the exploration of biodiversity for commercially valuable genetic resources and bio-chemicals, is an important aspect in enhancing conservation since it places a specific value on natural resources. As has been reported in this study, the people of Fafung use, enjoy and value plants and animals for their use in traditional medicines. Moreover, the people of Fafung co-own the Borakalalo Nature Reserve where there is a high abundance of biodiversity. The people of Fafung are involved in bioprospecting although this is not yet coordinated by means of a legal framework as envisaged in the National Environmental Management: Biodiversity Act (SA, 2004) and the Bioprospecting, Access and Benefit Sharing Regulations published in 2008 in accordance with this act. The intention here is that benefits stemming from bioprospecting should flow to the community and, for this reason, national parks and nature reserves must be accessible to and co-owned by local communities. It is believed that in this way, challenges pertaining to poaching and the illegal use of natural resources can be addressed (Anthony & Bellinger, 2017; Gordon-Cumming, 2017). For this reason, it is recommended that eco-guards be employed to protect the environment and biodiversity in and around Fafung.

There are compelling reasons to prevent soil loss and degradation as a result of sand mining, injudicious farming methods and erosion. Even though sand as a provisioning ecosystem service is in high demand, overexploitation of this resource will result in the loss of biodiversity and pose a serious threat to woodlands, grasslands, water sources (through siltation) and agriculture. Areas for sand mining must be carefully selected where such an activity would not result in adverse impacts on the ecosystem, and the local municipality must take this into consideration in its spatial planning.

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Appendix A: List of the 73 land cover

List of the 73 land-use classes available in the 2018 dataset

No.	SANLC 2018 class names
1.	Contiguous (indigenous) Forest (*combined* very high, high, medium)
2.	Contiguous Low Forest & Thicket (*combined classes*)
3.	Dense Forest & Woodland (35 - 75% cc)
4.	Open Woodland (10 - 35% cc)
5.	Contiguous & Dense Planted Forest (*combined classes*)
6.	Open & Sparse Planted Forest
7.	Temporary Unplanted Forest
8.	Low Shrubland (other regions)
9.	Low Shrubland (Fynbos)
10.	Low Shrubland (Succulent Karoo)
11.	Low Shrubland (Nama Karoo)
12.	Sparsely Wooded Grassland (5 - 10% cc)
13.	Natural Grassland
14.	Natural Rivers
15.	Natural Estuaries & Lagoons
16.	Natural Ocean, Coastal
17.	Natural Lakes
18.	Natural Pans (flooded @ obsv time)
19.	Artificial Dams (incl. canals)
20.	Artificial Sewage Ponds
21.	Artificial Flooded Mine Pits
22.	Herbaceous Wetlands (currently mapped)
23.	Herbaceous Wetlands (previous mapped extent)
24.	Mangrove Wetlands
25.	Natural Rock Surfaces
26.	Dry Pans
27.	Eroded Lands
28.	Sand Dunes (terrestrial)
29.	Coastal Sand Dunes & Beach Sand
30.	Bare Riverbed Material
31.	Other Bare
32.	Cultivated Commercial Permanent Orchards
33.	Cultivated Commercial Permanent Vines
34.	Cultivated Commercial Sugarcane Pivot Irrigated
35.	Commercial Permanent Pineapples
36.	Cultivated Commercial Sugarcane Non-Pivot (all other)
37.	Cultivated Emerging Farmer Sugarcane Non-Pivot (all other)
38.	Commercial Annuals Pivot Irrigated
39.	Commercial Annuals Non-Pivot Irrigated
40.	Commercial Annuals Crops Rain-Fed / Dryland / Non-Irrigated
41.	Subsistence / Small-Scale Annual Crops
42.	Fallow Land & Old Fields (Trees)
43.	Fallow Land & Old Fields (Bush)
44.	Fallow Land & Old Fields (Grass)
45.	Fallow Land & Old Fields (Bare)
46.	Fallow Land & Old Fields (Low Shrub)
47.	Residential Formal (Tree)
48.	Residential Formal (Bush)
49.	Residential Formal (low veg / grass)
50.	Residential Formal (Bare)

51.	Residential Informal (Tree)
52.	Residential Informal (Bush)
53.	Residential Informal (low veg / grass)
54.	Residential Informal (Bare)
55.	Village Scattered (bare only)
56.	Village Dense (bare only)
57.	Smallholdings (Tree)
58.	Smallholdings (Bush)
59.	Smallholdings (low veg / grass)
60.	Smallholdings (Bare)
61.	Urban Recreational Fields (Tree)
62.	Urban Recreational Fields (Bush)
63.	Urban Recreational Fields (Grass)
64.	Urban Recreational Fields (Bare)
65.	Commercial
66.	Industrial
67.	Roads & Rail (Major Linear)
68.	Mines: Surface Infrastructure
69.	Mines: Extraction Sites: Open Cast & Quarries *combined*
70.	Mines: Extraction Sites: Salt Mines
71.	Mines: Waste (Tailings) & Resource Dumps
72.	Land-fills
73.	Fallow Land & Old Fields (wetlands)

Appendix B: Questionnaire in English

ECOSYSTEM SERVICES QUESTIONNAIRE

Section A: Socio-demographic Profile

1. **What is your current age: __________**
2. **Please indicate your gender?**

1 Male	2 Female

3. **What is your ethnicity (culture)?**

1 White	2 African	3 Coloured	4 Indian	5 Asian

4. What is your nationality as it is indicated on your identification document/passport?

1 Botswana	2 Lesotho	3 Mozambique	4 RSA	5 Swaziland	6 Other

5. **What is your home language?**

1 Zulu (isiZulu)	2 Xhosa (isiXhosa)	3 Afrikaans	4 English	5 Northern Sotho (Sesotho sa Leboa)	6 Tswana (Setswana)	7 Sesotho (Sesotho)
8	9	10	11	12	13	

Tsonga (Xitsonga)	Swati (siSwati)	Venda (Tshivenda)	Ndebele (isiNdebele)	SA Sign Language	Other languages: _______________	

6. What is your highest level of education?

1	2	3	4	5	6	7	8
No education	Some primary education	Completed primary education	Some secondary education	Completed secondary education	Post-school qualification (diploma, trade, etc.)	University degree/s	Post-graduate degree

7. What is your current relationship status?

1	2	3	4	5
Single	Married	Divorced	Widowed	Living with a partner (but not formally married)

8. What was your monthly household income?

Between R0,000-R2,000	1	Between R18,001-R20,000	10
Between R2,001-R4,000	2	Between R20,001-R22,000	11
Between R4,001-R6,000	3	Between R22,001-R24,000	12
Between R6,001-R8,000	4	Between R24,001-R26,000	13
Between R8,001-R10,000	5	Between R26,001-R28,000	14
Between R10,001-R12,000	6	Between R28,001-R30,000	15
Between R12,001-R14,000	7	Between R30,001-R32,000	16
Between R14,001-R16,000	8	Between R32,001-R34,000	17
Between R16,001-R18,000	9	Between R34,001-R36,000	18
		More than R36,000.00	19

9. **How many dependants do you have?** ___________________

Appendix B: Questionnaire in English

DIPOTSO MABAPI LE DITIRELO TSA TLHAGO

Kgaolo ya Ntlha (A): Seemo sa dipalopalo tsa se Setshabo/Motse

4. **O na le dingwaga tse kae?: __________**
5. **Tlhalosa bong ba gago?**

1 Monna	2 Mosadi

6. **O mokae (setso)?**

1 Mosweu	2 Mo-Afrika	3 Wa Mmala	4 Mo-India	5 Mo-Asian

4. Tlhalosa hore o modudi wa naga efe hoya le ka bukana yahao ya boitshupo/passporoto?

1 Botswana	2 Lesotho	3 Mozambique	4 RSA	5 Swaziland	6 Enngwe

10. Leleme la haho la puo ke lefe?

1 Zulu (isiZulu)	2 Xhosa (isiXhosa)	3 Afrikaans	4 English	5 Northern Sotho (Sesotho sa Leboa)	6 Tswana (Setswana)	7 Sesotho (Sesotho)
8 Tsonga	9 Swati	10 Venda	11 Ndebele	12 SA Sign	13 Maleeme a	

(Xitsonga)	(siSwati)	(Tshivenda)	(isiNdebele)	Language	mangwe: ______________	

11. O fihleletse maemo/mphato ofe wa thuto?

1	2	3	4	5	6	7	8
Ha ka ruteha/Ha ka tsena sekolo	Ke fihlelletse maemo a itseng a thuto ya kwa tlase	Ke feditse sekolo sa kwa tlase	Ke fihlelletse maemo a itseng a sekolo se kwa hodimo	Ke feditse sekolo se kwa hodimo.	Kena le lekwalo/makwalo a dithuto tsa kwa hodimo (diploma, trade, etc.)	Kena le grata/digrata ya/tsa Universiti	Kena le digrata tsa kwa hodimo

12. Maemo a hao a golagano/lenyalo ke afe?

1	2	3	4	5
Ga ke is eke nyalwe	Ke nyetse/nyetswe	Ke mo tlhalonong	Ke motlholohadi	A o dula le mongwe (vat en sit)

13. Letseno lahao mo ntlong ke lefe?

Magareng a R0,000-R2,000	1	Magareng a R18,001-R20,000	10
Magareng a R2,001-R4,000	2	Magareng a R20,001-R22,000	11
Magareng a R4,001-R6,000	3	Magareng a R22,001-R24,000	12
Magareng a R6,001-R8,000	4	Magareng a R24,001-R26,000	13
Magareng a R8,001-R10,000	5	Magareng a R26,001-R28,000	14
Magareng a R10,001-R12,000	6	Magareng a R28,001-R30,000	15
Magareng a R12,001-R14,000	7	Magareng a R30,001-R32,000	16
Magareng a R14,001-R16,000	8	Magareng a R32,001-R34,000	17
Magareng a R16,001-R18,000	9	Magareng a R34,001-R36,000	18
		Ho feta R36,000.00	19

14. **O na lebana goba batho ba o batlhokomelang ba ba kae?** ____________________

____

<u>Kgaolo ya bobedi (B): Dipotso ka ha tlhago</u>

15. A dirisa, go rata le go bona botlhokwa ba tlhago (i.e. the following ecosystem goods and services) for:

1 Nnyaa	2 Di dirisiwa gole gonnye	3 Tiriso magareng	4 E dirisiwa thata	5 E dirisiwa gole gontsi

Tirelo ya tsa tlhago						Goreng edirisiwa/ Goreng e sa dirisiwe?
a) Mabaka a bopila (bopila ba tlhago)	1	2	3	4	5	
b) Moya o o ohemang	1	2	3	4	5	
c) Tiriso ya diphedi	1	2	3	4	5	
d) Polokelo ya Carbone mo mmung	1	2	3	4	5	
e) Thibelo ya kgogolo ya mmu	1	2	3	4	5	
f) Mollo (go futhumatsa, go apea, etc.)	1	2	3	4	5	
g) Ditlhapi jaka dijo (go tswa mo letamong gotsa tse dingwe)	1	2	3	4	5	
h) Bojang jaka dilo tsa go aga (go rulela dintlo)	1	2	3	4	5	
i) Bojang ba go fudisa diphologolo	1	2	3	4	5	
j) Bodulo jwa diphologolo	1	2	3	4	5	
k) Thotloetso ya art le designe	1	2	3	4	5	
l) Go rotloetsa setso	1	2	3	4	5	
m) Maemo a loapi mo gae	1	2	3	4	5	
n) Ditlhare tsa naga tse dijeang	1	2	3	4	5	
o) Tlhokomelo ya genetic diversity	1	2	3	4	5	

p) Tlhokomelo ya mmu gore o none	1	2	3	4	5	
q) Tiriso ya tlhago jaka ditlhare (Medicine)	1	2	3	4	5	
r) Boitekanelo ba Monagano le Mmmele	1	2	3	4	5	
s) Go fokotsa Matlakadibe (e.g., merwalela, magadima)	1	2	3	4	5	
t) Pollination	1	2	3	4	5	
u) Didiriswa tsa tlhago (Raw materials)	1	2	3	4	5	
v) Boitapoloso	1	2	3	4	5	
w) Matlapa	1	2	3	4	5	
x) Mmu	1	2	3	4	5	
y) Maitemogelo a lefelo	1	2	3	4	5	
z) Maitemogelo a semoya	1	2	3	4	5	
aa) Ditsono tsa boeti	1	2	3	4	5	
bb) Tloso ya leswe mo metseng	1	2	3	4	5	
cc) Metse (go nwa, go tlhatswa, go apea, etc.)	1	2	3	4	5	
dd) Diphologolo tsa naga jaka dijo	1	2	3	4	5	

ee) Dikota tsa go aga (go aga dintlo, masaka a dikgomo, etc.)	1	2	3	4	5	
ff) Dikgo go futumatsa, go apea, etc.	1	2	3	4	5	

Appendix C: Letter of Goodwill permission for Fafung Community

NWU®

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Elvis Kgotjane Choma
Cell: 076 732 2667
Echoma@environment.gov.za

Date: 04 February 2019

To: Fafung Community.
Community Committee.

RE: REQUEST TO CONDUCT RESEARCH REGARDING ECOSYSTEM SERVICES IN FAFUNG AREA

I am Elvis Kgotjane Choma, a part-time Msc student at North-West University (Potchefstroom) based in Brits.

North-West University is intending to conduct a study titled "Assessing Ecosystem Services in Fafung Community of South Africa".

The primary aim of this study is to assess the availability and use, enjoyment and value of Ecosystem Services (ES) in the Fafung area and to make recommendations as to how the local communities in the area can further benefit from available ES. It seeks to find out if residents in Fafung Settlements still get value from the ecosystems (e.g., Woodlands, rivers, wetlands etc). The objectives are as follows:

(i) The documentation & mapping of existing ES in Fafung area,
(ii) Determining which of these ES are currently being used by local communities,
(iii) Developing and administering a survey to verify and quantify the uses, and finally
(iv) Make recommendations on the further use and marketing for ES.

This is part of a bigger study project called "Bush Expert" commissioned and/or sponsored by the Department of Environmental Affairs: NRM. The primary objective of the study project is to conduct research regarding natural assets in the Savannah biomes of South Africa and develop a Decision Support System (DSS) that will guide the Department of Environmental Affairs regarding future restoration and/or rehabilitation projects.

The study will document the state of ES in Fafung and make recommendations about what needs to be done to enhance the services to support human well-being. This may result in natural resource rehabilitation project which will improve the state of ecosystems from which socio-economic benefits may flow.

The following can be contacted as references:

Study Leader: Prof Klause Kellner + 27 (0)18 299 2510, + 27 (0) 82 569 6145; Klaus.Kellner@nwu.ac.za

Supervisor: Prof Hendrie Cotzee: +27 (0)18 299 4348; +27 (0) 82 213 4816; Hendri.Coetzee@nwu.ac.za

Yours Faithfully

Elvis Kgotjane Choma

07/02/2019 -

Msc Research Student at NWU (Applicant)

APPROVAL BY CHIEF OF FAFUNG COMMUNITY

I PETER MOSUOE the leader of Fafung Community hereby give permission for the study to be conducted following sound research ethical values in the area.

17/02/2019

KGOSANA JPR MOSUE

07/02/2019

Signature

Date

Appendix D: Letter of Goodwill for Borakalalo National Park

NWU®

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Elvis Kgotjane Choma
Cell: 076 732 2667
Echoma@environment.gov.za

Date: 04 February 2019

To: Borakalalo Nature Reserve.

RE: REQUEST TO CONDUCT RESEARCH REGARDING ECOSYSTEM SERVICES IN BORAKALALO NATURE RESERVE AREA

I am Elvis Kgotjane Choma, a part-time Msc student at North-West University (Potchefstroom) based in Brits.

North-West University is intending to conduct a study titled "Assessing Ecosystem Services in Borakalalo Nature Reserve Community of South Africa".

The primary aim of this study is to assess the availability and use, enjoyment and value of Ecosystem Services (ES) in the Borakalalo Nature Reserve area and to make recommendations as to how the local communities in the area can further benefit from available ES. It seeks to find out if residents in Borakalalo Nature Reserve Settlements still get value from the ecosystems (e.g., Woodlands, rivers, wetlands etc). The objectives are as follows:

(i) The documentation & mapping of existing ES in Borakalalo Nature Reserve area,
(ii) Determining which of these ES are currently being used by local communities,
(iii) Developing and administering a survey to verify and quantify the uses, and finally
(iv) Make recommendations on the further use and marketing for ES.

This is part of a bigger study project called "Bush Expert" commissioned and/or sponsored by the Department of Environmental Affairs: NRM. The primary objective of the study project is to conduct research regarding natural assets in the Savannah biomes of South Africa and develop a Decision Support System (DSS) that will guide the Department of Environmental Affairs regarding future restoration and/or rehabilitation projects.

The study will document the state of ES in Borakalalo Nature Reserve and make recommendations about what needs to be done to enhance the services to support human well-being. This may result in natural resource rehabilitation project which will improve the state of ecosystems from which socio-economic benefits may flow.

The following can be contacted as references:

Study Leader: Prof Klause Kellner + 27 (0)18 299 2510, + 27 (0) 82 569 6145; Klaus.Kellner@nwu.ac.za

Supervisor: Prof Hendrie Cotzee: +27 (0)18 299 4348; +27 (0) 82 213 4816; Hendri.Coetzee@nwu.ac.za

Yours Faithfully

Elvis Kgotjane Choma

05/02/2019.

Msc Research Student at NWU (Applicant)

APPROVAL BY CHIEF OF BORAKALALO NATURE RESERVE COMMUNITY

I RAMOFSAKI ELIAS SEUTANE the leader of Borakalalo Nature Reserve Community hereby give permission for the study to be conducted following sound research ethical values in the area.

Signature — Date: 18/02/2019

Annexure E: Ethics Approval Letter

Private Bag X1290, Potchefstroom
South Africa 2520

Tel: 018 299-1111/2222
Fax: 018 299-4910
Web: http://www.nwu.ac.za

Research Ethics Regulatory Committee
Tel: 018 299-4849
Email: nkosinathi.machine@nwu.ac.za

31 March 2019

ETHICS APPROVAL LETTER OF STUDY

Based on approval by the North West University Health Research Ethics Committee (NWU-HREC) on 31/03/2019, the NWU Health Research Ethics Committee hereby approves your study as indicated below. This implies that the North-West University Research Ethics Regulatory Committee (NWU-RERC) grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the study may be initiated, using the ethics number below.

Study title: Assessing Ecosystem Services in Molatedi Dam Communities of South Africa.
Study Leader/Supervisor (Principal Investigator)/Researcher: Prof K Kellner
Student: EK Choma

Ethics number:

N	W	U	-	0	0	1	0	8	-	1	8	-	A	1

Institution — Study Number — Year — Status

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Application Type: Single Study
Commencement date: 31/03/2019 **Risk:** Minimal
Expiry date: 31/03/2020
Approval of the study is initially provided for a year, after which continuation of the study is dependent on receipt and review of the annual (or as otherwise stipulated) monitoring report and the concomitant issuing of a letter of continuation.

Special in process conditions of the research for approval (if applicable):

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, the following general terms and conditions will apply:

- *The study leader/supervisor (principle investigator)/researcher must report in the prescribed format to the NWU-HREC:*
  - *annually (or as otherwise requested) on the monitoring of the study, whereby a letter of continuation will be provided, and upon completion of the study; and*
  - *without any delay in case of any adverse event or incident (or any matter that interrupts sound ethical principles) during the course of the study.*
- *The approval applies strictly to the proposal as stipulated in the application form. Should any amendments to the proposal be deemed necessary during the course of the study, the study leader/researcher must apply for approval of these amendments at the NWU-HREC, prior to implementation. Should there be any deviations from the study proposal without the necessary approval of such amendments, the ethics approval is immediately and automatically forfeited.*
- *Annually a number of studies may be randomly selected for an external audit.*
- *The date of approval indicates the first date that the study may be started.*
- *In the interest of ethical responsibility the NWU-RERC and NWU-HREC reserves the right to:*
  - *request access to any information or data at any time during the course or after completion of the study;*
  - *to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process;*
  - *withdraw or postpone approval if:*
    - *any unethical principles or practices of the study are revealed or suspected;*

- it becomes apparent that any relevant information was withheld from the NWU-HREC or that information has been false or misrepresented;
- submission of the annual (or otherwise stipulated) monitoring report, the required amendments, or reporting of adverse events or incidents was not done in a timely manner and accurately; and / or
- new institutional rules, national legislation or international conventions deem it necessary.

- *NWU-HREC can be contacted for further information or any report templates via Ethics-HRECApply@nwu.ac.za or 018 299 1206.*

The NWU-HREC would like to remain at your service as scientist and researcher, and wishes you well with your study. Please do not hesitate to contact the NWU-HREC or the NWU-RERC for any further enquiries or requests for assistance.

Yours sincerely

Digitally signed by Wayne Towers
Date: 2019.04.12 08:49:12 +02'00'

Prof Wayne Towers
Chairperson NWU Health Research Ethics Committee

Original details: (22351930) C:\Users\22351930\Desktop\ETHICS APPROVAL LETTER OF STUDY.docm
8 November 2018

Current details: (22351930) M:\DSS\18533\Monitoring and Reporting Cluster\Ethics\Certificates\Templates\Research Ethics Approval Letters\9.1.5.4.1 HREC Ethical Approval Letter.docm
3 December 2018

File reference: 9.1.5.4.2

Appendix F: Statistical Approval Letter

NWU Ethics Application

Project Leader (Title, Initials & Surname)	Project Title (see § 3.1)
Prof Hendri Coetzee Prof Klaus Kellner	Assessing Ecosystem Services in Molatedi Dam Communities of South Africa

NWU Ethics Number

N	W	U	-						-			-		

Institution — Project Number — Year — Status

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

(for office use only)

Sec 8e: Statistical Consultation Service

The statistician of the Statistical Consultation Service of the North-West University completes this section (where applicable).

More information

Prior consultation with Statistical Consultation Service can eliminate many problems, simplify and expedite the evaluation and also prevent applications from being returned due to poor project planning and/or statistical justifiability. Where the project leader has sufficient statistical expertise at his disposal, this is, however, not compulsory.

The Ethics Committee relies completely on the professional judgement of the statistician.

Have you ascertained the experimental design of the study and is it statistically justifiable according to your judgement?
*(Please mark with **X** in the appropriate box and provide details)*

Yes	No	Remarks
☐x	☐	

Name (Title, Full Names & Surname)	Qualifications
Prof Susanna Maria Ellis (Pr Sci Nat)	PhD (Statistics)

Signature	Date
	2018 - 08 - 15 (c c y y - m m - d d)

Remember to save your document regularly as you complete it!

Appendix G: Spreadsheet derived from Statistics

Number	ES Classification	ES	Mean	Standard Deviation	Median	Highest range Score	Analysis
1	**Provisioning Ecosystem Services**	Sand	3.72	0.67	3.85	4.54	6 used to a fairly extent, 4 to a moderate extent, 3 to a small extent.
2		Water (to drink, wash, cook, etc.)				4.49	
3		Grass for the grazing of your livestock				4.47	
4		Wood as energy source (e.g., fuel wood for cooking and heating)				4.22	
5		Wood for beneficiation				4.12	
6		Wood as timber (i.e., to construct houses and/or kraals)				4.07	
7		Medicinal resources				3.85	
8		Rocks and stones				3.48	
9		Raw materials				3.45	
10		Local wild plants as food				3.43	
11		Wild animals as food				2.98	
12		Fish as food (from the dam and other sources in the area)				2.79	
13		Grass as a building (e.g., thatching) and raw material (e.g., artefacts)				2.5	
						3.85	
Number	**ES Classification**	**ES**	**Mean**	**Standard Deviatio**	**Median**	**Highest range**	**Analysis**

				n		**Score**	
14	**Regulating Services**	Air you breathe	3.32	0.55	3.34	4.19	1 ES use to a fairly large extent, 6 to a moderate extent & 1 to a small extent
15		Biological control				3.7	
16		Erosion prevention				3.46	
17		Local climate				3.36	
18		Moderation of extreme events				3.33	
19		Maintenance of genetic diversity				3.22	
20		Pollination				3.01	
21		Waste water treatment				2.25	
Number	**ES Classification**	**ES**	**Mean**	**Standard Deviation.**	**Median**	**Highest range Score**	**Analysis**
22	**Cultural Services**	Aesthetic reasons (nature's beauty)	3.23	0.32	3.16	3.7	6 ES used to a moderate extent, 2 to a small extent
23		Mental and physical health well-being				3.64	
24		Sense of place				3.38	
25		Recreation				3.19	
26		Tourism opportunities				3.14	
27		Spiritual experience				3.02	
28		Inspiration for your culture				2.97	
29		Inspiration for art and design				2.76	
Number	**ES Classification**	**ES**	**Mean**	**Standard Deviation**	**Median**	**Highest range Score**	**Analysis**

30	**Supporting Services**	Habitats for species	3.37	0.24	3.42	3.58	3 ES used to a moderate extent
31		Maintenance of soil fertility				3.42	
32		Carbon sequestration/storage				3.1	