

Agroforestry development and implementation in South Africa: An assessment of selected case studies

by

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Thesis presented in partial fulfilment of the requirements for the degree of
MFor in the Faculty of AgriSciences, Stellenbosch University



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December 2016

DECLARATION

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ABSTRACT

Agroforestry (AF) is the integrated approach of producing trees and agricultural crops and/or livestock in a single system on the same piece of land. Elements of AF have been practiced in South Africa (SA) since the late 1800's, through what's known as the Taungya system. AF has numerous environmental, economic and social benefits. However, there is limited research in SA to qualify and validate these benefits. The available information and research on AF practices in SA is also highly fragmented, difficult to access or out-dated. There is also no formal national policy or strategy that directly addresses the development and implementation of AF in SA. This national study composed of two phases. The first phase consisted of an assessment of AF development and implementation at the national level where a self-administered questionnaire was distributed to key stakeholders and individuals, involved in the development, promotion and implementation of AF in SA. The second phase entailed the assessment of selected AF projects, using a combination of case studies and survey methods. The results and outcomes of the study provided qualitative and quantitative data on AF development and implementation in SA. This include an analysis of the extent and geographical distribution of AF projects; the major AF systems and practices used; the main barriers factors that hinder the development and implementation of AF. The key organisations developing and implementing AF were defined and an assessment of the main direct and indirect goods and services derived from AF. The strengths, weaknesses, opportunities and threats (SWOT) associated with AF projects; and the design and diagnosis (D&D) of AF systems were also identified.

The study concluded that AF systems are currently being developed and implemented in SA at various scales, level and with multiple management objectives, but potential to expand does exist. Several goods and services are also derived from AF systems, which make it a viable sustainable production alternative to conventional production. However, there are a number of barriers (institutional, technical, economic, policy/governance and social) affecting AF adoption, which need to be addressed. One of the recommendations is the development of a national AF policy and strategy. Furthermore, the top ranking national level barriers, which were identified and assessed through the research study, should be addressed. A more comprehensive assessment of the extent and distribution of AF in SA are also required. Finally, a detailed quantitative assessment of the AF goods and services and addressing the outcomes from the D&D of AF case studies in SA is needed.

OPSOMMING

Agrobosbou (AF) is die gekombineerde verbouing van bome en landbou gewasse en/of diere op dieselfde grondeenheid. AF het dus verskeie omgewings, ekonomiese en sosiale voordele. Dit word al sedert die 1800's beoefen in Suid Africa (SA) in die vorm van die Taungya sisteem. Daar is egter beperkte navorsing oor AF in SA om dié voordele te kwantifiseer en te bevestig. Verder is beskikbare inligting van AF sisteme in SA baie gefragmenteerd, moeilik om te bekom of verouderd. Daar bestaan ook geen formele strategie of beleid wat die ontwikkeling en implimentering van AF in SA direk aanspreek nie.

Hierdie nasionale studie het uit twee eenhede bestaan. Die eerste fase het die AF ontwikkeling en implementering op nasionale vlak ondersoek deur middel van 'n self geadministreerde vraelys wat aan belanghebbendens, betrokke by die bemarking en implementering van AF in SA, uitgestuur is. Die tweede fase was die assessering van geselekteerde AF projekte deur middel van 'n kombinasie van gevallestudies en direkte waarnemings. Gevolglik het die uitslag kwalitatiewe en kwantitatiewe data van AF ontwikkeling en implementering in SA aangedui. Dit het ook ingesluit die geografiese verspreiding en grootte van die AF projekte; die AF sisteme wat toegepas word; moontlike hindernisse ten opsigte van ontwikkeling en implementering. Die sleutel organisasies in die ontwikkeling en implementering van AF was ook geïdentifiseer en geassesseer om die direkte en indirekte goedere en dienste van AF te lys. Verder is die sterkpunte, swakpunte, geleenthede en bedreigings (SWOT) geassosieer met AF projekte; die ontwerp en diagnose van die AF sisteme ook geïdentifiseer.

Gevolgtrekkings wys dat AF sisteme in SA tans op verskeie vlakke ontwikkel en geïmplementeerd word met verskillende bestuursdoelwitte. Die moontlikheid van uitbreiding is dus moontlik. Verskeie goedere en dienste afkomstig vanaf die AF sisteme kan ook help om AF as 'n volhoubare en suksesvolle alternatiewe konvensionele manier van produksie te vestig. Daar is egter verskeie hindernisse (institusionele, tegniese, ekonomiese, beleid / bestuur en sosiale) wat eers oorkom sal moet word. Een van die aanbevelings is die ontwikkeling van 'n nasionale AF beleid en strategie om die hindernisse aan te spreek. 'n Meer omvattende assessering van die verspreiding en effek van AF in SA moet onderneem word. Laastens, 'n gedetailleerde kwantitatiewe assessering van die goedere en dienste verkry uit AF sisteme asook die uitkomst van die ontwerp en diagnose van die AF gevallestudies in SA moet eers onderneem word.

AKNOWLEDGEMENTS

Firstly, I wish to thank my family and especially my parents (Ian and Ruby Jacobs) for all their support, encouragement and understanding. This has been an extremely long and treacherous journey!

I am sincerely grateful to the following individuals and their organisations for providing data and inputs for the national level assessment: Dr. Alan Manson (DAE KZN); Prof. Paxie Chirwa; Prof. Coert Geldenhuys; Mike Underwood; Dr Tony Knowles (Cirrus Group); Johan Bester & Theo van der Merwe (DAFF); and Thabiso Mudau (ARC).

To the following individuals and organisations that assisted with the collection of the project level data and whom without this research study would have been impossible and a mere concept and idea, my heartfelt thanks: Anton Louw and Dr. Anthony Mills (Spekboom Trading (Pty) Ltd (Private) & C4Ecosolutions); Dutliff Smith and Murray Wilson-Browne (Sappi); Prof. Kingsley Ayisi (University of Limpopo); Eugene Kraamwinkel (Lionmatch Forestry (Pty) Ltd); as well as Dr. Johan de Graaf and Kuno Venter (Hans Merensky Holdings). I especially would like to thank these individuals and organisations for the very informative and insightful site visits and data collection visits.

Thanks to Barney Kgope (Department of Environmental Affairs) my work supervisor for his understanding and support through my data collection and compilation of my thesis, since my studies were on a part-time basis. I would also like to thank a very special person, Selome van Niekerk, for all her support, including funding, and the motivation throughout this study.

Last but not least, I would like to offer many thanks and gratitude to my supervisors Hannél and Cori Ham of the Department of Forestry and Wood Science. I appreciate all your patience, help and vital support.

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ACRONYMS

AF	Agroforestry
AHP	Analytic Hierarchy Process method
CS	Case Study
DAFF	Department of Agriculture, Forestry and Fisheries
D&D	Diagnosis and Design
DWAF	Department of Water Affairs and Forestry
FAO	Food and Agricultural Organisation
GIS	Geographic Information Systems
Ha	Hectare
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
ICRAF	International Centre for Research in Agroforestry
LMF	Lion Match Forestry
M/L	Municipal/Local
N	National
NGO	Non-governmental organisation
NTFP	Non-timber Forest Products
P	Provincial
SA	South Africa
SOE	State Owned Entity
SWOT	Strengths, Weaknesses, Opportunities and Threats

CHAPTER 1: INTRODUCTION

1.1 General introduction

The International Council for Research in Agroforestry defines Agroforestry (AF) as “a sustainable land management system which increases the overall yield of the land, combines the production of crops (including tree crops) and forest plants and/or animals simultaneously or sequentially, on the same unit of land, and applies management practices that are compatible with the cultural practices of the local population” (Lundgren, 1982) and King (1987).

AF has numerous benefits aimed at meeting the triple bottom line of economic, ecological and social needs (Nair, 1993; Nair et al. 2004; Gold & Garrett, 2009; Kalaba *et al.*, 2010; Leakey, 2010; Zerihun *et al.*, 2014). These benefits include, but are not limited to, the improvement of crop yields with low input costs (i.e. fertilisers); reduction and prevention of soil erosion; increased fuelwood production and supply; conservation of wildlife and water resources; diversification and provision of products and services from one site, and to increase overall productivity of the land (Mudau *et al.*, 2000; Geyer *et al.* 2004; Ajayi, 2007; Atangana *et al.*, 2013a, Jerneck & Olsson, 2013).

AF systems integrate agriculture and forestry into a single system and on the same land area (King, 1987; Mudau *et al.*, 2000; Atangana *et al.*, 2013a). This enables land users to produce a wider variety of goods and services on the same piece of land, in comparison to implementing conventional forestry and agricultural (livestock or crop production) (Zerihun *et al.*, 2014).

This integrated approach of trees, crops and livestock has been practiced in various countries for centuries (Nair, 1993; Garrity, 2004; Briggs, 2012; Nerlich *et al.*, 2012) and in South Africa (SA) from the late 1800's (Hailey, 1957; Menzies, 1988) until prior to the apartheid era (Ayisi *et al.*, 1999). Although it is severely under developed and implemented in SA (Zerihun *et al.*, 2014), AF can aid in addressing observed land use related challenges such as the unavailability of sufficient arable land for agriculture. It can also help to reduce land degradation and soil erosion; decrease competition between land uses; and increase food production (Hoffmann *et al.*, 1999; Le Roux *et al.*, 2007; Niedertscheider *et al.*, 2012; ARC, 2014; DEA, 2015a, 2015b).

1.2 Problem statement

There are currently very few published research studies (Everson *et al.*, 2009, 2011; Mukolwe, 1999; Zerihun *et al.*, 2014) in SA that assess the Diagnosis and Design (D&D) of AF development and implementation. Furthermore, a formal national policy or strategy to promote and support the development and implementation of AF in SA is lacking (Bester, 2013).

1.3 Rationale of project

Even though, AF was first introduced in SA around 1887 (Hailey, 1957), it is still not as well developed and implemented as in most southern African countries and other parts of the world (Zerihun *et al.*, 2014). This study was conducted to provide more information and data on AF development and implementation in a SA context. The research findings can be used to upscale AF efforts in the country and also contribute towards a basis for the development of a national policy and/or strategy to address the development and implementation of AF. This was done by qualitatively and quantitatively assessing the current *status quo* of AF development and implementation in SA, by conducting a national level institutional assessment (macro-level) and a multiple case study assessment (micro-level) of four selected case studies.

D&D is a methodology that was developed by the International Centre for Research in Agroforestry (ICRAF), to assist in the diagnosis of land management problems and the development of solutions for AF. It was specifically developed to aid in the effective planning and implementation of AF research and development projects (Raintree, 1986).

The objectives and research questions of this study are summarised as follows:

1. Assess the status of AF in SA and identify the barriers that inhibit success
 - i. What is the extent and geographical distribution of AF projects?
 - ii. What are the main AF systems practiced?
 - iii. What are the main barriers inhibiting its success?
 - iv. Who are the organisations developing and implementing AF?
2. Assess the multiple goods and services derived from AF projects
 - i. What are the multiple benefits from AF projects?
 - ii. What are the barriers inhibiting the up-scaling of AF projects?
3. Identify and evaluate four AF case studies in SA

- i. Are AF systems better than conventional practices in terms of economic, social, environmental, land use and cultural services?
- ii. How are the particular AF systems beneficial?
- iii. What are the D&D of the chosen AF systems? What are the strengths, weaknesses, opportunities and threats (SWOT's) related to the AF case studies?

The collection, gathering and analysis involved two phases. Phase one was the national institutional level assessment, which involved the dissemination of a self-administered questionnaire to 90 stakeholders via email. Phase two was the micro diagnosis and design assessment of four case studies, through two questionnaires administered face to face.

1.4 Thesis structure

This thesis consists of six chapters. Chapter 2 focuses on the literature study, including background information on the benefits of developing and implementing AF. The methodology that was used is outlined in Chapter 3. Chapter 4 contains the results obtained from the data collection and data analysis while the results are discussed in Chapter 5. Chapter 6 concludes by suggesting recommendations for the three basic D&D stages described by Raintree (1986) and Atangana *et al.* (2013b), i.e. pre-diagnostic, diagnostic, design and evaluation.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

AF as defined by ICRAF, is a sustainable land management system that increases productivity by integrating crops, trees and/or animals on the same unit of land (Rahim & Hasnain, 2010). The applied management practices have to be compatible with the cultural practices of the local community (Nair, 1993, King 1987). Therefore, AF is the combination of economic, social and ecological sustainable management (Leakey & Izac, 1996; Gangadharappa *et al.*, 2003; Nair *et al.* 2004; Garrity *et al.*, 2006; Leakey, 2012; Rancāne *et al.*, 2014). It can address multiple developmental objectives within SA, such as environmental protection, poverty eradication and sustainable development. AF can also be seen as a relationship between forestry and agriculture (Erskine, 1991; Nair, 1993; Atangana *et al.*, 2013a), which originated from agriculture, rather than forestry (Torquebiau, 2000). It is more attractive for smallholder/ subsistence farmers with limited resources as opposed to commercial producers (Nair, 1993). AF is potentially a viable approach for approximately 225 000 South African subsistence producers (as of 2010 mainly found in the former homeland areas, covering about 14 million ha of agricultural land) and associated with approximately 2.8 million households (DAFF, 2011).

2.2 AF systems versus conventional mono-cropping systems

AF can be divided into the following typology (Nair, 1993): structure of the system (nature and arrangement of components); function of the system (role and output of components); agro-ecological zones where the system exists or is adoptable; socio-economic scales and management levels of the system. It can also be classified based on predominant components and land use (i.e. trees on cropland or crops on tree land), as well as arrangement, density and diversity of components (Sinclair, 1999). This aligns with the three conventionally applied categories of AF systems: agrisilviculture (trees and crops), silvopastoral (trees and livestock), and agrisilvopastoral (trees, livestock and crops) (Nair, 1993). The classification of Nair (1993) was used for the purposes of this research study.

AF promotes diversification of goods and services, resulting in sustainable production to enhance social, economic and ecological benefits for developers and implementers (Nair, 1993; FAO, 2005, Gold and Garrett, 2009; Kalaba *et al.*, 2010; Leakey, 2012; Zerihun *et al.*, 2014). Globally, it is

important for the livelihoods of rural people as it provides employment and ecosystem services, such as energy (firewood) and nutritious food (FAO, 2014). It has recently gained considerable attention particularly in Africa (especially Malawi and Zambia) and Asia (in countries such as India and Lao People's Democratic Republic), (FAO, 2014).

Previous studies illustrate that the benefits of AF systems exceed those of conventional mono-cropping systems (i.e. agriculture and forestry). It considerably enhances soil quality and productivity (Schwab *et al.*, 2015), while the combined growing of trees and grasses potentially cuts costs, and an income can be generated within the first year, equal to initial expenses (Rancāne *et al.*, 2014). Furthermore, the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), identified it as a 'win-win' approach that includes commodity (i.e. food, feed, fuel, fibre, etc.) and non-commodity goods (environmental protection, cultural and landscape services) (Smith *et al.*, 2012). Despite its appeal as a land use there are, however, still barriers to AF development.

2.3 Common barriers to AF development and implementation

Perceived barriers to AF development are broadly categorised under environmental, social, economic, technical, institutional, and policy/governance, but may overlap (Huang *et al.*, 1997; Mukolwe, 1999; De Baets *et al.*, 2007; Kelso & Jacobson, 2011; Merson *et al.*, 2011; FAO, 2013a; Zerihun *et al.*, 2014). Some examples of the specific barriers under these broad categories include:

- Environmental - lack of understanding of ecological benefits, lack of incentives for environmental services;
- Social – lack of interest due to its long term nature, ignorance of the advantages;
- Economic – linking farmers to relevant markets and delayed returns on investment;
- Technical – inadequate research, inability to match appropriate AF systems to geographical areas;
- Institutional – inadequate extension services, absence of partnerships and collaborations regarding AF development; and
- Policy/governance – lack of government and project support; insecure land tenure.

Establishing an effective and enabling policy environment is crucial for the implementation and up-scaling of AF development within countries (Franzel *et al.*, 2001). The effective promotion and regulation of AF through relevant policies or strategies can also aid in addressing the barriers identified above. However, relevant policies or strategies alone are inadequate if not coupled with

the other drivers of AF development and implementation. These drivers include buy-in from implementers, security of land tenure, coordination and collaboration among decision makers and stringent enforcing of forest management rules to ensure efficacy (FAO, 2013a).

2.4 AF development and implementation in SA

AF was introduced to SA around 1880 through the practice of combining the cultivation and production of woody species with agricultural crops and/or farm animals in a Taungya system (Hailey 1957), which is similar to shifting cultivation. During the first growth season only food crops are planted, followed by a combination of crops and trees in the second growth season, where after only the trees are left (Nair, 1993; Imo, 2009). Up to 1992, AF practices were mainly implemented on commercial farms in Secunda, Standerton, and Nelspruit (Bester, 2013). These projects were initiated and monitored by the provincial Department of Water Affairs and Forestry (DWAF), but managed by the farmers. It was then decided that AF projects should be prioritised to the former Homelands and rural areas but implementation was hampered by a lack of government resources (Ham and Theron 1998).

AF in principle is vital to a number of government departments and priorities, but in practice it belongs to none (Place *et al.*, 2012). It was initially a subset of forestry, but due to limited resources and capacity, and unfamiliarity with agricultural practices, there was a clear shift towards agriculture (Place *et al.*, 2012). The disparity between forestry and agriculture is highlighted by the fact that the two land uses were never combined in one government department (Ham and Theron, 1998) until 2009 when the Department of Agriculture, Forestry and Fisheries was formed.

Traditionally, AF was seen as a producer of firewood and not for other co-benefits such as enhancement of soil productivity and agricultural crops (Bester, 2013). Although Esterhuysen (1989) provided guidelines on how AF can be incorporated into agriculture and forestry in SA, it did not take into account the contemporary issues and dynamics related to AF development and implementation, such as climate change mitigation and adaptation. A number of previous studies however, have considered AF development and implementation on SA land users (Mukolwe, 1999; Bryan *et al.*, 2009; Everson *et al.*, 2011; Kelso & Jacobson, 2011; Zerihun *et al.*, 2014). For example, Everson *et al.* (2009) indicated that in an agrisilviculture system, trees do not compete with the crops for soil moisture in good rainfall seasons.

2.5 The Benefits of agroforestry for South Africa

Despite the low level of AF adoption in SA it is well recognised that the benefits of AF are significant, provide pragmatic options for the development of rural production systems, and enables sustainable land use for land users at all levels (Alao and Shuaibu, 2013). It can potentially assist in soil erosion control, optimise soil and land productivity, reduce pressure on indigenous forests, ensure a sustainable supply of timber and non-timber forest products (NTFP's) and services, mitigating climate change, as well as improve the livelihoods of the resource-poor rural households (Esterhuysen, 1989; Erskine, 1991; Mukolwe, 1999). Although it is severely under developed in SA (Zerihun *et al.*, 2014), if up-scaled the benefits of AF can address some land use and non-land use related challenges. These include the unavailability of sufficient arable land for agriculture; land degradation and soil erosion; competition between land uses; the need for increased food production as a result of a growing population, and unsustainable land use practices (Hoffmann *et al.*, 1999; Le Roux *et al.*, 2007; Niedertscheider *et al.*, 2012; ARC, 2014; DEA, 2015a; 2015b).

AF also has relatively low input costs, and offers options for improving the quality of life and ensures environmental sustainability (Govere, 2003; Nigussie & Alemayehu, 2013; Parwada *et al.*, 2010). The use of AF systems in certain parts of east, west and southern Africa has led to increased maize yields in the regions of 0.8, 1.3 and 1.6 tons per ha per year as opposed to conventional mono-cropping systems (Sileshi *et al.*, 2008). Therefore, a greater effort in the promotion and implementation of AF in SA can assist in the mitigation of the impacts associated with poverty, food insecurity and environmental degradation while supporting environmental services (De Baets *et al.*, 2007; FAO, 2013b).

Blinn *et al.* (2013) indicated that the practice of AF by farmers led to the promotion of forest recovery (reforestation) on their land. Careful analysis of the myriad of benefits offered by AF, can lead to social, economic and environmental benefits in SA. In countries such as Kenya and Ghana, it has been the backbone of successful commercial forestry whilst contributing significantly to communities adjacent to the forests (Imo, 2009; Kalame *et al.*, 2011).

2.6 The Diagnosis & Design of AF

According to Raintree (1986), the use of the D&D method assists in developing solutions for improving the management of land and AF design. It was specifically developed to support AF

developers and implementers in conducting and implementing effective research, programmes and projects.

2.6.1 How does it work?

D&D is built around five simple stages, which entails Prediagnostic, Diagnostic, Design and Evaluation, Planning, and Implementation (Raintree, 1986). In a study by Tolunay *et al.* (2007), D&D was used for the determination, definition and classification of traditional AF practices in Turkey by means of the pre-diagnostic stage. The D&D approach can be used/ applied to any problem in technology design in order to formulate possible interventions and solutions (Raintree, 1986; Krishnamurthy & Reddiar, 2011).

2.6.2 Why is it popular?

The D&D method has three distinct features (Raintree, 1987). These include flexibility (it can be adapted to suit the needs and resources of the implementers), speed (allows for rapid appraisal during planning and in-depth investigation during implementation), and repetition (the approach is open-ended and enables continuous learning and improvement). These features contribute to it being a method of choice by AF researchers, extension agents and community fieldworkers (Raintree, 1986).

2.6.3 The positives and negatives of D&D

D&D has several benefits as it can simplify complex areas of analysis; it can be applied at a micro- (small scale and household), meso- (community/watershed) and a macro-level (regional and national); and it provides a systematic approach for the assessment of AF (Raintree, 1986). The D&D approach was also developed with a specific focus on AF relevant barriers and opportunities, in order to identify elements ignored by other methodologies, such as farming systems research, land evaluation methodology and agro-ecosystems analysis (Young, 1985; Tolunay *et al.* 2007). However, a major shortcoming of the D&D approach is that it does not cover processes, such as marketing of AF goods and processing, beyond the project site (Tolunay *et al.*, 2007). Therefore, it needs to be adapted to incorporate these aspects of AF development and implementation.

CHAPTER 3: METHODOLOGY

3.1 Data Collection

Data collection was conducted in two major phases: the first phase consisted of a national level assessment (primary, secondary and tertiary stakeholders); and in phase two, four case studies were identified and evaluated. There are five research methods in science, i.e. experiment, survey, archival analysis, history and case study (COSMOS Corporation, 1998). In this study, a combination between the case study and survey method was used (highlighted in orange in Figure 1).

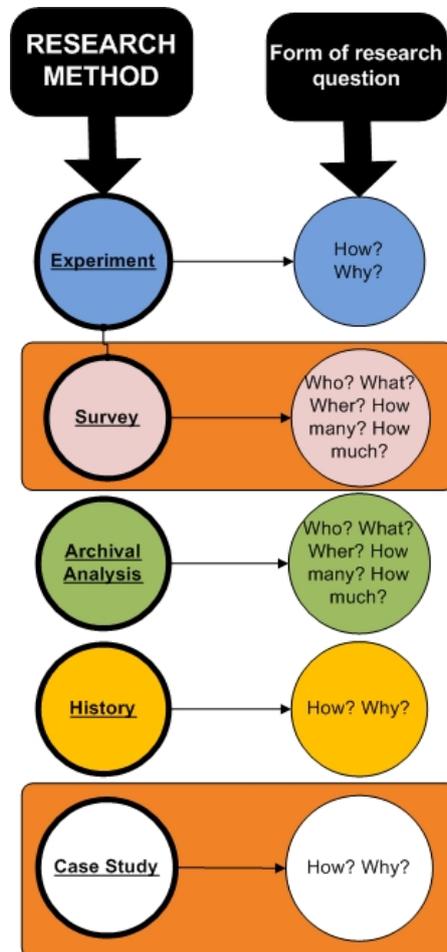


Figure 1: Summary of different research methods that can be employed. This study focused on a combination between case study and survey methods (adapted from COSMOS Corporation, 1998)

3.2 Stakeholder analysis

Stakeholder analysis (Grimble and Wellard, 1997; Skutsch, 2000) was used to identify the key AF stakeholders in SA, which formed the sample of 90 stakeholders for the national level assessment. A database of the stakeholders across the agriculture and forestry sectors was compiled and categorised into: government (National and Provincial); private companies; state owned entities (SOE's); parastatals; conservation agencies; academic institutions; research institutions; non-governmental organisations (NGOs); and other key informants. The respondents identified in the national level assessment were further categorised based on their level of interaction with AF, into primary, secondary and tertiary as outlined in Table 1 (Grimble 1998; Abdul-Razak 2008).

Table 1: Stakeholders involved in AF development and implementation in SA (adapted from Grimble (1998), and Abdul-Razak (2008))

Level of Interaction	Stakeholder Category	Possible interest in Agroforestry
Primary	Implementers	Benefits such as social, environmental, economic, land use, and cultural
Secondary	Developers	Transitional stakeholders involved in the elements related to development, implementation and regulation of agroforestry.
Tertiary	Regulators or enablers	Policies and systems to regulate, enable and provide support for AF.

3.2.1 Phase 1: National level

Semi-structured questionnaires consisting of both closed ended questions (limited and structured responses) and open-ended questions (more flexibility to interviewees) (Babbie and Mouton, 2001) were used to interview stakeholders (Appendix A) (Bryman, 2012). The questionnaires were self-administered and distributed via e-mail to the key stakeholders which were identified during the stakeholder analysis. A “snowball” sampling technique was employed, where identified key stakeholders recruited other interest groups (stakeholders) involved with AF although they were not part of the initial stakeholder database (Abdul-Razak, 2008).

3.2.2 Phase 2: Identify and evaluate case studies

Case studies were selected using six criteria, which included relevance; similarity of AF systems; outcomes and goals; structured monitoring; sustainability; and potential to up-scale. Initially there was a set of 15 criteria, but these were refined and reduced to only six. A score from 1 to 15 was assigned to each of the initial indicators based on its importance to the aims and objectives of the study. This was followed by a pairwise ranking to identify the six main criteria. The final set of criteria was applied to the eight case studies to prioritise the four that were assessed as part of the multiple case study assessment. A total of seven case studies were identified but only four were ongoing projects and thus assessed during this study (Yin, 2009).

Case studies were evaluated to highlight D&D and results of projects. Evaluation of case studies was combined with direct observations, questionnaire surveys and interviews to gain insight and comprehension (Babbie & Mouton, 2001; Yin, 2014). Although statistically challenging to analyse (Easton 2010), this approach provided data for both qualitative (descriptive) and quantitative (empirical) analysis

Research based on case study analysis, aims to obtain cross case findings or lessons learnt (Yin 2014). Survey interviews were done as indicated by Yin (2014) and consisted of two separate questionnaires. Firstly project managers (unit of analysis) (Bless & Higson-Smith, 1995), of the four case studies were interviewed with face-to-face semi-structured questionnaires, while open-ended questionnaires (consisting of 12 questions) were completed upon visiting the selected four case studies and photographs were taken. The unit of analysis was considered to be sufficient as the project managers are familiar with their respective projects. Advantages of administering questionnaires face-to-face include clarifying unclear questions, while sensitive questions can be asked with ease (Bernard, 2000). Cross referencing between the two questionnaires improved data reliability and quality (Yin, 2014). Appendix B and C provide samples of the questionnaires used in the evaluation of the case studies. The same questionnaires were used across the case studies, in order to allow for comparability and cross case analysis.

3.3 Data analysis

The data and information from the questionnaires were imported into Microsoft Excel worksheets and Microsoft Word. This involved coding, grouping and ranking of answers for ease of analysis.

The analytic hierarchy process (AHP) method was used to analyse ranked data, in order to assess the D&D of AF at a micro-level (case studies).

The AHP analysis broadly consists of three stages (Dwivedi and Alavalapati, 2009; Stainbank *et al.*, 2012):

- selection and identification of Strengths, Weaknesses, Opportunities and Threats (SWOT) applicable to the AF project by the project managers
- pairwise comparison of the factors within each SWOT category (Appendix B, Figure 2) and
- application of the AHP method to the SWOT's.

Pair-wise comparisons (Figure 2) were conducted separately for all factors within a category and a priority value for each factor is computed using the eigenvalue method. A unique feature of this method is that the user can perform a consistency check by calculating a confidence ratio.

a. Strengths

1. Compare the relative importance of Strength to Strength, and circle ONE appropriate number:



2. Compare the relative importance of Strength to Strength, and circle ONE appropriate number:



Figure 2: Examples of a pairwise comparison of strength factors. The respondent is asked to assign a value of 1–9 to one of the factors to indicate the relative importance of that factor over the other (adapted from Stainbank *et al.*, 2012)

The confidence ratio was calculated as follows:

$$CR = \frac{CI}{RI} \text{ with } CI = \frac{(\mu_{max} - n)}{n - 1}$$

with consistency ratio (CR), consistency index (CI), random index (RI), number of factors in the SWOT category (n), and Lambda maximum (μ_{max}). A CR of less than 0.1 is preferable while 0.2 is tolerable (Saaty, 1977; Stainback *et al.*, 2012).

Data reliability was ensured by data triangulation through interviews and direct observations by transect walks (Yin, 2014).

3.3.1 National level data

The total estimated extent of formal AF practices and approximate extent (ha) was calculated. This was repeated for each of the seven case studies identified to determine the total estimated extent of the combined case studies. Furthermore, key stakeholders developing and implementing AF were determined as described under the stakeholder analysis (section 3.2). National level barriers were analysed with the AHP method (section 3.3). Close-ended responses from the key respondents were grouped and analysed as main issues with their corresponding responses (i.e. yes, no, and no comment) represented as a percentage of the total responses. This was done to analyse and identify the implementation level of AF (National, Provincial, and Municipal/Local) by the key organisations.

3.3.2 Individual case study analysis

Data from the semi-structured questionnaire was grouped, ranked, and also analysed with the AHP method. This included the goods and services, as well as the SWOT data. The goods and services were identified through the literature review (Sinclair, 1999; De Baets *et al.*, 2007; Everson *et al.*, 2009; Nair, 2011; Rancāne *et al.*, 2014; Schwab *et al.*, 2015, Newaj *et al.*, 2016) and grouped in five categories (i.e. economic, environmental, social, land use and cultural) (De Baets *et al.*, 2007). However, the interviewees were also given the opportunity add more AF goods and services to the already identified list. The five categories were classified from highest to lowest relative importance. Open-ended questionnaire data was grouped to provide descriptive data for the four case studies, based on the responses (i.e. yes, no or no comment) from the project managers. In-field photographs were used to provide more descriptive data.

3.3.3 Cross-case analysis

The data from the four case studies were consolidated and a comparative analysis was conducted. Average relative rankings were done by calculating the means across the four case studies for the goods and services and the SWOT data (Yin, 2014). The objective of the cross-case analysis was to identify patterns across the four case studies, and also to identify distinct similarities as well as

differences between the four case studies. The AF goods and services were identified and grouped using the process in section 3.3.2.

CHAPTER 4: RESULTS

4.1 Stakeholder analysis

As the development and implementation of AF in SA is dependent on stakeholders, it is important to understand who the key stakeholders are; their role in AF (implementer, developer, and/or regulator/enabler); and their level of interaction (primary, secondary, and/or tertiary). A comprehensive database of stakeholders and contacts related to agriculture and forestry that may have an interest in AF, was compiled. Only 13 stakeholders (i.e. 14%) responded in the national level assessment from the initial 90 identified stakeholders. The three levels of interaction with AF are primary (the project/ implementation level), secondary (development level), and tertiary (regulations).

The results indicated that there are a number of overlaps between the stakeholder categories (developers, implementers and regulators/enablers) and the levels of interaction (primary, tertiary and secondary) by stakeholders with AF in SA. Seven of the stakeholders fall within two stakeholder categories and six of the stakeholders interact at dual levels of AF. The results clearly showed that 6 stakeholders are implementers, 10 are Developers and 3 are regulators/enablers. Furthermore, 7 stakeholders interact with AF at the primary level, 10 at the secondary level and 3 at the tertiary level. From the analysis it is evident that most stakeholders are involved at the development stage (i.e. developer and secondary) of AF in SA.

4.2 National level assessment of AF

4.2.1 Extent and distribution of formal AF practices

Seven AF projects were identified from the 13 respondents (Table 2). These are all formal projects, which were or have been established around SA. AF is also a practice that is informally developed and implemented at the household level; therefore there might be a number of subsistence level projects that haven't been identified through this research project due to time and budgetary limitations.

The case study with the greatest extent (approximately 5 000ha) was CS1, of the approximate total Projects were established in six of the nine provinces (Limpopo, KwaZulu-Natal, Eastern Cape,

North West, Mpumalanga, and Western Cape). However, it seemed that AF practices were more prominent in Limpopo and KwaZulu-Natal, with the highest estimated extent in Eastern Cape (about 5 000ha) and Mpumalanga (approximately 2 500ha).

4.2.2 Major AF systems and practices

An overview of the seven identified projects, and corresponding practices are summarised in Table 2. During interviews it was determined that three major AF systems (agrisilviculture, silvopastoral, and agrisilvopastoral) were implemented in the identified projects. However, agrisilviculture and silvopastoral AF systems were the most prevalent.

Table 2: AF systems and practices identified per case study (CS)

Identifier	Project Title	AF System	AF practice(s)
CS 1	Kuzuko Lodge private game reserve thicket restoration project	Silvopastoral	Trees on degraded rangeland or pastures - trees scattered according to some systematic pattern
CS 2	Mposa peanut intercropping project (SAPPI)	Agrisilviculture	Plantation crop (<i>Eucalyptus</i> clones) combinations - intercropped with an agricultural crop (peanuts)
CS 3	Fertiliser trees, fodder trees, fruit trees and medicinal trees in AF systems in Limpopo province.	Agrisilviculture, silvopastoral, agrisilvopastoral	Multiple practices within the major three AF systems
CS 4	Lion Match Forestry (LMF) Cattle Project	Silvopastoral	Plantation crops (<i>Pinus</i> species) with pastures and animals
CS 5	Commercial/Community AF project (Merensky)	Agrisilviculture	Plantation crop (<i>Eucalyptus</i> species) combinations - intercropping agricultural crop (peanuts and common groundnuts or doemara)
CS 6	The importance of traditional AF for <i>circusitum</i> (farmer-based conservation) conservation of tree diversity in Vhembe Biosphere reserve	Agrisilviculture, silvopastoral, agrisilvopastoral	Multiple practices within the major three AF systems
CS 7	Greater Ethekwini woodlot and fruit tree programme	Agrisilviculture, silvopastoral, agrisilvopastoral	Multiple practices within the major three AF systems

4.2.3 Analysis of national barriers

National level barriers (i.e. institutional, technical, social, economic, and policy/governance) were classified into five broad categories. Respondents ranked them (Figure 3) based on their own perception and identified further national level barriers. Institutional barriers were the most prominent at 23.9%, followed by technical (23.8%), economic (22.2%), policy/governance (17.3%) and social (12.8%).

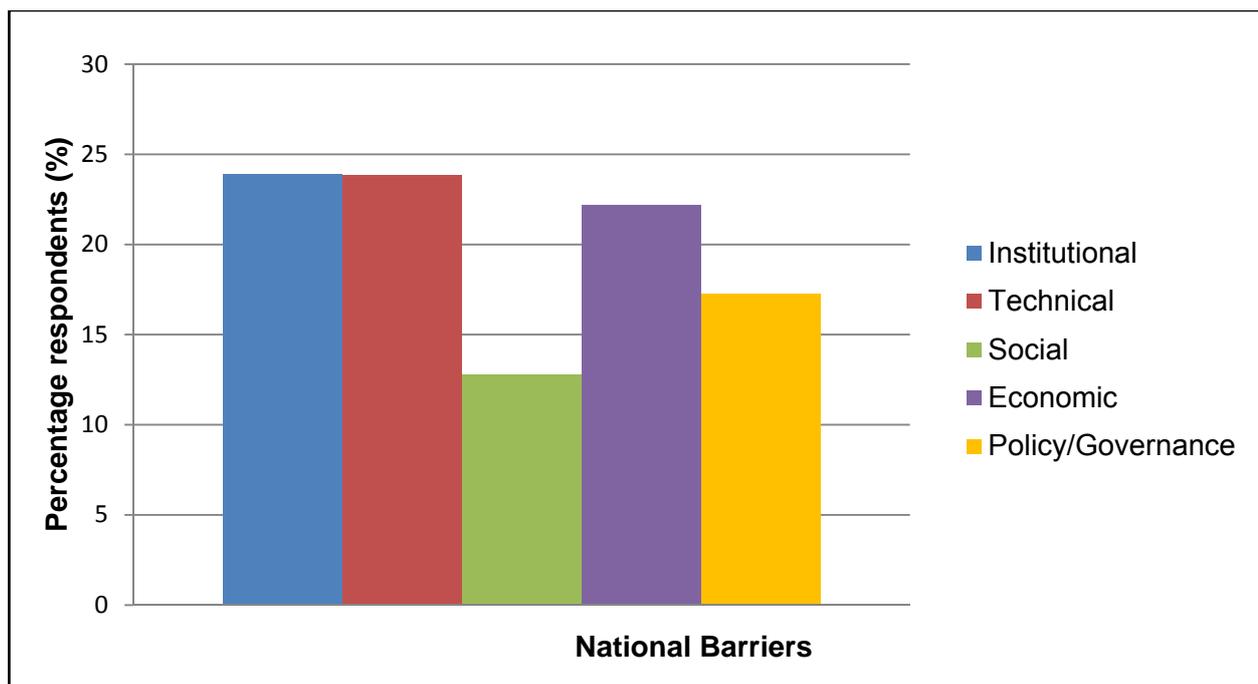


Figure 3: Ranking of the five broad categories of the national level barriers, based on the perceptions of the respondents ($n = 13$)

4.2.4 Assessment of the development and implementation of AF at the institutional level in SA

The majority of interviewed respondents indicated the value in adopting AF nationally (92.3%), while 84.6% realised it was necessary to assist in the development of a national strategy or programme (Table 3). Only 61.5% of the respondents have AF as a formal mandate/programme of their organisation, while 61.5% supports the development and implementation of AF in some form. When questioned on whether SA has a formal policy/strategy on AF, 69.2% respondents were not aware of any policy, whereas the remaining 30.8% identified the White Paper on Sustainable Forest

Development. However, the White Paper only refers to AF as an element of community forestry, but does not provide clear guidance on implementation and development of AF in SA (DWAF, 1997; Mukolwe, 1999). Furthermore, the potential climate change mitigation and adaptation benefits of AF were realised by 84.6% of respondents, while 15.4% were reluctant to provide a conclusive response.

Table 3: Summary of close-ended responses from key respondents

No.	Main issues	Yes (%)	No (%)	No comment (%)
1.	Is AF a formal mandate/activity/programme of your organisation?	61.5	38.5	0
2.	Does your organisation support any institution(s) in the development and implementation of AF?	38.5	61.5	0
3.	Is your organisation directly involved in the development and implementation of AF projects, programs or research?	61.5	38.5	0
4.	Does your organisation see any value in developing or implementing AF?	92.3	7.7	0
5.	Are you aware of any formal policy, strategy, or programme, which directly addresses development and implementation of AF in SA?	30.8	69.2	0
6.	Do you see any value and would you be willing to participate in the development of a national strategy or programme for the development and implementation of AF in SA?	84.6	0	15.4
7.	Does AF have any climate change mitigation and/or adaptation benefits for SA?	84.6	15.4	0

The levels of AF development and implementation were divided into three categories namely National (N), Provincial (P), and Municipal/Local (M/L). The key organisations were requested to indicate at what level their organisation functioned (Figure 4). This helped to understand the current institutional arrangements and discuss ways to utilise it to increase adoption and implementation of AF more effectively. Most of the organisations that were interviewed functioned at the municipal/local level (30.8%), followed by provincial (23.1%) and national (15.4%). The remaining 38.5% did not provide any comment.

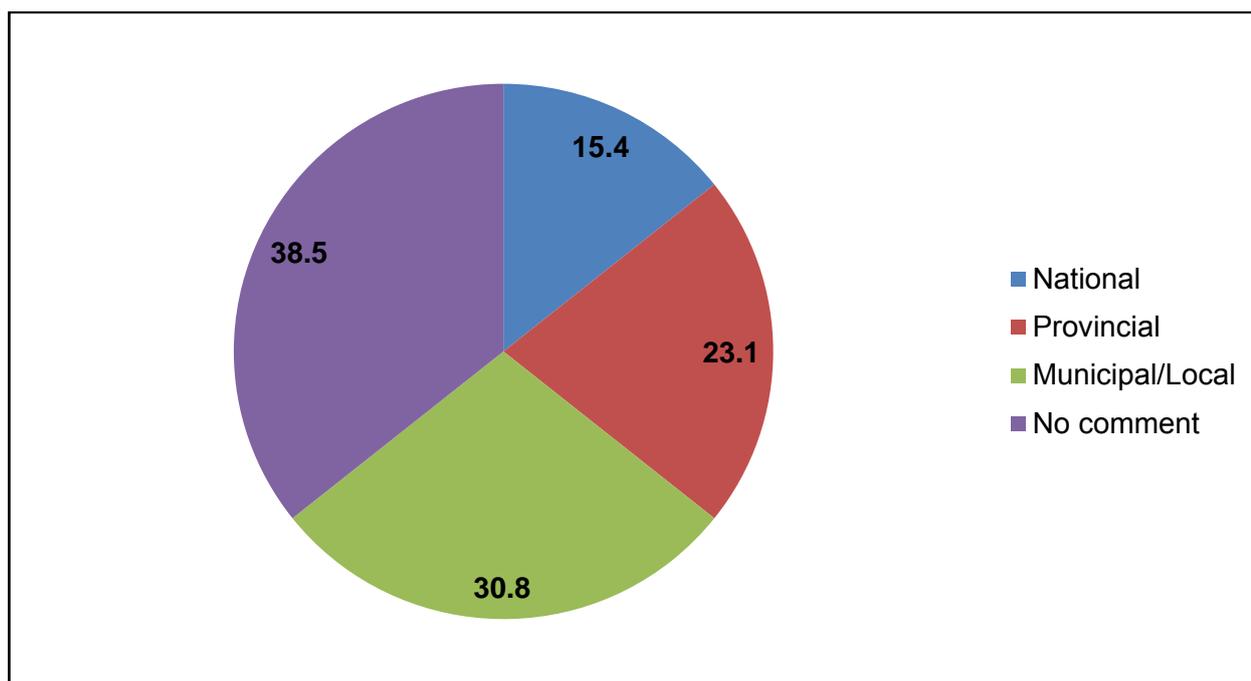


Figure 4: Level of implementation by the key stakeholders/institutions (n = 13)

Respondents indicated their preferences and perceptions of where the institutional mandate of national AF development and implementation (Figure 5) ideally should be. DAFF should drive AF nationally (46.2%), followed by DAFF and “other” (23.1%), DAFF and DEA (15.4%), and lastly the Agricultural Research Council (ARC) (7.7%).

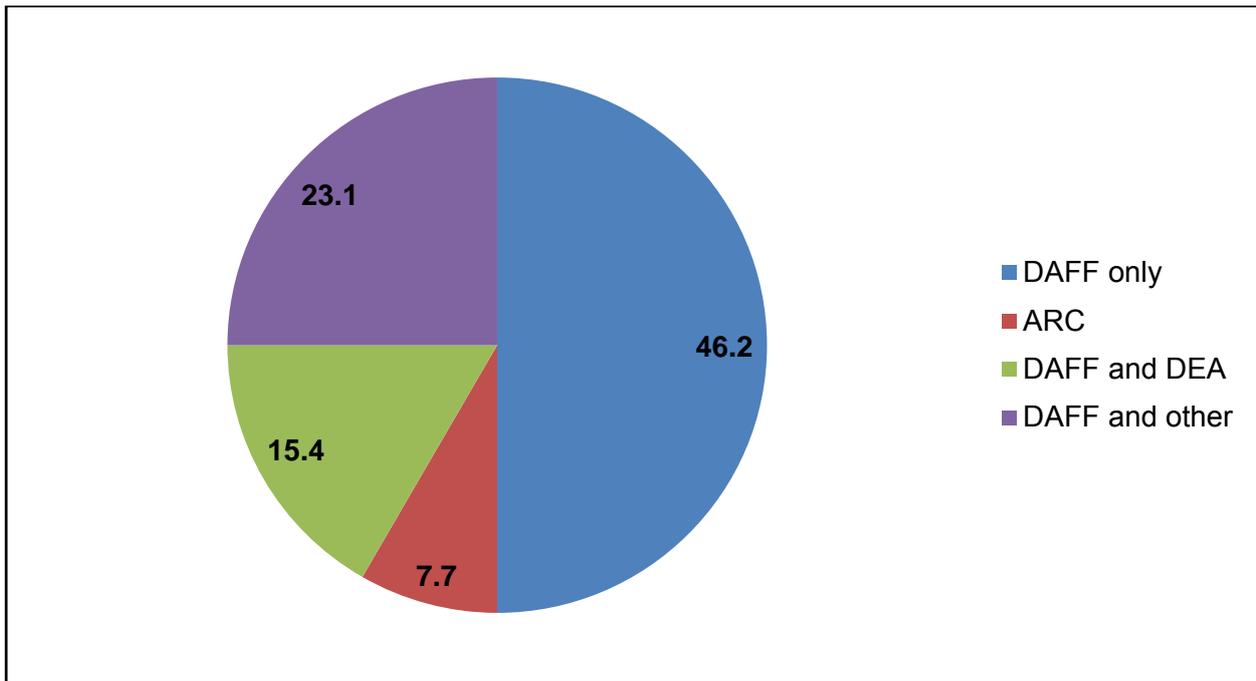


Figure 5: The institutional mandate of AF development and implementation in SA, as identified by the key respondents (%) (n = 13)

4.3 Assessment of the selected AF case studies in SA

4.3.1 Identification of AF case studies

Only on-going projects were selected (Table 4), therefore project seven was excluded. The case studies were refined and ranked through the application of the selection criteria (APPENDIX D: SCREENING AND SELECTION CRITERIA) to identify a final set of four case studies (1, 2, 4, and 5) for the multiple case study assessment (Table 4).

Table 4: Final set of selected case studies

	Title of Project	Size (ha)
CS 1	Kuzuko lodge private game reserve thicket restoration project	~5 000
CS 2	Mposa Peanut intercropping Project (SAPPI)	8
CS 4	LMF Cattle Project	2 500
CS 5	Commercial forestry AF project (Merensky)	100 - 500ha/yr

4.3.2 Single Case Study Assessments

This section introduces the individual case studies and provides the results obtained per individual case study, in order to assess the D&D of the four AF case studies. This includes the five basic stages of D&D (Chapter 2): (1) Pre-diagnostic; (2) Diagnostic; (3) Design and Evaluation; (4) Planning; and (5) Implementation.

4.3.2.1 Description and assessment of Case Study 1: Kuzuko Lodge Private Game Reserve - Thicket Restoration Project

4.3.2.1.1 Description of CS1

The project is located in the Eastern Cape Province adjacent to the Addo Elephant National Park (33°12'51.40" S, 25°29'39.62" E) (Figure 6). It combines silvopastoral with the restoration of spekboom thicket, after severe over-grazing of goat farming (Figure 7). The climate is semi-arid with a mean annual temperature of between 16°C and 19°C, while mean annual precipitation is approximately 385 mm (C4Ecosolutions, 2014). The soils comprise of sandstone, shale, mudstone and tillites, while the majority of the geological formations fall under the Karoo supergroup. The vegetation is predominantly shrubby thicket typified by the Waterford Doringveld (42% of the project area), Sundays Spekboomveld (23%), Saltaire Karroid Thicket (19%) and Sundays Noorsveld (11%) (C4Ecosolutions, 2014). The land is privately owned with no pending land claims. The project was initiated in 2012 and has an extent of approximately 5 000ha (Louw, 2015). Restoration is primarily for the sequestration and storage of carbon in the soil and vegetation biomass to subsequently generate carbon credits. The restoration will be financed by the sale of the carbon credits. There will also be a number of other co-benefits generated through this project, such as ecosystem goods and services.



Figure 6: Geographic location of the study area of case study 1 (C4 Ecosolutions, 2014)



Figure 7: An area recently replanted with Spekboom (*Portulacaria afra*) at Kuzuko lodge private game reserve, Eastern Cape

4.3.2.1.2 Assessment of CS1

4.3.2.1.2.1 Identification and assessment of goods and services

A comprehensive list of the goods and services deriving from this project, based on the perceptions from the respondent, are summarised in Table 5. The most important goods and services (economic, environmental, social, land use and cultural) to the project are illustrated in Figure 8. This project alone provides 20 (60%) goods and services from the 33 identified across the four case

studies. In order to understand the different categories of goods and services gained from this project, outcomes/objectives and management of this specific AF system, the first D&D stage (pre-diagnostic) was assessed. The relative rankings were calculated and analysed using the AHP method. For CS1 the economic goods and services ranked the highest (33%), followed by environmental (27%), social (20%), land use (13%) and cultural (7%).

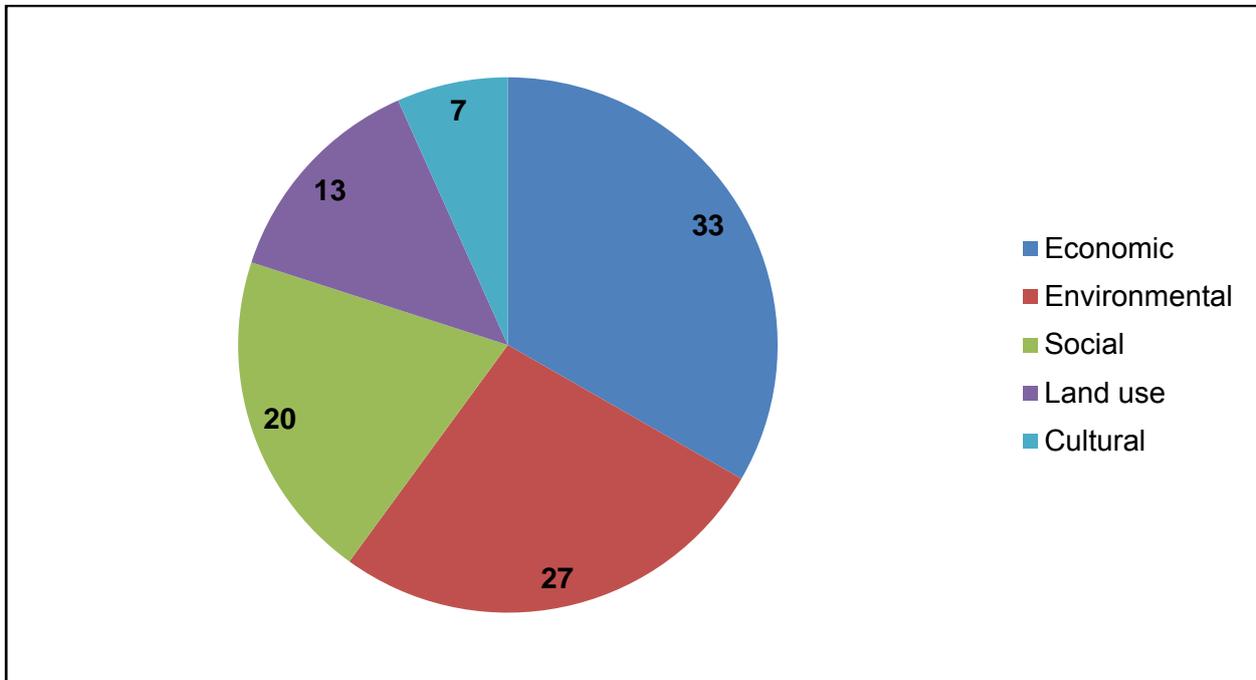


Figure 8: Relative importance of the main categories of goods and services derived from CS 1

Table 5: Major AF goods and services identified during the assessment of case study 1

Main categories	Good and services
Economic goods and services	Diversification of economic/income activities
	Diversification of agricultural/forestry revenues
	Increase in yield/production
	Reclamation of fragile or marginal lands / Rehabilitation/ Restoration
	Reduction in energy and chemical inputs
	Bioenergy production (firewood)
	Energy conservation
	Fodder
	Food production
	Medicinal production
	Timber production
	Nutrition and human health
	Generation for carbon credits
Environmental services	Increase in biodiversity and landscape diversity
	Decrease in wind and water erosion
	Improvement in soil fertility
	Improvement in soil hydrology
	Water treatment and purification; Improved water use / management
	Carbon sequestration and storage (Climate change mitigation); Climate change mitigation (increase in carbon sink)
	Reduction in deforestation and degradation
	Improvement in microclimates
	Climate change adaptation (increased resilience)
	Significant reduction in the application of herbicides/pesticides
Social services	Job creation
	Food security
	Landscape enhancement
	Improvement in public opinion regarding agricultural and forestry activities
	Promotes secure land tenure / land ownership
Land use services	Diversified land uses
	Use of marginal lands (abandoned agricultural land, hill slope plots, etc.)
	Integrated sustainable land use management
	Rehabilitation/restoration of degraded land
Cultural services	Use of local and indigenous (traditional) knowledge

4.3.2.1.2.2 SWOT-AHP Analysis

The respondent was provided with an extensive list of SWOT factors. They were increased agriculture/forestry production (1), increased provision of environmental services (2), diversification of income and risk education (3), and climate change mitigation and adaptation benefits (4). The SWOT factors were ranked against each other and analysed using the AHP method (**Error! Reference source not found.**s 9-12) to identify and assess the key factors to consider in the remaining four D&D stages (diagnostic; design and evaluation; planning; and implementation). Strength 4 (climate change mitigation and adaptation benefits) ranked the highest (66%), followed by increased provision of environmental services (21%), increased agriculture/forestry production (7%) and diversification of income and risk education (5%) (Figure 9).

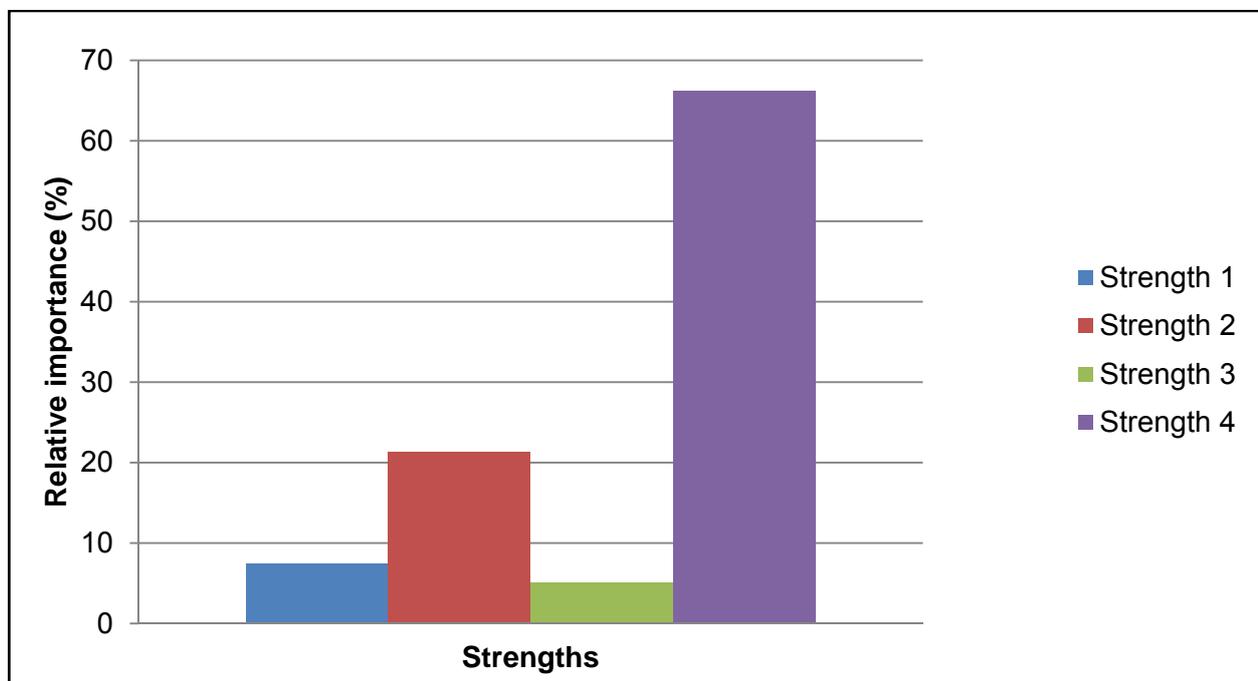


Figure 9: Ranking of the strengths from the assessment of CS 1 (increased agriculture/ forestry production (1), increased provision of environmental services (2), diversification of income and risk education (3), and climate change mitigation and adaptation benefits (4))

The analysis of the weaknesses (Figure 10) indicated that delayed benefits from AF activities (long term investment of about 5 to 7 years) ranked the highest (46%), followed by lack of on the ground technical skills (22%), limited practical knowledge and applied research for addressing issues that affect agroforestry (10%), management of project is remote (8%), skills shortage (7%), lack of

focused and documented research (4%) and lack of national coordination of agroforestry intervention (3%).

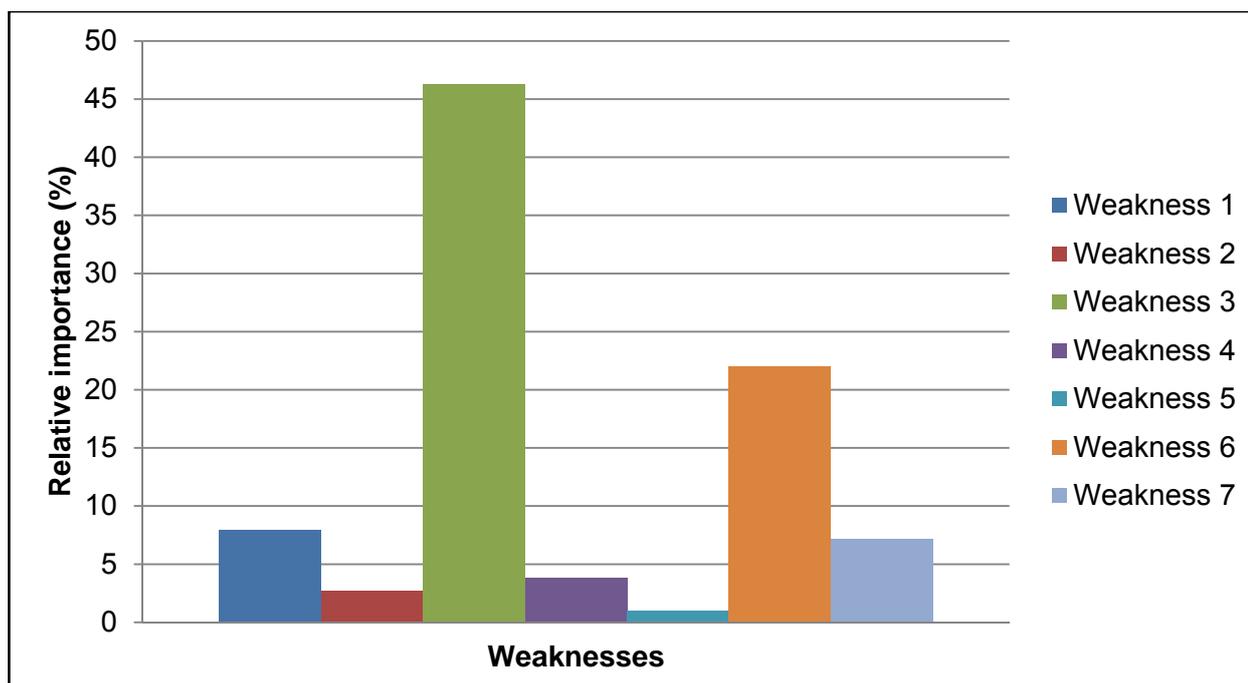


Figure 10: Ranking of the weaknesses identified during the assessment of CS 1 (management of project is remote – people on the ground needed (1), lack of national coordination of agroforestry intervention (2), delayed benefits from AF activities (long term investment of about 5-7 years) (3), lack of focused and documented research (4), limited practical knowledge and applied research for addressing issues that affect agroforestry (5), lack of on the ground technical skills (6), skills shortage (7))

Opportunities consisted of various aspects. Opportunity generation and sale of carbon credits (47%) ranked the highest, followed by global carbon market (and other environmental service markets) (20%), potential government support (16%), increased land value : Preservation of land productivity and restoration of degraded land (10%), co-benefits such as socio-economic (4%) and potential linkages with conservation agriculture and climate smart agriculture (2%) (Figure 11).

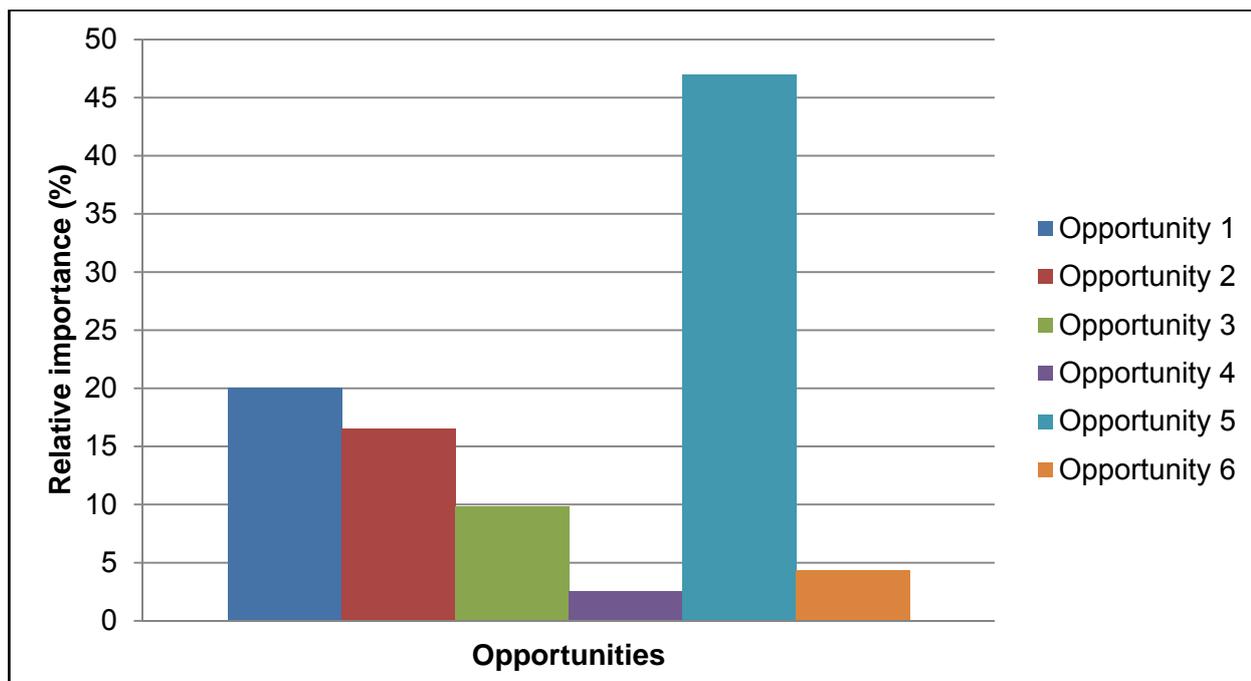


Figure 11: Ranking of the opportunities identified during the assessment of CS 1 (global carbon market (and other environmental service markets) (1), potential government support (2), increased land value (3), potential linkages with conservation agriculture and climate smart agriculture (4), generation and sale of carbon credits (5), co-benefits (socio-economic) (i.e. honey production and tourism - increased wildlife viewing) (6))

A total of five threats were identified and ranked (Figure 12). Threats from highest to least importance were: unpredictability of carbon markets and lack of government legal and institutional framework for carbon markets (57%); lack of markets/incentives for ecosystem services or non-carbon benefits (20%); climate change and climate variability (13%); while maintaining positive image for voluntary carbon credits and no formal government AF policy/programme to support/promote the development and implementation of AF with 5% each.

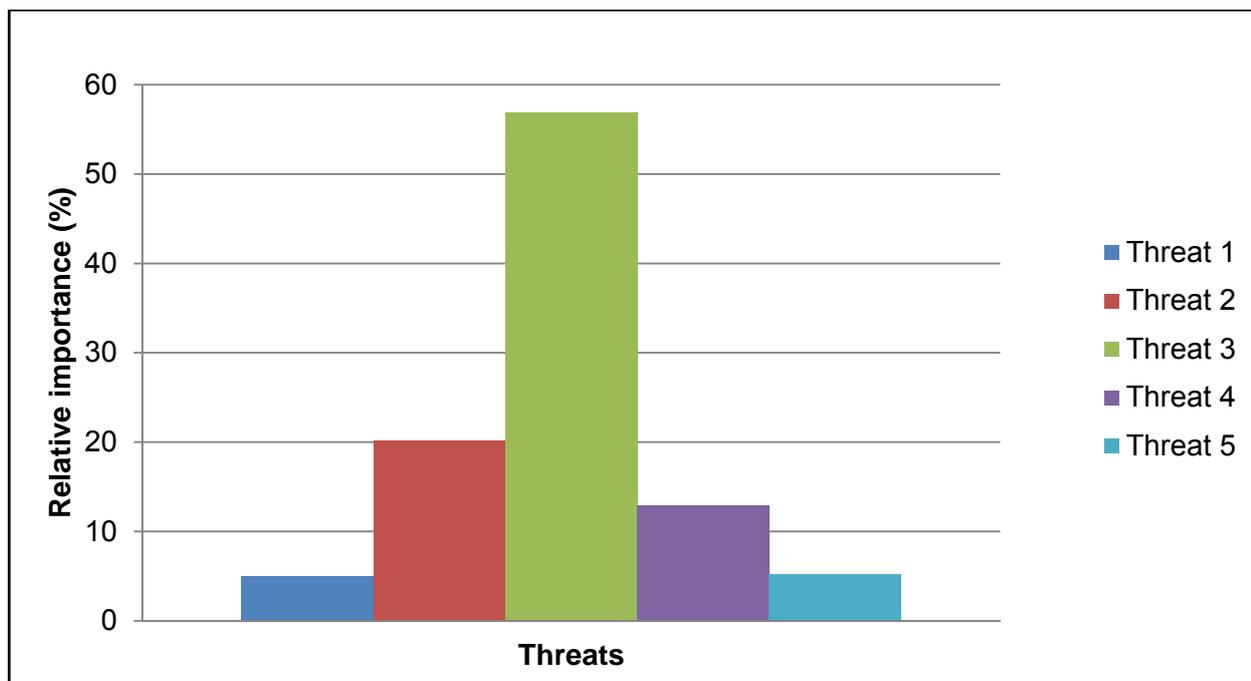


Figure 12: Ranking of the threats identified during the assessment of CS 1 (maintaining positive image for voluntary carbon credits (1), lack of markets/incentives for ecosystem services or non-carbon benefits (2), unpredictability of carbon markets and lack of government legal and institutional framework for carbon markets (3), climate change and climate variability (4), no formal government AF policy/programme to support/promote the development and implementation of AF (5))

In summary, the highest ranking SWOTs within each category for CS 1 are: strength 4 (climate change mitigation and adaptation benefits) at 66%, weakness 3 (delayed benefits from AF activities) at 46%, opportunity 5 (generation and sale of carbon credits) at 47% and threat 3 (unpredictability of carbon markets and lack of government legal and institutional framework for carbon markets) at 57%.

4.3.2.2 Description and Assessment of CS 2: Mposa peanut intercropping project (SAPPI)

4.3.2.2.1 Description of CS2

The project is situated in Mposa/KwaMbonambi in Richards Bay, KwaZulu-Natal (28°38'12.06" S, 32°03'36.89" E) (Figure 13). It comprises of the intercropping of peanuts with plantation trees (*Eucalyptus* clones) for subsistence use (i.e. agrisilviculture) and was initiated during October 2014 (Figure 14). Although the project is still in the early stages, the opportunity exists to be up-scaled to

a commercial venture. The rationale for the project was to assist the neighbouring community with fertile land to produce a subsistence crop and also to foster a healthy relationship with the communities adjacent to the forestry activities. Main management objectives of the project include: maintenance and improvement of the relationship between the timber company and the adjacent communities; reducing the cost of weeding; and to reduce the amount of timber theft in the area, by having “friendly” eyes on the ground. The project area has high humidity and temperature, with no incidence of frost. The area has a mean annual precipitation of 1123mm and an annual mean temperature of 20.4°C (Mucina & Rutherford, 2011). It has approximately 18 000 years old Quaternary sediments of marine origin, yellowish and argillaceous redistributed sands (Berea and Muzi of the Maputaland Group). Soils are nutritionally very poor and well leached (Mucina & Rutherford, 2011). The project area falls within the Maputaland Coastal Belt vegetation unit, which occurs in the Indian Ocean Coastal Belt. The surrounding vegetation is composed of fragmented patches of different forest types, thickets, primary and secondary grasslands, extensive timber plantations and cane fields. The land is privately owned and the project area is approximately 8ha in size (Wilson-Browne, 2015).

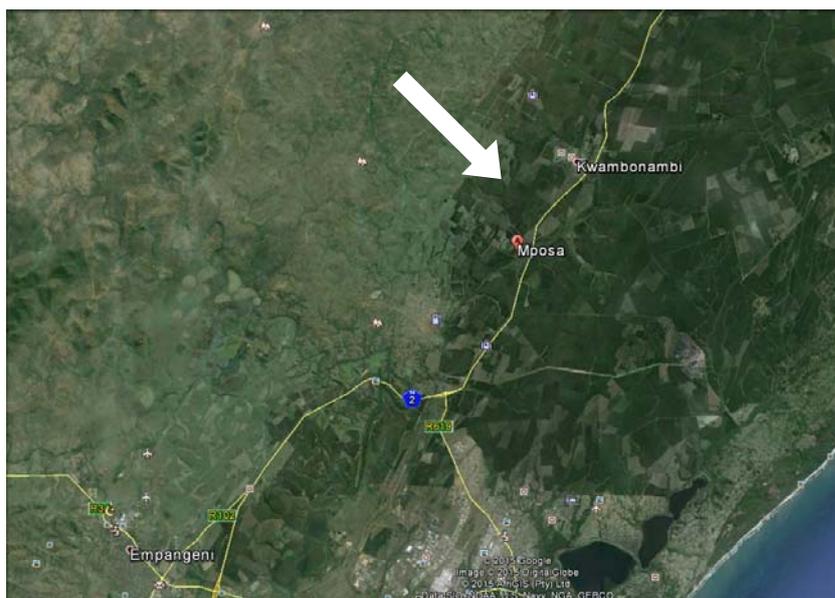


Figure 13: Geographic location of the study area of case study 2 (Google Earth, 2015)



Figure 14: A villager harvesting peanuts, which have been intercropped with *Eucalyptus* clones at the plantation in Mposa, Richards Bay, KwaZulu-Natal

4.3.2.2.2 Assessment of CS 2

4.3.2.2.2.1 Identification and assessment of goods and services

A comprehensive list of the goods and services deriving from this project, based on the perceptions from the respondent, is summarised in Table 6. The project only yielded 15 (45.5%) AF goods and services from the identified 33 across the four case studies investigated. This is the lowest number for the four case studies and might be as this project was the youngest and smallest. The main categories of goods and services were ranked by the respondent and assessed using the AHP method (Figure 15). Social goods and services (33%) ranked the highest, followed by economic (27%), environmental (20%), land use (13%), and cultural (7%).

Table 6: Major AF goods and services for CS2

Main categories	Goods and services
Economic goods and services	Diversification of economic/income activities
	Diversification of agricultural/forestry revenues
	Increase in yield/production
	Reclamation of fragile or marginal lands / Rehabilitation/ Restoration
	Reduction in energy and chemical inputs
	Bioenergy production (firewood)
	Energy conservation
	Fodder
	Food production
	Medicinal production
	Timber production
	Nutrition and human health
	Generation for carbon credits
Environmental services	Increase in biodiversity and landscape diversity
	Decrease in wind and water erosion
	Improvement in soil fertility
	Improvement in soil hydrology
	Water treatment and purification; Improved water use / management
	Carbon sequestration and storage (Climate change mitigation); Climate change mitigation (increase in carbon sink)
	Reduction in deforestation and degradation
	Improvement in microclimates
	Climate change adaptation (increased resilience)
	Significant reduction in the application of herbicides/pesticides
Social services	Job creation
	Food security
	Landscape enhancement
	Improvement in public opinion regarding agricultural and forestry activities
	Promotes secure land tenure / land ownership
Land use services	Diversified land uses
	Use of marginal lands (abandoned agricultural land, hill slope plots, etc.)
	Integrated sustainable land use management
	Rehabilitation/restoration of degraded land
Cultural services	Use of local and indigenous (traditional) knowledge

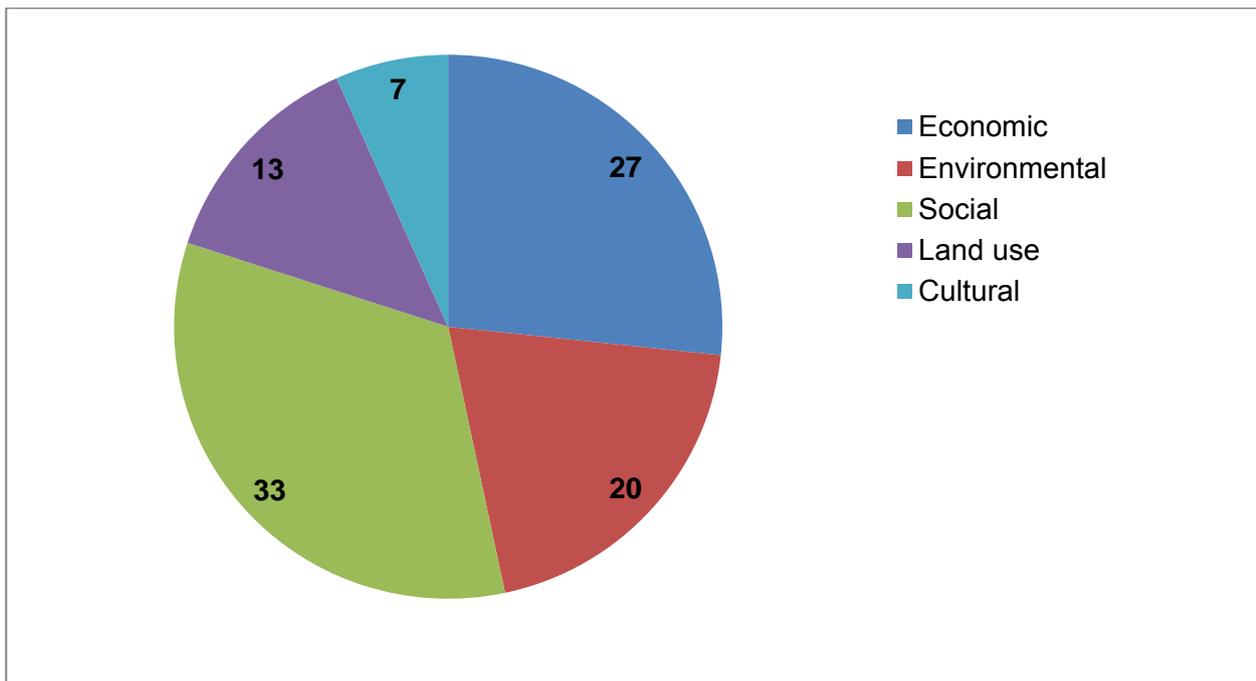


Figure 15: Relative importance of the main categories of goods and services derived from CS 2

4.3.2.2.2 SWOT-AHP analysis

The SWOT factors were analysed and ranked. Strengths were ranked as follows (Figure 16): Decreased operational/input costs at 51%, potential prevention of fires 28%, increased agriculture/forestry production with 13%, while increased provision of environmental services and climate change mitigation and adaptation benefits were both 4%.

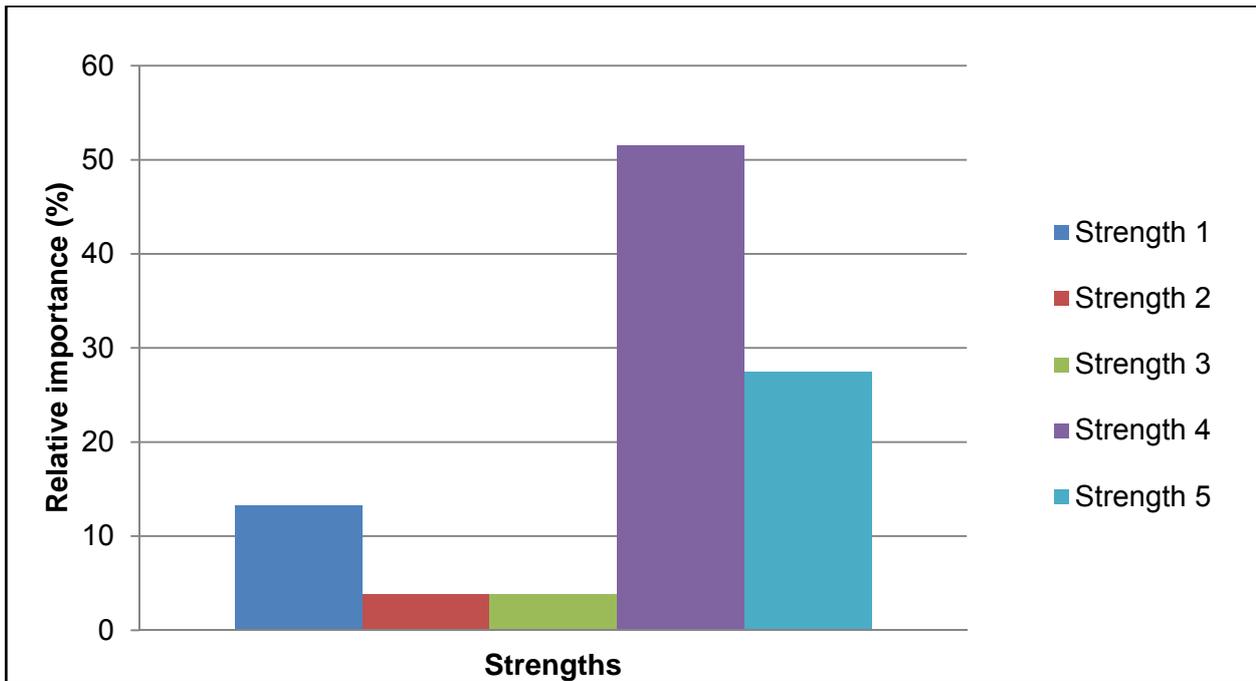


Figure 16: Ranking of the identified strengths from the assessment of CS 2 (increased agriculture/forestry production (1), increased provision of environmental services (2), climate change mitigation and adaptation benefits (3), decreased operational/input costs (i.e. herbicides and direct labour) (4), potential prevention of fires (5))

Weaknesses were ranked as follows: lack of national coordination of agroforestry interventions ranked the highest (38%), followed by limited practical knowledge and applied research for addressing issues that affect agroforestry (30%); skills shortage (15%), lack of monitoring and evaluation of agroforestry efforts (10%); and lack of focused and documented research (7%) (Figure 17).

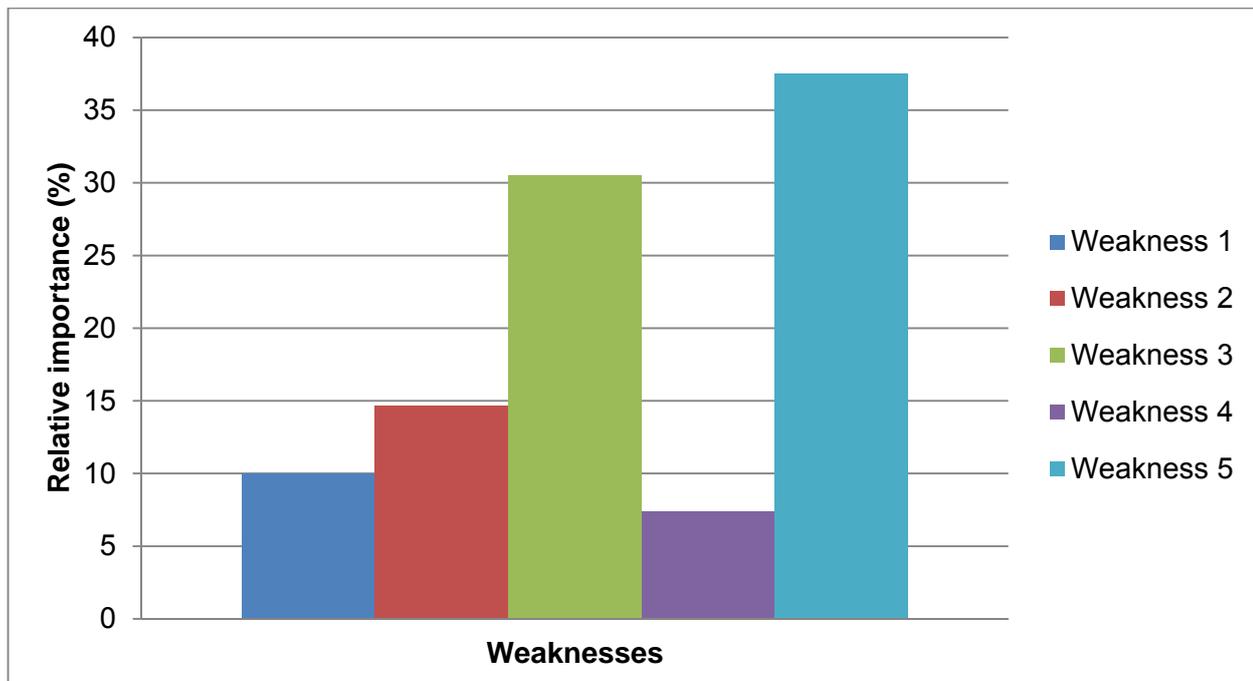


Figure 17: Ranking of the weaknesses identified during the assessment of CS 2 (lack of monitoring and evaluation of agroforestry efforts (1), skills shortage (2), limited practical knowledge and applied research for addressing issues that affect agroforestry (3), lack of focused and documented research (4), lack of national coordination of agroforestry interventions (5))

When comparing the relative rankings of the identified opportunities for CS2 (Figure 18), socio-economic co-benefits and maintaining positive image with neighbouring communities (31%) and collaborated/coordinated research (29%) ranked the highest. These were followed by potential government formal agroforestry policy/programme to promote the development and implementation of agroforestry (20%) and incentives to promote the development and implementation of agroforestry activities (16%). Markets for diverse goods had the lowest relative importance at 4%.

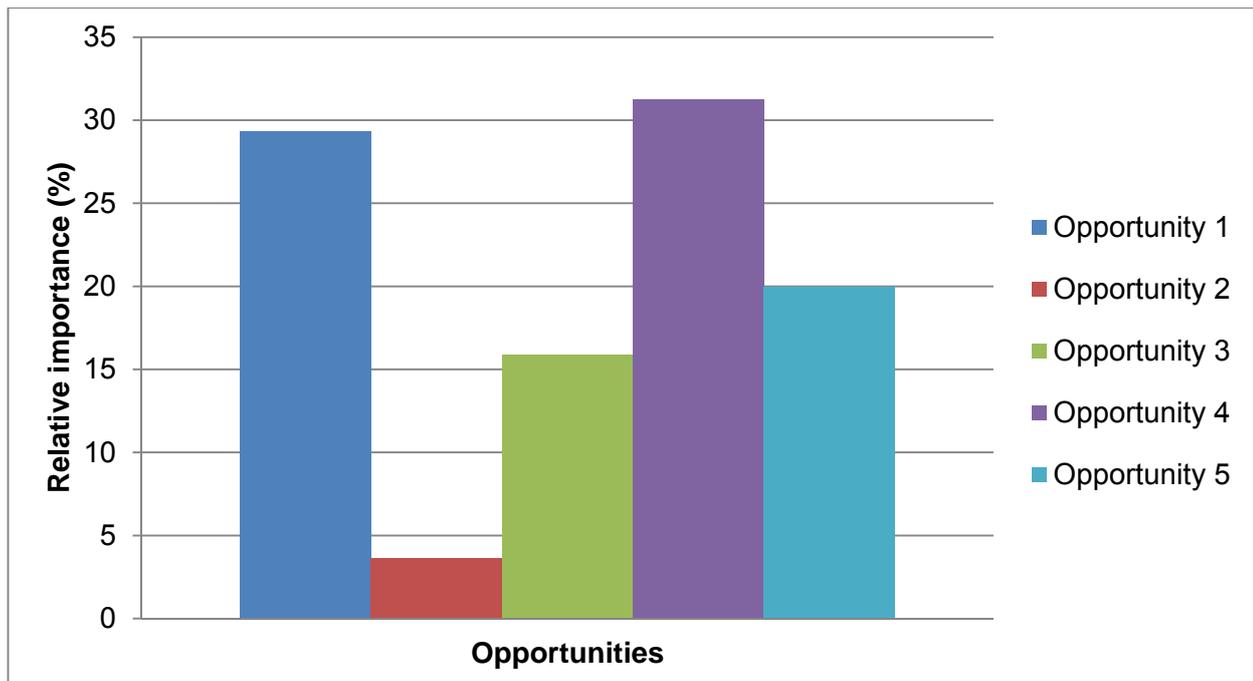


Figure 18: Ranking of the opportunities identified during the assessment of CS 2 (collaborated/coordinated research (1), markets for diverse goods (2), incentives to promote the development and implementation of agroforestry activities (3), socio economic co-benefits and maintaining positive image with neighbouring communities (4), potential government formal agroforestry policy/programme to promote the development and implementation of agroforestry (5))

There were only three threats identified for CS2 (Figure 19), and were ranked as follows: Potential risk of fire, pest and disease, theft, and destruction (69%); lack of markets for agroforestry goods (21%); and climate change & variability (10%).

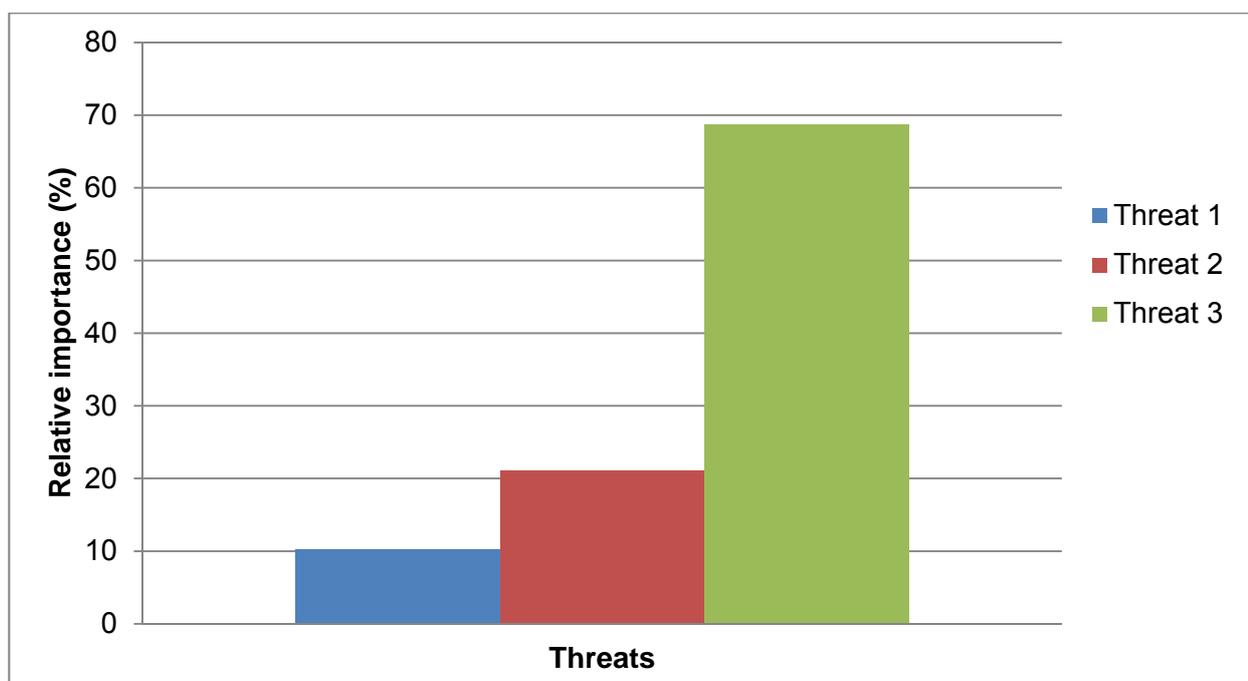


Figure 19: Ranking of the threats identified during the assessment of CS 2 (climate change and climate variability (1), lack of markets for agroforestry goods (2), potential risk of fire, pest and disease, theft, and destruction (3))

The data indicated that the SWOT's ranking the highest for CS2 were strength 4 (decreased operational/input costs) at 51%, weakness 5 (limited practical knowledge and applied research for addressing issues that affect agroforestry) at 38%, opportunity 4 (socio-economic co-benefits and maintaining positive image with neighbouring communities) at 31%, and threat 3 (potential risk of fire, pest and disease, theft, and destruction) at 69%.

4.3.2.3 Description and assessment of CS 4: LMF Cattle farming project

4.3.2.3.1 Description of CS 4

The case study is based on Clifton Farm in the Ermelo area of the Mpumalanga Highveld region (26°28'29.89" S, 30°28'26.07" E) (Figure 20). It is a silvopastoral system integration of timber production (*Pinus patula*) and livestock farming (cattle) on the same land area (Figure 21). The project started in 2005 with five heads of cattle on 3ha. The main idea was to assess its impact and viability over a trial period of four months. Thereafter, the impact and financial possibilities were assessed. The first herd of cattle (40) was later purchased (2007), followed by another 100 in 2008, which grew to a herd of 600 at present. The forestry section of LMF is reasonably small and as a result it is expected that management should find other innovative and diversified ways to generate

funds in an effort to ensure business sustainability. This is done through the diversified production of goods and services on the same land area. Climate is strongly seasonal summer rainfall, with very dry winters, and a mean annual precipitation of 650 to 900mm and a mean annual temperature of 14.4 °C (Mucina & Rutherford, 2011). Red to yellow sandy soils of the Ba and Bb land types are found on shales and sandstones of the Madzaringwe Formation are present (Mucina & Rutherford, 2011). The project is located in the grassland biome in the Mesic Highveld Grassland, more specifically the Eastern Highveld Grassland. The vegetation is short dense grassland dominated by the usual Highveld grass composition with small, scattered rocky outcrops with wiry, sour grasses and some woody species (Mucina & Rutherford, 2011). The land is privately owned with a project extent of approximately 2 500ha.

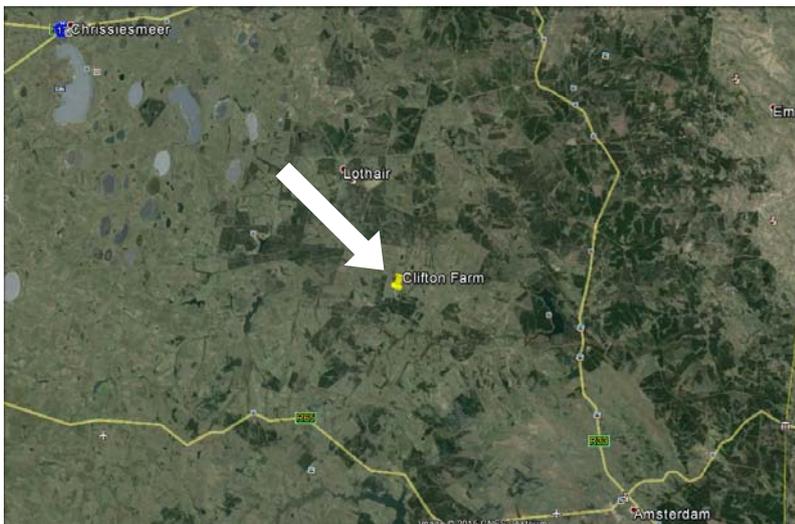


Figure 20: Geographic location of the study area for CS4 (Google Earth, 2015)



Figure 21: Cattle foraging on grass produced in the pine plantation on Clifton Farm in Ermelo, Mpumalanga

4.3.2.3.2 Assessment of CS 4

4.3.2.3.2.1 Identification and assessment of goods and services

The relative importance of the main goods and services categories are shown in Figure 22. This project had the highest goods and services out of the four case studies (Table 7). In total, 29 (87.9%) goods and service out of the potential 33 identified across the four case studies were present in this project. Economics ranked the highest at 33%, followed by environmental (27%), land use (20%), social (13%) and cultural (7%).

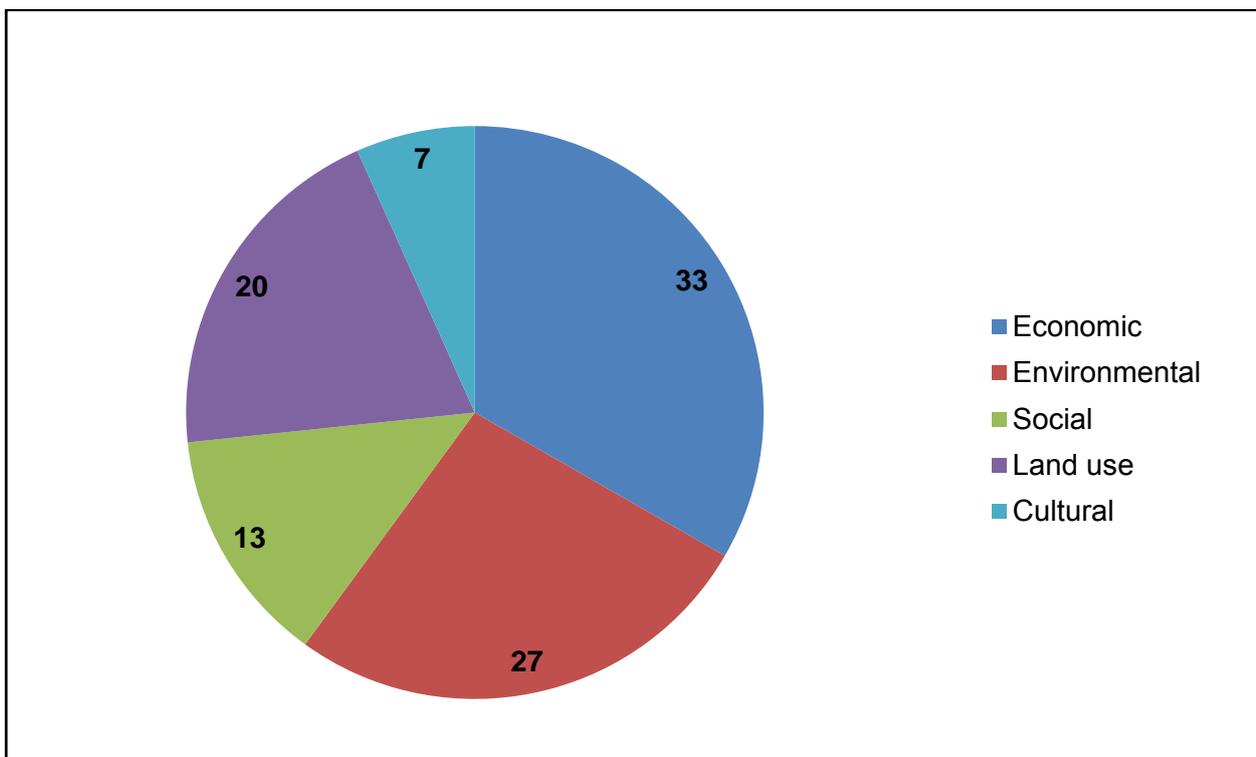


Figure 22: Relative importance of the main categories of goods and services derived from CS 4

Table 7: Major AF goods and services identified for CS 4

Main categories	Goods and services
Economic goods and services	Diversification of economic/income activities
	Diversification of agricultural/forestry revenues
	Increase in yield/production
	Reclamation of fragile or marginal lands / Rehabilitation/ Restoration
	Reduction in energy and chemical inputs
	Bioenergy production (firewood)
	Energy conservation
	Fodder
	Food production
	Medicinal production
	Timber production
	Nutrition and human health
	Generation for carbon credits
Environmental services	Increase in biodiversity and landscape diversity
	Decrease in wind and water erosion
	Improvement in soil fertility
	Improvement in soil hydrology
	Water treatment and purification; Improved water use / management
	Carbon sequestration and storage (Climate change mitigation); Climate change mitigation (increase in carbon sink)
	Reduction in deforestation and degradation
	Improvement in microclimates
	Climate change adaptation (increased resilience)
	Significant reduction in the application of herbicides/pesticides
Social services	Job creation
	Food security
	Landscape enhancement
	Improvement in public opinion regarding agricultural and forestry activities
	Promotes secure land tenure / land ownership
Land use services	Diversified land uses
	Use of marginal lands (abandoned agricultural land, hill slope plots, etc.)
	Integrated sustainable land use management
	Rehabilitation/restoration of degraded land
Cultural services	Use of local and indigenous (traditional) knowledge

4.3.2.3.2.2 SWOT-AHP analysis

The SWOT factors were analysed and ranked. Strengths were ranked as follows: monetary benefits was the highest at 27%; followed by increased agriculture/forestry production and increased provision of environmental services (including increased productivity and restoration of degraded land) both at 25%, diversification of income and risk reduction (14%) and climate change mitigation and adaptation benefits (10%)(Figure 23).

With regards to weaknesses, lack of monitoring and evaluation of agroforestry efforts had the lowest ranking of 14%. This was followed by similar rankings of 29% for limited knowledge, research & expertise formally documented on agroforestry; delayed benefits from AF activities (Long term investment of about 5-7 years); and lack of a national AF research/information sharing network and technical skills was (Figure 24).

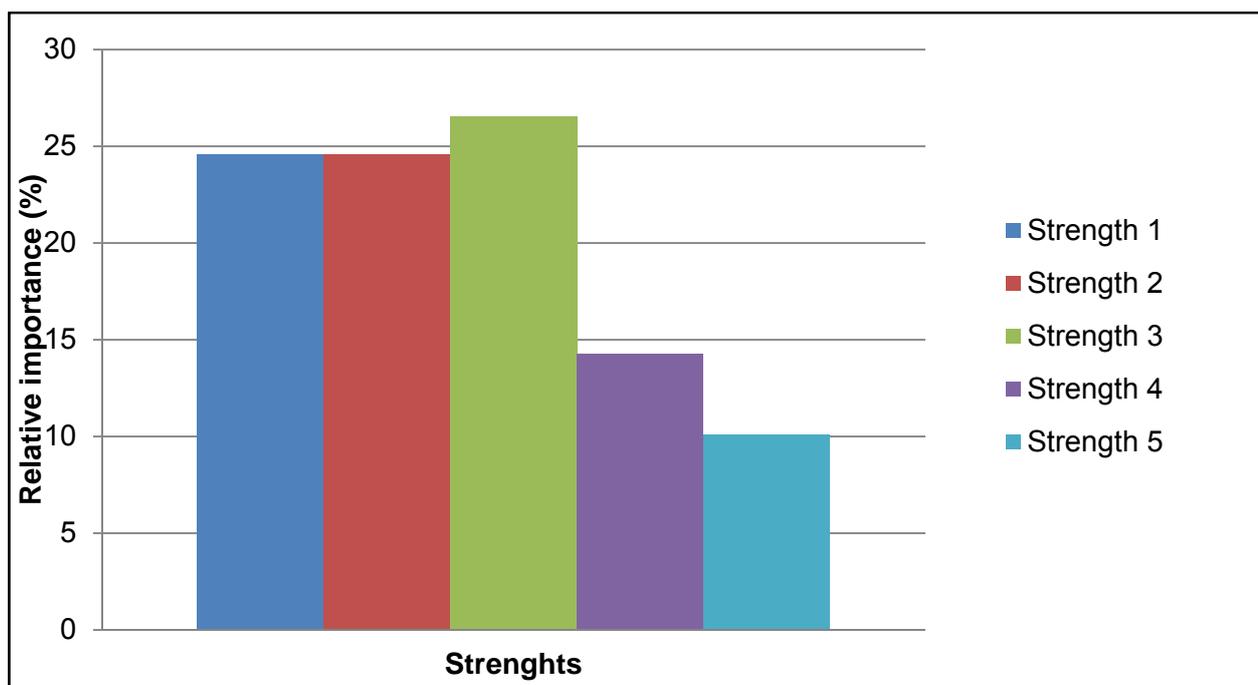


Figure 23: Ranking of the identified strengths from the assessment of CS 4 (increased agriculture/forestry production (1), increased provision of environmental services; productivity; and restoration of degraded land (2), monetary benefits: Increased income from AF adoption (3), diversification of income and risk reduction (4), climate change mitigation and adaptation benefits (5))

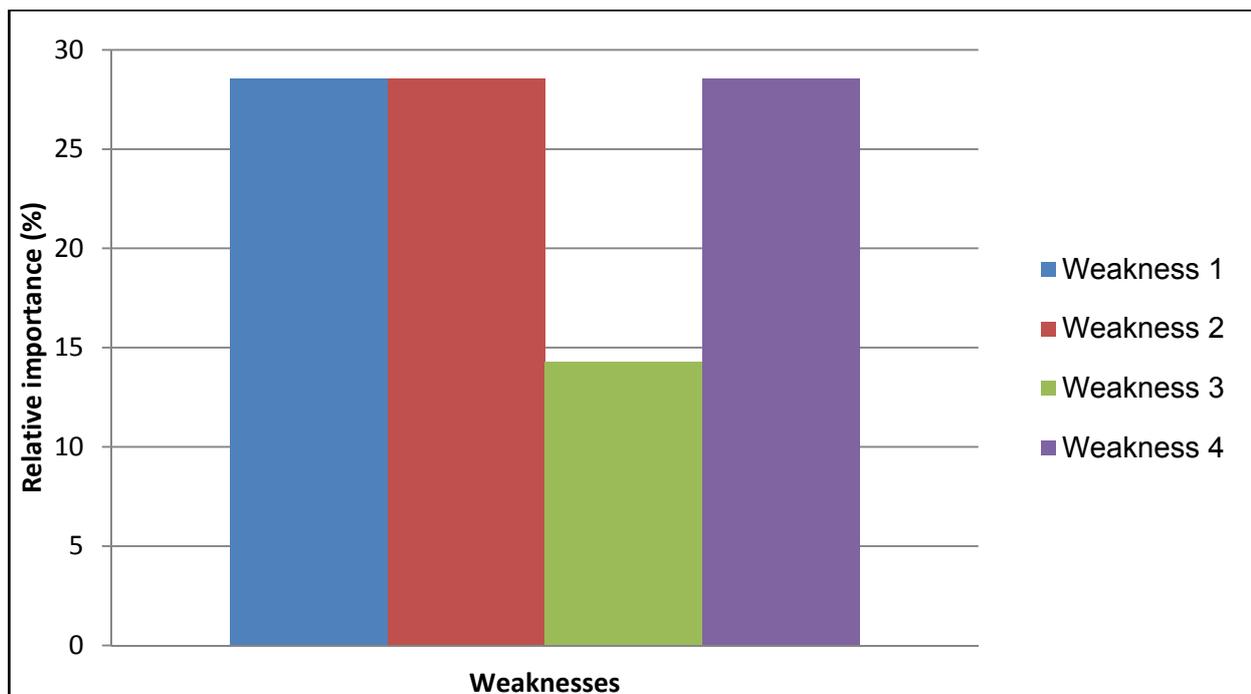


Figure 24: Ranking of the weaknesses identified during the assessment of CS 4 (limited knowledge, research & expertise formally documented on agroforestry (1), delayed benefits from AF activities (Long term investment of about 5-7 years) (2), lack of monitoring and evaluation of agroforestry efforts (3), lack of a national AF research/information sharing network and technical skills (4))

Incentives to promote the development and implementation of AF activities ranked the highest at (36%), followed by a formal potential government AF policy/programme to support/promote the development and implementation of AF (32%), global carbon market (and other environmental service markets) (19%) and potential linkages with conservation agriculture and climate smart agriculture (13%) as illustrated in Figure 25.

Regarding the threats: the potential risks of fire, pest and disease, theft, destruction and insecure land tenure and land reform were ranked the highest at 34% and 30% respectively, followed by climate change and climate variability (15%), lack of incentives for ecosystem services (13%) and unpredictability of carbon markets and lack of government legal and institutional framework for carbon markets and other incentive schemes (8%) (Figure 26).

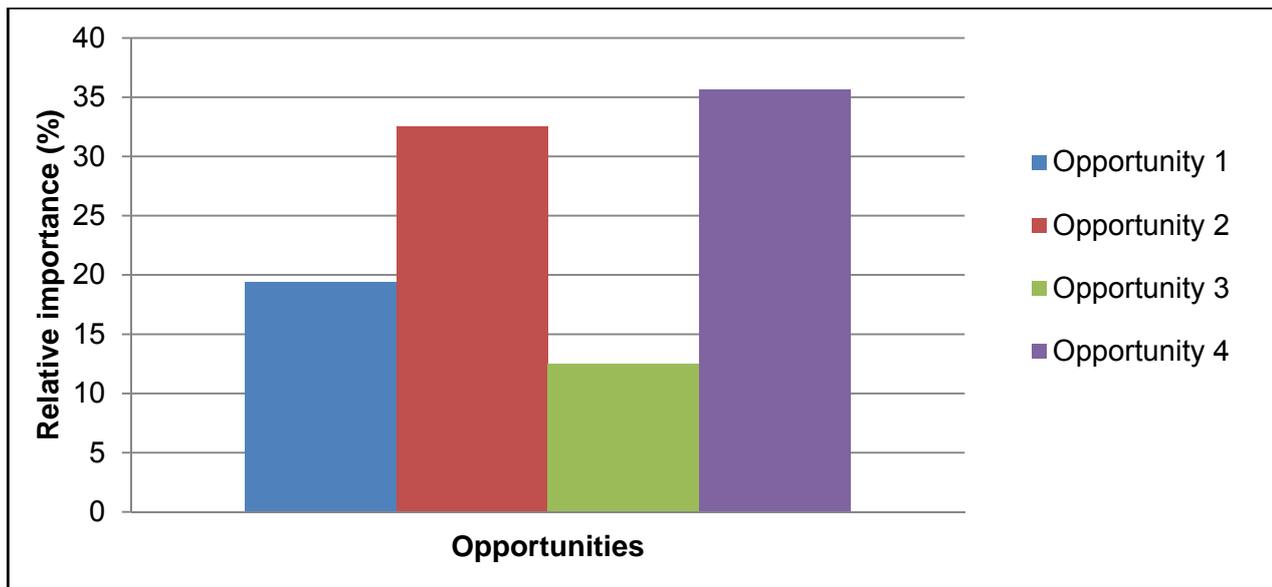


Figure 25: Ranking of the opportunities identified during the assessment of CS 4 (global carbon market (and other environmental service markets) (1), potential government formal AF policy/programme to support/promote the development and implementation of AF (2), potential linkages with conservation agriculture and climate smart agriculture (3), incentives to promote the development and implementation of AF activities (4))

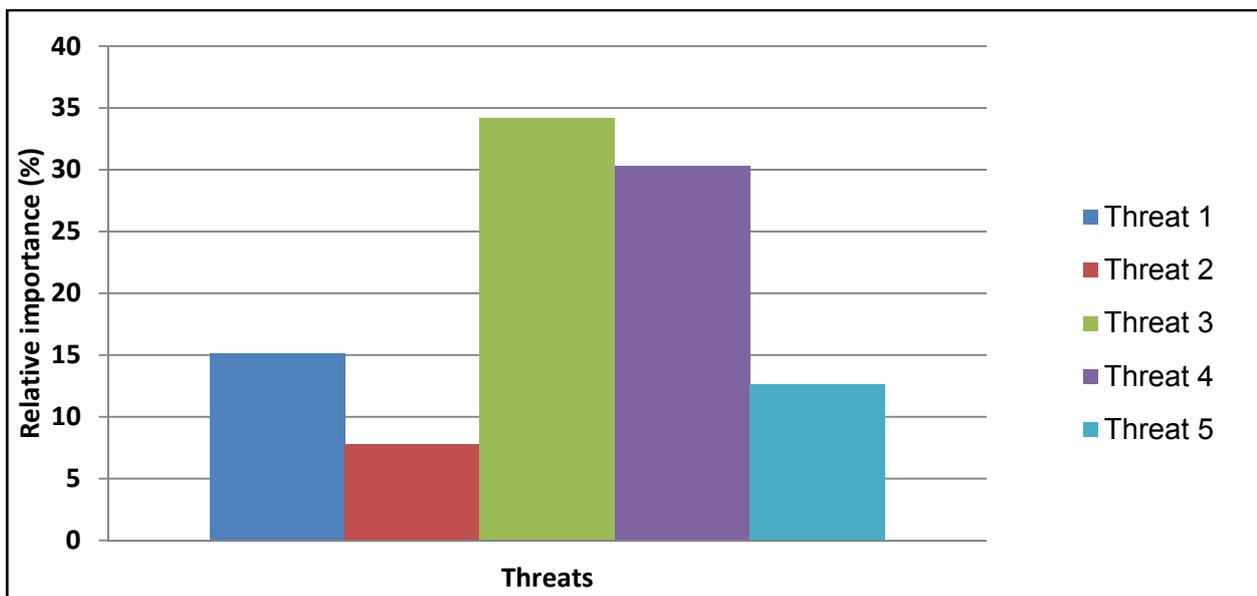


Figure 26: Ranking of the threats identified during the assessment of CS 4 (Climate change and climate variability (1), Unpredictability of carbon markets and lack of government legal and institutional framework for carbon markets and other incentive schemes (2), Potential risks of fire, pest and disease, theft, destruction (3), Insecure land tenure and land reform (4), Lack of incentives for ecosystem services (5))

The SWOT factors that rank the highest for CS5 were Strength 3 (monetary benefits: increased income from AF adoption) 27%, Weakness 1, 2 and 4 (limited knowledge, research & expertise formally documented on agroforestry, delayed benefits from AF activities, and lack of a national AF research/information sharing network and technical skills) each at 29%, Opportunity 4 (incentives to promote the development and implementation of AF activities) 36% and Threat 3 (potential risks of fire, pest and disease, theft, destruction) 34%.

4.3.2.4 Description and Assessment of CS 5: Commercial forestry and community intercropping AF project

4.3.2.4.1 Description of CS 5

The project is in Tzaneen, which is situated in the Limpopo Province (23°46'07.58" S, 30°06'23.75" E) (Figure 27). It is an agrisilviculture system, which involves intercropping of peanuts (*Arachis hypogaea*) and common groundnuts (doemarap) with plantation trees (*Eucalyptus grandis*) (Figure 28). *Eucalyptus* seedlings are intercropped with peanuts about two weeks after establishment. Intercropping is only done within the first two years of establishment of new plantations; thereafter the canopy is too dense for undergrowth. Communities are given authorisation to intercrop planted seedlings with peanuts. This process is mutually beneficial, i.e. the community derives subsistence and economic benefits and the timber company saves money on weeding and reducing fuel loads that is a potential fire hazard. The area receives summer rainfall and has dry winters, with a mean annual precipitation (MAP) of 781mm and mean annual temperature (MAT) of 19.7°C (Mucina and Rutherford, 2011). The geology includes potassium-poor gneisses of the Goudplaats (Swazian Erathem) and an Archaean granite dyke underlies most of the area. Shales and quartzite of the Wolkberg Group are present, but not common. Soils are Mispah, Glenrosa or Hutton forms (Mucina and Rutherford, 2011). The project area is presently commercial plantation, but is found in the Tzaneen Sour Bushveld vegetation type. Land is privately owned and the project area is approximately 100 to 500ha/year (Venter, 2014).

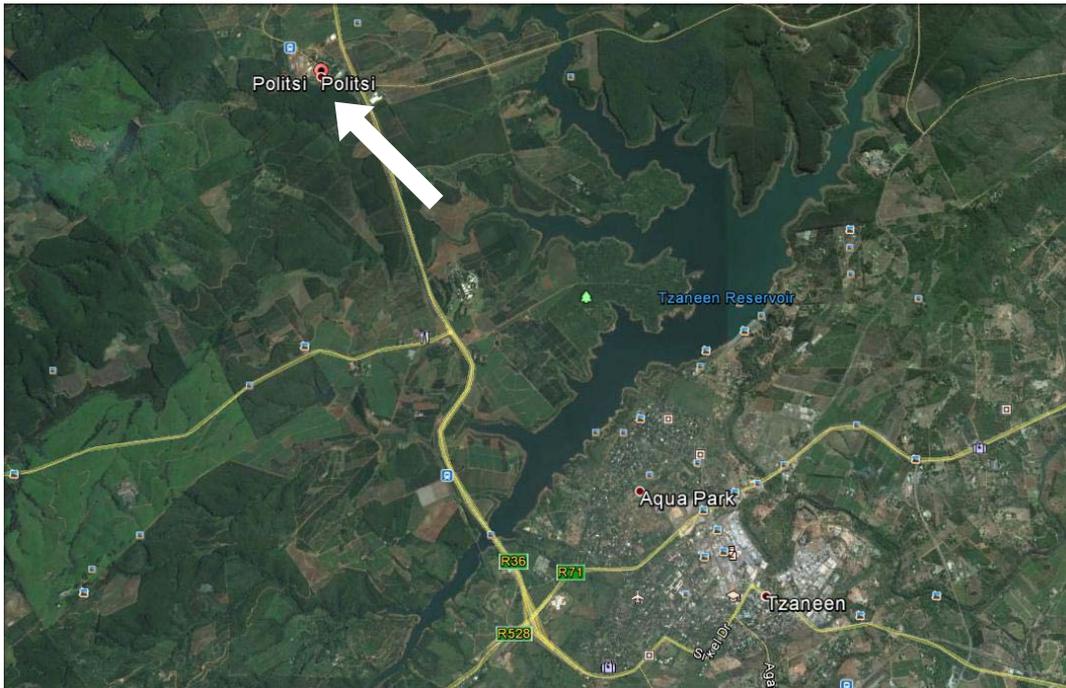


Figure 27: Geographic location of the study area for case study 5 (Google Earth, 2015)



Figure 28: A newly established intercropped site.

4.3.2.4.2 Assessment of CS 5

4.3.2.4.2.1 Identification and assessment of goods and services

A list of the goods and services, derived from the project and based on the perceptions from the respondent, is represented in Table 8. The relative importance of the main goods and services categories are shown in Figure 29. A total of 23 (69.7%), out of the 33 AF goods and services identified across the four case studies, were found in this project. Economic ranked the highest (33%), followed by environmental (27%), social (20%), land use (13%) and cultural (7%) as indicated in Figure 30.

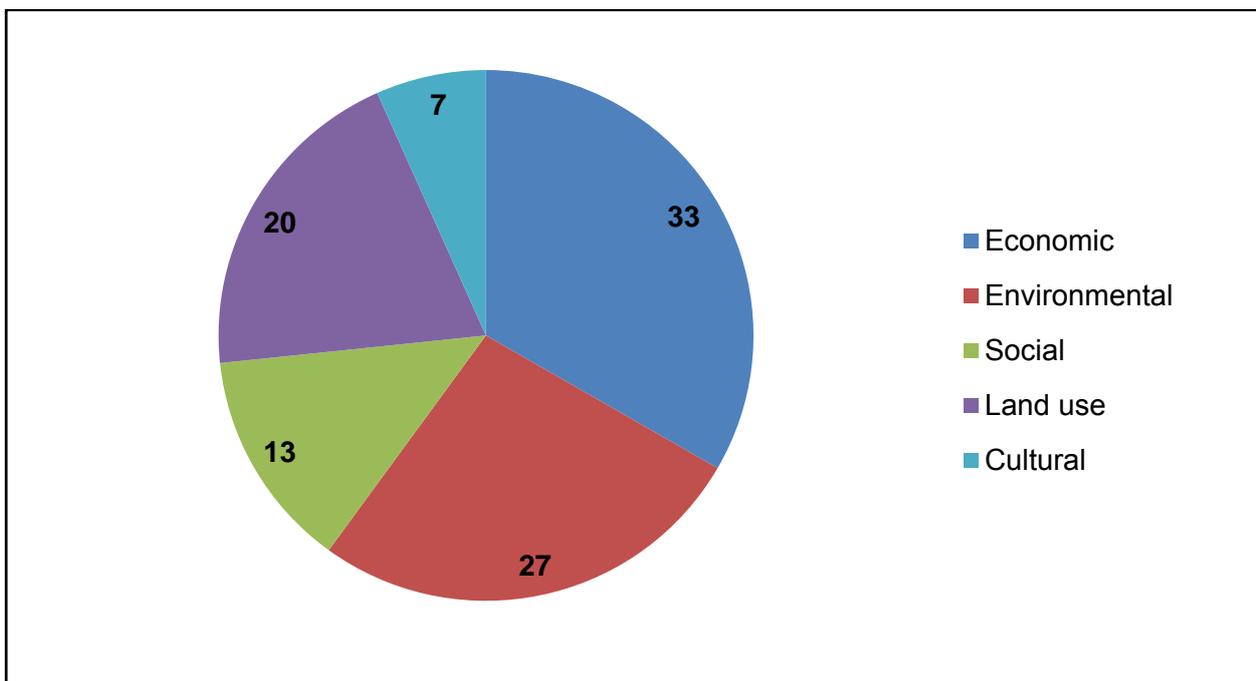


Figure 29: Relative importance of the main categories of goods and services derived from CS 5

Table 8: Major AF goods and services identified for CS 5

Main category	Goods and services
Economic goods and services	Diversification of economic/income activities
	Diversification of agricultural/forestry revenues
	Increase in yield/production
	Reclamation of fragile or marginal lands / Rehabilitation/ Restoration
	Reduction in energy and chemical inputs
	Bioenergy production (firewood)
	Energy conservation
	Fodder
	Food production
	Medicinal production
	Timber production
	Nutrition and human health
	Generation for carbon credits
Environmental services	Increase in biodiversity and landscape diversity
	Decrease in wind and water erosion
	Improvement in soil fertility
	Improvement in soil hydrology
	Water treatment and purification; Improved water use / management
	Carbon sequestration and storage (Climate change mitigation); Climate change mitigation (increase in carbon sink)
	Reduction in deforestation and degradation
	Improvement in microclimates
	Climate change adaptation (increased resilience)
	Significant reduction in the application of herbicides/pesticides
Social services	Job creation
	Food security
	Landscape enhancement
	Improvement in public opinion regarding agricultural and forestry activities
	Promotes secure land tenure / land ownership
Land use services	Diversified land uses
	Use of marginal lands (abandoned agricultural land, hill slope plots, etc.)
	Integrated sustainable land use management
	Rehabilitation/restoration of degraded land
Cultural services	Use of local and indigenous (traditional) knowledge

4.3.2.4.2.2 SWOT-AHP analysis

The SWOT factors were analysed and ranked. The strengths ranked as follows: increased agriculture/forestry production and monetary benefits ranked the highest at 37% each, followed by diversification of income and risk reduction (13%), while increased provision of environmental services and climate change mitigation and adaptation benefits were both 6% (Figure 31). The weaknesses rankings: Competition with other crops ranked the highest at 50%, followed by Limited technical knowledge & expertise and formally documented research on agroforestry and Lack of national coordination of agroforestry interventions (both 14%), Lack of focused and documented research (13%) and Lack of monitoring and evaluation of agroforestry efforts (9%) as indicated by Figure 32.

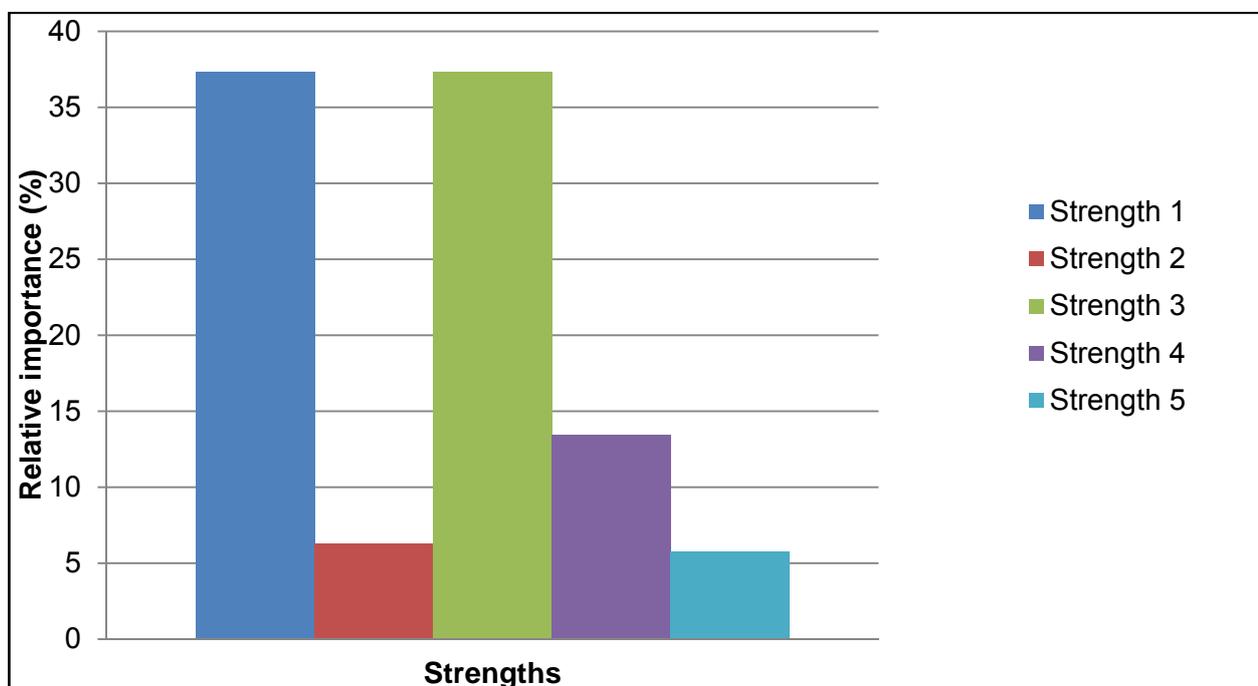


Figure 30: Ranking of the identified strengths from the assessment of CS 5 (increased agriculture/forestry production (1), increased provision of environmental services (2), monetary benefits: increased income from AF adoption (3), diversification of income and risk reduction (4), climate change mitigation and adaptation benefits (5))

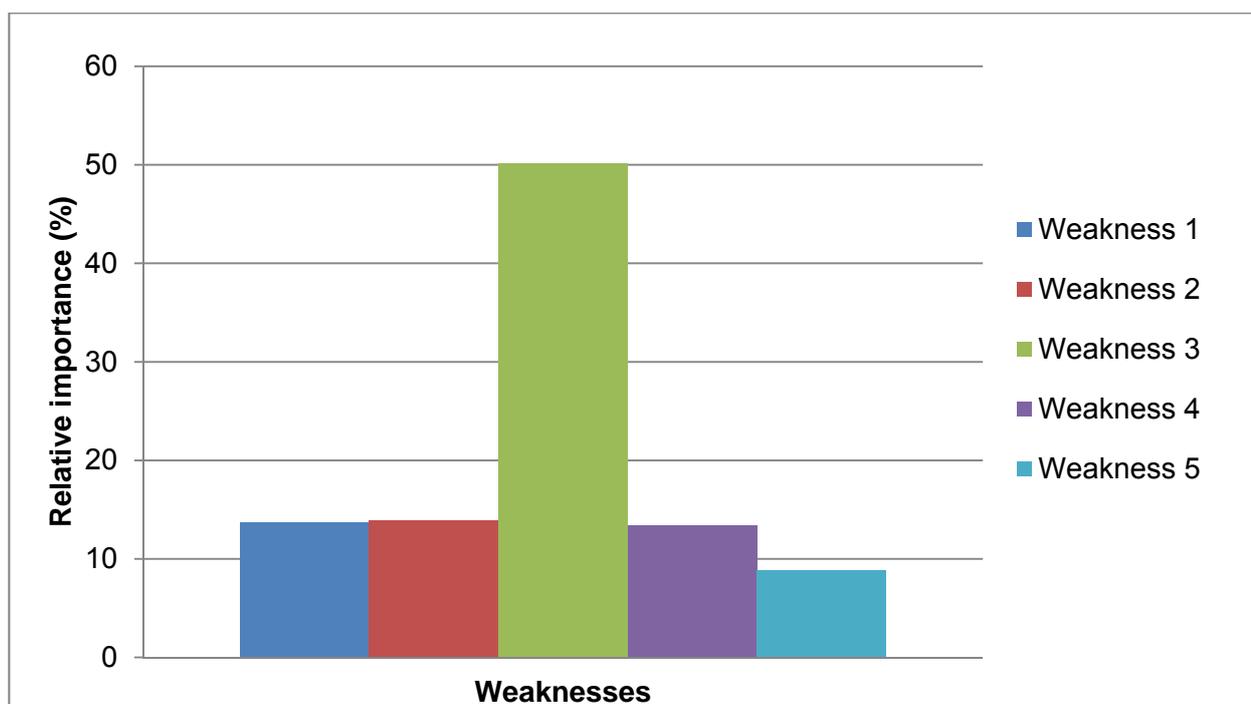


Figure 31: Ranking of the weaknesses identified during the assessment of CS 5 (Limited technical knowledge & expertise and formally documented research on agroforestry (1), Lack of national coordination of agroforestry interventions (2), Competition with other crops (3), Lack of focused and documented research (4), Lack of monitoring and evaluation of agroforestry efforts (5))

The following results were obtained for the opportunities: Markets for diverse goods ranked the highest at 45%, followed by potential government support (27%), potential linkages with conservation agriculture and climate smart agriculture (13%), global carbon market (and other environmental service markets) (9%), and collaborated/coordinated research (7%) as indicated in Figure 32. Threats (Figure 33) differed as potential risks of pest and disease, theft, destruction ranked the highest (49%), followed by insecure land tenure and land reform (25%), lack of a formal government AF policy/programme to support/promote the development and implementation of AF (13%), climate change and climate variability (7%) and lack of incentives for ecosystem services (6%).

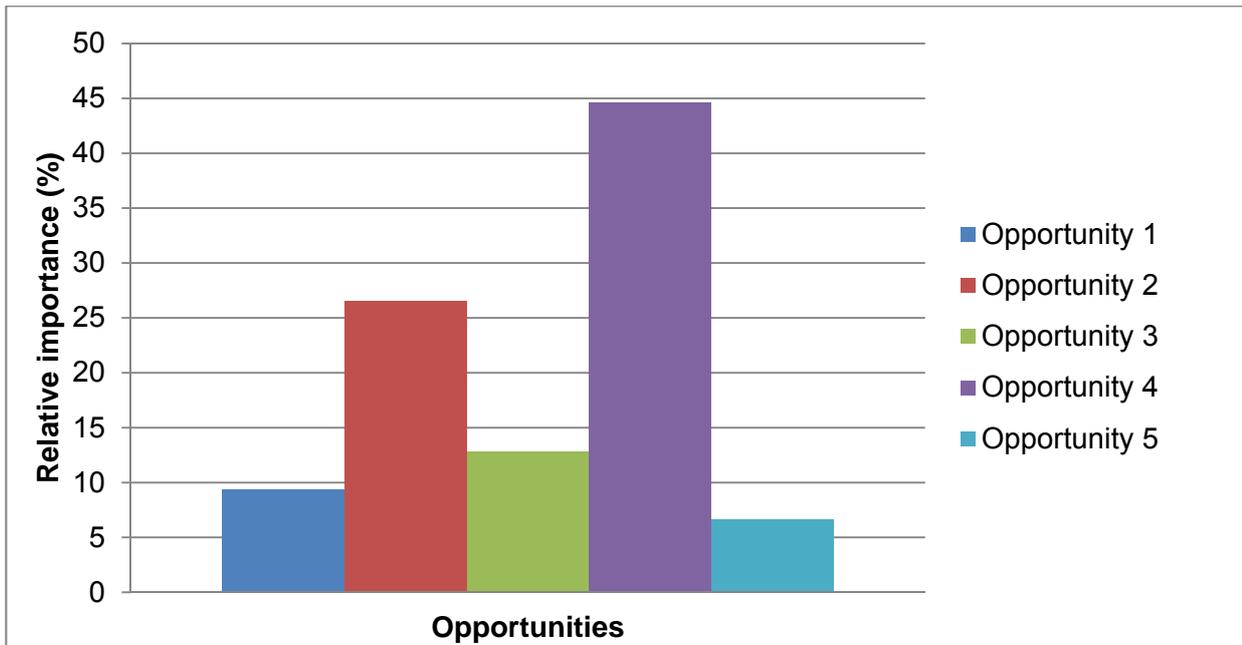


Figure 32: Ranking of the opportunities identified during the assessment of CS 5 (global carbon market (and other environmental service markets) (1), potential government support (2), potential linkages with conservation agriculture and climate smart agriculture (3), markets for diverse goods (4), collaborated/coordinated research (5))

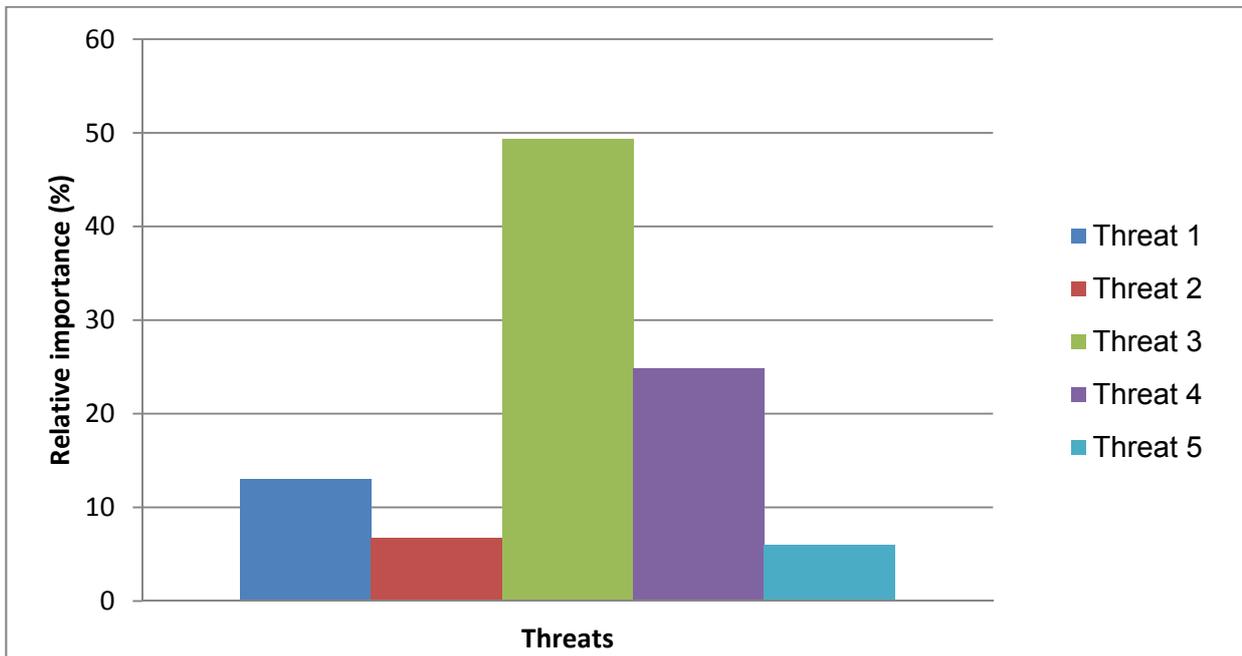


Figure 33: Ranking of the threats identified during the assessment of CS 5 (lack of a formal government AF policy/programme to support/promote the development and implementation of AF (1), climate change and climate variability (2), potential risks of

pest and disease, theft, destruction (3), insecure land tenure and land reform (4), lack of incentives for ecosystem services (5))

The identified SWOT factors that rank the highest were: Strengths 1 and 3 (increased agriculture/forestry production and monetary benefits: increased income from AF adoption) at 37% each; Weakness 3 (competition with other crops) 50%; Opportunity 4 (markets for diverse goods) 45%; and Threat 3 (potential risks of pest and disease, theft, destruction) 49%.

4.4 Cross-Case analysis of the four AF projects

4.4.1 AF goods and services from the projects

Only six of the 33 AF goods and services identified across the four case studies were present in all four case studies (Table 9, Figure 34), resulting in an 18.2% overlap. CS4 had the highest percentage goods and services (87.9%), followed by CS5 (69.7%), CS1 (60.6%) and CS2 (45.5%).

Table 9: Summary of common major direct/indirect goods and services identified across the case studies

Major Categories	Common AF goods and services across the four case studies
Economic goods and services	<ul style="list-style-type: none"> • Increase in yield/production
Environmental services	<ul style="list-style-type: none"> • Improvement in soil fertility • Water treatment and purification; improved water use / management • Climate change adaptation – increased resilience
Social services	<ul style="list-style-type: none"> • Improvement in public opinion regarding agricultural and forestry activities
Land use services	<ul style="list-style-type: none"> • Integrated sustainable land use management

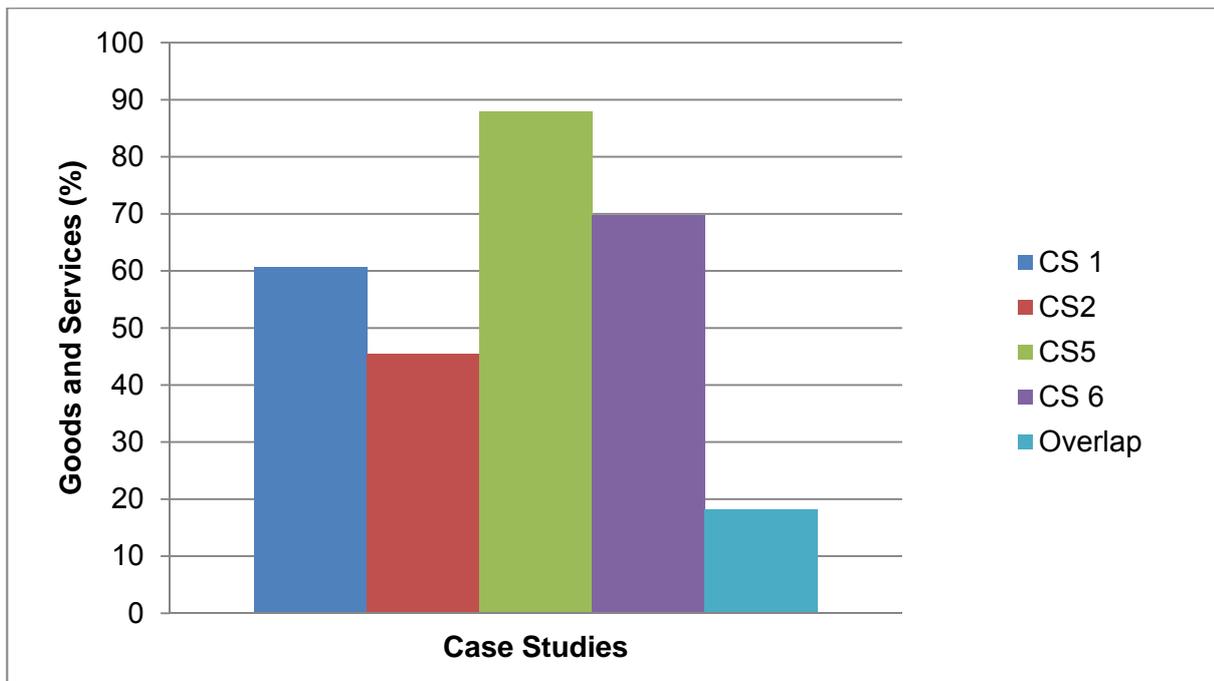


Figure 34: Comparison of AF goods and services from and across case studies relative to total goods and services identified

4.4.2 SWOT-AHP cross-case analysis

The mean for the SWOT factor weights across the four case studies were calculated (Figures 35 to 38). For factors that were absent in one case study, but present in another a zero value was assigned. This was done to assess the D&D of AF systems at the micro-level and also to assess which SWOT's should be prioritised in a national level policy or strategy, if AF development and implementation was to be promoted as a sustainable land management system in SA. The SWOT analysis identified a comprehensive set of main SWOT's that need to be addressed at the micro-level D&D in order to effectively promote the adoption of AF in the country (Table 20). A total number of 7 strengths, 11 weaknesses, 9 opportunities and 7 threats were identified.

Table 20: Summary of the SWOT factors identified by respondents in each SWOT category across the case studies and analysed using the analytic hierarchy process (AHP) method

STRENGTHS	WEAKNESSES
<ul style="list-style-type: none"> • Increased agriculture/forestry production • Increased provision of environmental services • Diversification of income and risk reduction • Climate change mitigation and adaptation benefits • Monetary benefits: Increased income from AF adoption • Decreased operational/input costs (i.e. herbicides and direct labour) • Potential prevention of fires 	<ul style="list-style-type: none"> • Management of project is remote – many people on the ground needed, and increased management costs • Lack of national coordination of AF interventions • Delayed benefits from AF activities (Long term investment of about 5-7 years) • Lack of focused and documented research • Limited practical knowledge and applied research for addressing issues that affect AF • Lack of on the ground technical skills • Skills shortage – management and administration of on the ground operations • Lack of monitoring and evaluation of AF efforts • Lack of on the ground technical skills • Lack of a national AF research/information sharing network and technical skills • Competition with other crops
OPPORTUNITIES	THREATS
<ul style="list-style-type: none"> • Global carbon market (and other environmental service markets) • Potential government formal AF policy/programme to support/promote the development and implementation of AF • Increased land value: Preservation of land productivity and restoration of degraded land • Potential linkages with conservation agriculture and climate smart agriculture • Generation and sale of carbon credits • Co-benefits (socio-economic) (i.e. honey production and tourism - Increased wildlife viewing) • Incentives to promote the development and implementation of AF activities. • Markets for diverse goods • Collaborated/coordinated research 	<ul style="list-style-type: none"> • No formal government AF policy/programme to support/promote the development and implementation of AF • Climate change and climate variability • Unpredictability of carbon markets and lack of government legal and institutional framework for carbon markets • Lack of markets/incentives for ecosystem services or non-carbon benefits • Maintaining positive image for voluntary carbon credits • Potential risks of fire, pest and disease, theft, destruction. • Insecure land tenure and land reform

4.4.2.1 Strengths

The rankings for strengths identified across the AF case studies, are presented in Figure 36. Climate change mitigation and adaptation benefits, as well as increased agriculture/forestry production ranked the highest at 22%. This was followed by: monetary benefits - increased income from AF adoption (16%); increased provision of environmental services (14%); decreased operational/input costs (i.e. herbicides and direct labour) (13%); diversification of income and risk reduction (8%); and potential prevention of fires (7%).

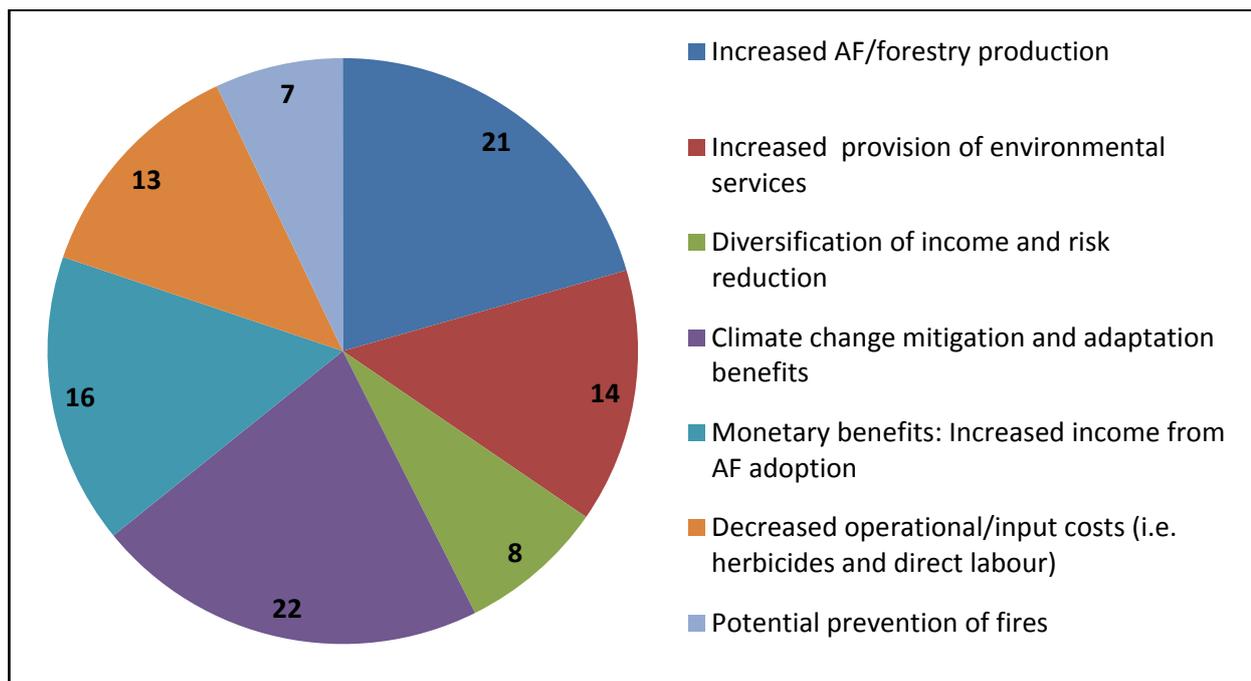


Figure 35: Average relative ranking (%) of strengths across all the case studies

4.4.2.2 Weaknesses

The rankings for weaknesses identified across the four case studies, are presented in **Error! Reference source not found.**³⁷. These in descending order of importance were: delayed benefits from AF activities (long term investment of about 5 to 7 years) at 19%; limited practical knowledge and applied research for addressing issues that affect AF (17%); lack of national coordination of AF intervention (14%); competition with other crops (13%); lack of monitoring and evaluation of AF efforts (12%); the lack of a national AF research/information sharing network and technical skills (7%); and the lack of focused and documented research, skills shortages – management and administration of on the ground operations, and lack of on the ground technical skills (6%).

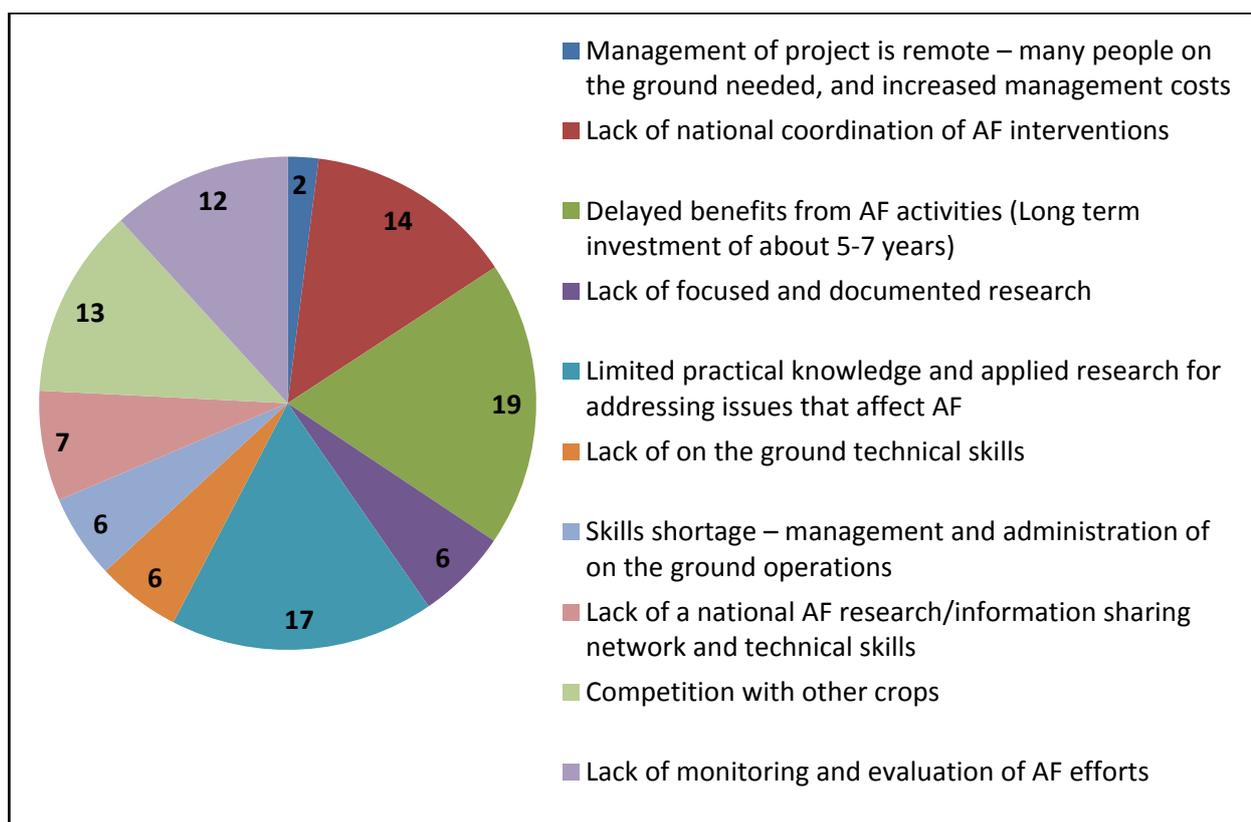


Figure 36: Average relative ranking (%) of weaknesses across all the case studies

4.4.2.3 Opportunities

The rankings for opportunities identified across the four case studies, are presented in Figure 37. The opportunity that came out the highest was the development of a potential government formal AF policy/programme to support/promote the development and implementation of AF in order to upscale AF development and implementation in the country at 24%. The respondents mentioned that this should not be a policy to regulate the sector, but to unlock the potential for AF adoption. It was followed by incentives to promote the development and implementation of AF activities (13%), global carbon market (and other environmental service markets), generation and sale of carbon credits, and the provision of markets for diverse goods (all 12%), collaborated/coordinated research as well as other co-benefits from AF (9%), while potential linkages that AF might have with conservation agriculture and climate smart agriculture at 7%.

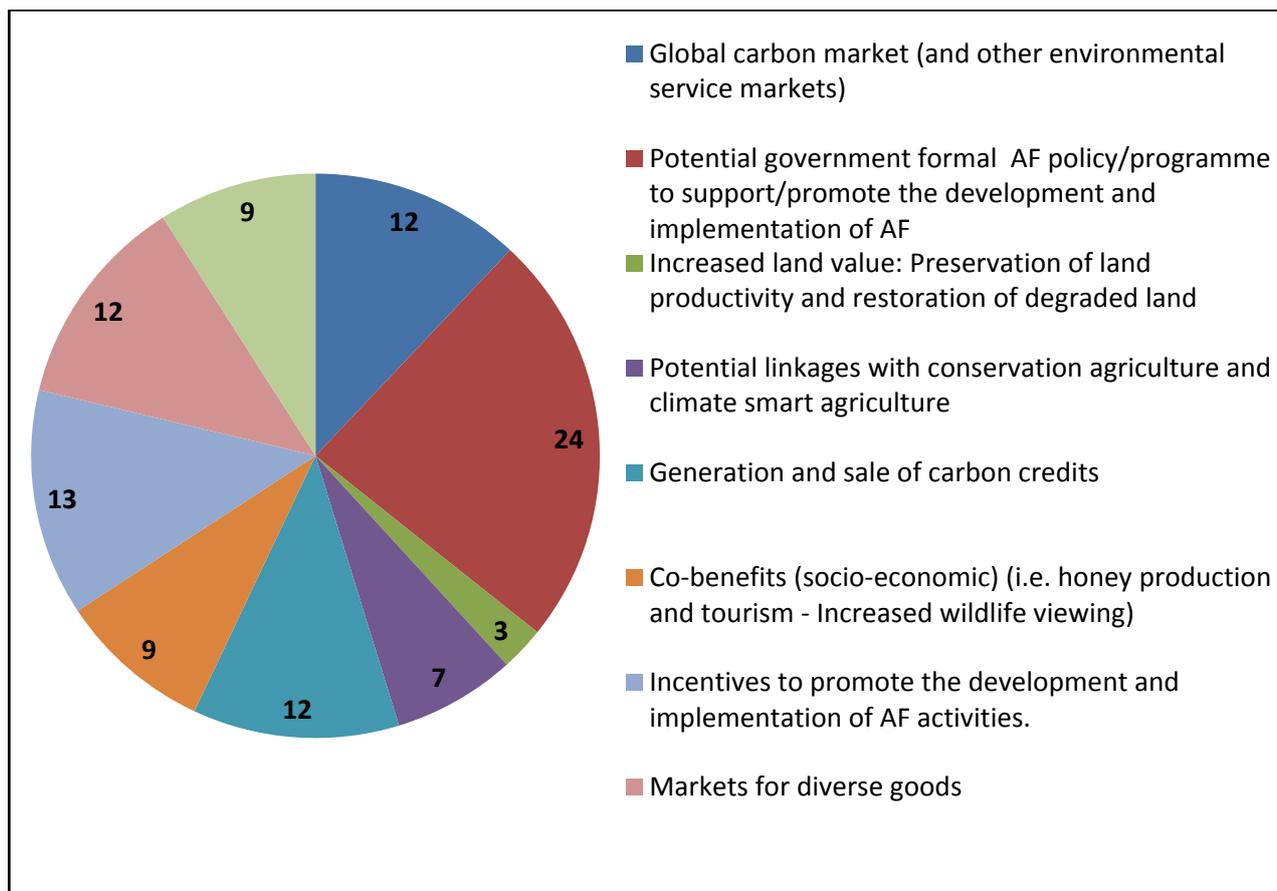


Figure 37: Average relative ranking (%) of opportunities across all the case studies

4.4.2.4 Threats

The rankings for threats identified across the four case studies, are presented Figure 38. Respondents indicated that the potential risks of fire, pest and disease, theft, destruction was the biggest threat at 38%. Although AF is under-developed it was felt that it has the potential to generate carbon credits; therefore, the unpredictability of carbon markets and lack of government legal and institutional framework for carbon markets was ranked the second major threat (16%). The other threats included: the issue of insecure land tenure and land reform (14%), climate change and climate variability (13%); the lack of markets/incentives for ecosystem services or non-carbon benefits (13%); and the fact that currently there is no formal government AF policy/programme to support/promote the development and implementation of AF (5%).

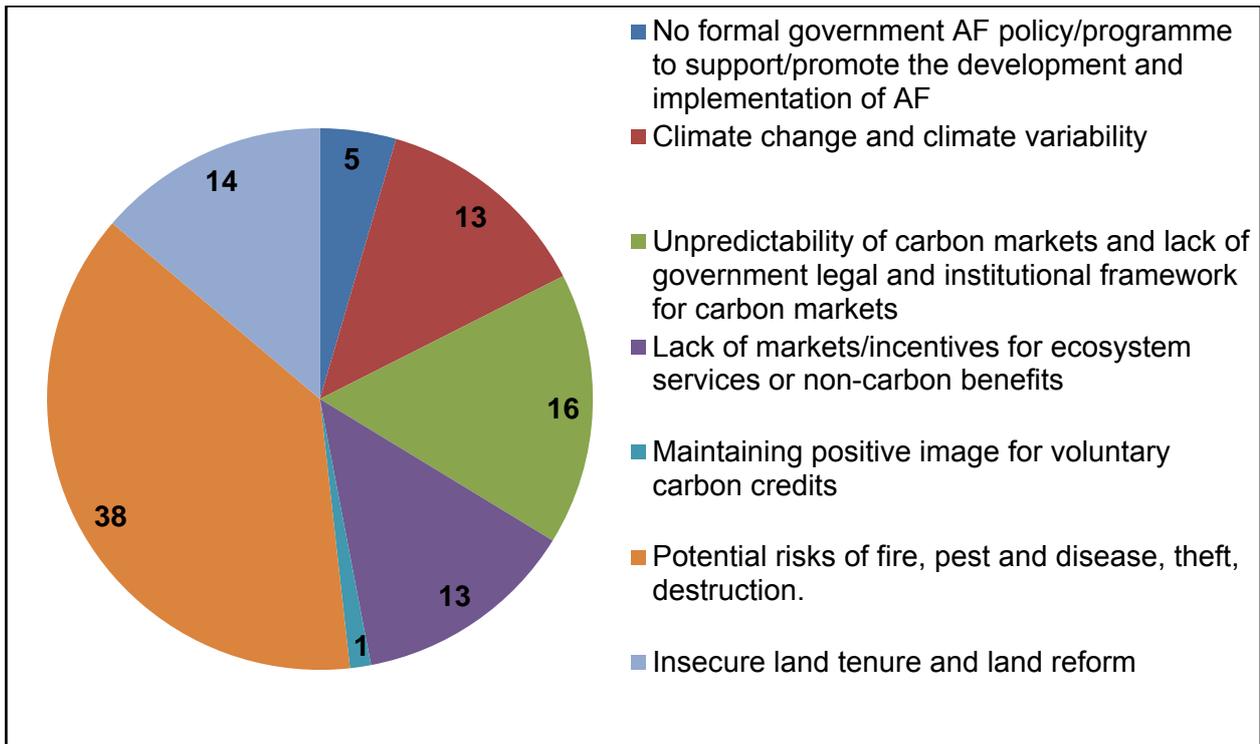


Figure 38: Average relative ranking (%) of threats across all the case studies

In summary, the strengths that rank the highest across the four case studies were climate change mitigation and adaptation benefits, as well as increased agriculture/forestry production (22% each). The weakness was delayed benefits from AF activities (long term investment of about 5 to 7 years) (19%); the opportunity was the development of a potential government formal AF policy/programme to support/promote the development and implementation of AF in order to upscale AF development and implementation in the country (24%). The threat that ranks highest was the potential risks of fire, pest and disease, theft, destruction (38%).

CHAPTER 5: DISCUSSION

5.1 Assessing the status of AF in SA and identifying the barriers

AF is severely under developed and researched in SA (Kelso & Jacobson, 2011; Zerihun *et al.* 2014). Therefore, limited country specific data and information is available on the status and the barriers affecting the development and implementation of AF. The focus was on the major AF systems and practices implemented; description of the main barriers constraining AF adoption and success; categorising the key organisations developing and implementing AF; and to analyse the macro-level D&D of AF. According to Zerihun *et al.* (2014), there has been very little effort to promote AF technologies in South Africa irrespective of their vast potential in the country.

5.1.1 The extent and geographical distribution of AF projects

The study identified seven AF projects in SA. These are projects that have been formally established and that indicated to have a certain level of monitoring (mainly qualitative). They also have yielded multiple goods and services, and successes since implementation and have the potential to be replicated. From the seven projects, six are on-going and one is no longer formally monitored.

The projects with the highest extent are CS1 (silvopastoral restoration of thicket vegetation) on 5 000ha located in the Eastern Cape and CS4 (Lion Match Forestry Cattle Project) on 2 500ha in Mpumalanga. Furthermore, dynamic entrepreneurs or farmers who saw an opportunity and had the budget to initiate the projects might be another reason. Data indicated that projects are located in only six of the nine provinces (Limpopo, KwaZulu-Natal, Eastern Cape, North West, Mpumalanga, and Western Cape). However, there might be a number of projects that were not identified through this project. Although AF is practiced by many smallholder farmers in Sub-Saharan Africa and Africa as a whole (Mbow *et al.*, 2014a), it is still relatively under explored in SA (Zerihun *et al.*, 2014).

5.1.2 The main AF systems and practices being implemented

Based on the survey and case studies it seems that the AF systems implemented around the country include all three major AF systems (agrisilviculture, silvopastoral and agrisilvopastoral) as described by Nair (1993), but at different scales and levels (i.e. commercial and subsistence).

According to Everson *et al.* (2011), silvopastoral AF (plantation trees with livestock) has the most potential in SA but only two of the final four case studies were silvopastoral AF, whereas the other two were agrisilviculture. Therefore, in SA, plantation trees with animals (silvopastoral) and plantation trees with agricultural crops were found to be prevalent. Although there are a number of overlaps and linkages between the different AF systems and practices and their objectives, these systems are area, scale and case specific. Therefore, these systems are not a one size fits all, but should be developed, implemented and adapted on a case-by-case basis (Everson *et al.*, 2011; Newaj *et al.*, 2016) and to suit predominant socio-economic conditions of area or region (Mwase *et al.*, 2015).

5.1.3 The main barriers and issues affecting AF adoption at the national level

Data indicates five broad categories of national level barriers: institutional, technical, economic, policy/governance and social which are confirmed by Rancāne *et al.* (2014), Schwab *et al.* (2015) and Newaj *et al.* (2016). Respondents were mainly concerned about institutional, technical and economic barriers, which include inadequate coordination between stakeholders and extension services; unavailability of relevant country specific information, training and research; lack of sustainable funding, incentives and subsidy programs; and the delayed returns on investment from AF. Research on small-scale farmers in KwaZulu-Natal revealed related AF adoption barriers (Everson *et al.*, 2011). Barriers that were less of an issue, according to the respondents, for the national development and implementation of AF were policy/governance and social barriers, i.e. lack of a formal AF national policy/strategy and lack of interest in AF. Similar barriers affecting the development and implementation of AF are found in most parts of Africa (FAO, 2013b; Johansson, 2015; Mwase *et al.*, 2015) and other developing countries (FAO, 2013b; Catacutan & Naz, 2015; Nawaz *et al.*, 2016). Mbow *et al.* (2014b) indicated that successful AF development and implementation requires an improvement in policy actions; this includes identifying, establishing and developing appropriate institutions, local capacities, technologies, social setting, equity, gender, and governance systems.

In comparison, respondents were in favour of the adoption of AF in SA. When asked about the issues affecting AF implementation, most organisations (61.5%) have a formal mandate to support AF. This provides significant motivation for AF development and implementation from an organisational and institutional level. A number of organisations are already supporting other institutions in the implementation of AF (61.5%) or are directly involved in developing and implementing AF projects, programs and research, which will provide an adequate foundation for

enhancing AF adoption nationally. It is therefore clear that the required institutions and governance (Mbow *et al.*, 2014b) for the development and implementation of AF exists in SA.

A substantial number of organisations (92.3%) realise the value of AF and 84.6% indicated their willingness to participate actively in the development of AF in SA. This data suggests that a number of champions already exist, in taking AF forward and replicating its impacts and benefits. Another important issue that was highlighted by 84.6% of organisations interviewed is that AF does have climate change mitigation and adaptation benefits. Currently, there is a great deal of work and support for climate change mitigation and adaptation both globally and nationally. Therefore, if the carbon sequestration potential and other ecosystem services can be quantified, it can serve as additional revenue streams. Newaj *et al.* (2016) highlights that AF addresses climate change adaptation (by enhancing resilience to cope with the adverse impacts of climate change) and mitigation (through carbon sequestration).

5.1.4 The key organisations involved in AF and its institutional mandate

The study identified 13 organisations already involved in the development and implementation of AF in SA. These organisations fall within all of the selected stakeholder categories (implementers, developers and regulators) as well as the different levels of interaction (primary, secondary and tertiary) and most are cross-cutting. Data indicated that 13 key organisations function at three broad levels (national, provincial, and municipal/local). The data indicates that buy-in, support and interest in AF already exist. However, effective coordination and collaboration of AF among policy makers or government (regulators/developers), researchers (developers/implementers) and extension providers and practitioners (implementers) is required to ensure the increased adoption and success of AF (Mwase *et al.*, 2015). Many countries consider AF as the responsibility of all sectors, but in reality it falls between the agriculture, forestry and environment departments, with no institution taking a lead role (FAO, 2013b).

Currently in SA, it is unclear which organisation is driving the mandate of developing and implementing AF. The White Paper on Sustainable Forest Development (DWAF, 1997) does to some extent put the responsibility with the Department of Agriculture, Forestry and Fisheries (DAFF), but only as a sub-component of community forestry. Most of the respondents interviewed (46.2%) indicated that the institutional mandate should sit with DAFF. According to Zerihun *et al.* (2014), DAFF should mainly aid AF practitioners with innovative science and information on AF systems and practices; and the facilitation of credit services, grants and incentive schemes. Finally,

the effective development and implementation of AF policies and programmes require a multi-stakeholder approach between government departments in charge of rural development, land use, agriculture, forestry, environment, finance and commerce, at both national and local level (FAO, 2013b). In India the mandate of AF is with the Ministry of Agriculture and through their National Agroforestry Policy of 2014, AF is mainstreamed to meet developmental and environmental goals (Newaj et al., 2016).

5.2 Assessment of the AF Case studies

5.2.1 Assessing the multiple goods and services from AF systems

Results indicated that AF is under explored, established and researched in SA. This is supported by Zerihun *et al.* (2014) in his study of AF in SA. However, there are multiple goods and services that are derived from the development and implementation thereof (Nair, 1993; Gold and Garrett, 2009; Kalaba *et al.*, 2010; Leakey, 2010; Alao & Shuaibu, 2013; Zerihun *et al.*, 2014). This study also demonstrated benefits such as increase in yield/production, improvement in soil fertility, and water treatment and purification, which can be derived from the development and implementation of AF. These derived goods and services are multiple in nature and cut across the five main categories (economic, environmental, social, land use and cultural). Results showed that AF improves food security (social), incomes (economic), increases climate resilience and reduces environmental degradation (environmental) (Wilson & Lovell, 2016; Ofori *et al.*, 2014). AF based systems yield higher benefits than a conventional mono-cropping (agricultural/forestry) system (Cardinael *et al.*, 2012; Alao & Shuaibu, 2013). A total amount of 33 goods and services were identified across the four case studies assessed.

The study indicated that the benefits derived from AF are project specific and depend on a number of factors, such as type of AF system or practice, project objectives and also the area. This is demonstrated by only 18.2% (six out of 33) of the identified total goods and services which are common to the four projects. A study by Kelso & Jacobson (2011) in SA also revealed this, where eight different AF practices each had their own specific benefits associated with them. Furthermore, Everson *et al.* (2011) highlights that although the benefits of AF are well known, certain elements of the systems and practices have to be modified in order to suit the areas where they are developed and implemented.

5.2.2 SWOT-AHP analysis of the case studies

A number of SWOT analyses have been performed across the case studies. A similar approach was taken by several studies (Suh & Emtage, 2005; Srinidhi *et al.*, 2007; Stainback *et al.*, 2012; Margles *et al.*, 2013) to identify SWOT's pertaining to AF and land use. These SWOT's were ranked using the AHP method, to determine the main factors impacting the AF projects and the top two were selected as priorities (Table 31). These top ranking factors correspond to SWOT's identified in a similar study conducted on AF in Rwanda (Stainback *et al.*, 2012). The results from the SWOT analysis indicated that the implementers view AF systems as a suitable approach for foresters and farmers, but with caveats and uncertainties. These SWOT's could be effectively addressed through a conducive policy and institutional environment (FAO, 2013a).

Table 31: Top ranking SWOT factors across the CS

SWOT Category	Top two ranking SWOT's
Strengths	1. Climate change mitigation and adaptation benefits derived from AF
	2. Increased agriculture/forestry production from AF
Weaknesses	1. Delayed benefits from AF activities
	2. Limited practical knowledge and applied research for addressing issues that affect AF
Opportunities	1. The development of a potential government formal AF policy/programme to support/promote the development and implementation of AF in order to upscale AF development and implementation in the country
	2. Incentives to promote the development and implementation of AF activities
Threats	1. The potential risks of fire, pest and disease, theft, destruction to AF activities
	2. The unpredictability of carbon markets and lack of government legal and institutional framework for carbon markets

According to Kelso & Jacobson (2011), community based natural resource management interventions, such as AF, are impossible to develop, implement and maintain without any policy or strategy. In India for instance the government developed a National Agroforestry Policy in 2014 to enhance strengths, address weakness, unlock opportunities and reduce threats and risks to AF

(Government of India. 2014). It would be an advantageous intervention for SA to also consider the development of a formal policy or strategy that promotes the development, implementation and sustainability of AF. Any policy that is developed should not over regulate or prevent the integration of trees, agricultural crops and livestock (Mbow *et al.*, 2014b).

5.2.3 Assessing the D&D of the AF case studies

The last objective of this study was to assess the micro-level D&D of the four AF case studies (CS1, 2, 5 and 6), by applying the three basic stages developed by Raintree (1986). In this study only the first three stages (pre-diagnostic, diagnostic and design & evaluation) were assessed (Table 42). This basic assessment can assist in future AF development and implementation in SA. It is similar to the D&D approach applied by Atangana *et al.* (2013b).

Table 42: D&D of the AF CS investigated during this study

D&D Stages with Basic questions	Questions	Assessment Results
Pre-diagnostic	Definition of the land use systems and the sites selection	<ul style="list-style-type: none"> The assessed land use systems are all AF systems/practices, which includes two agrisilviculture and two silvopastoral systems These systems are located in four provinces of SA, i.e. Limpopo, Mpumalanga, KwaZulu-Natal and Eastern Cape
	How do the systems work?	<ul style="list-style-type: none"> CS1 entails the silvopastoral restoration of Spekboom thicket which has been degraded by overgrazing. Restoration is financed by the sale of carbon credits generated. CS2 is peanut intercropping with plantation trees (<i>Eucalyptus</i> clones) for subsistence (Agrisilviculture) CS4 is a silvopastoral system, which integrates forestry with livestock farming CS5 - <i>Eucalyptus</i> seedlings are intercropped with peanuts about two weeks after establishment. Intercropping is only done within the first two years of establishment of new plantations
Diagnostic	How well do the systems work? (what are the weaknesses and threats)	<ul style="list-style-type: none"> Lack of national coordination of AF interventions Delayed benefits from AF activities (long term investment of about 5-7 years) Lack of focused and documented research Limited practical knowledge and applied research for addressing issues that affect AF Lack of on the ground technical skills Skills shortage – management and administration of on the ground operations Lack of monitoring and evaluation of AF efforts Lack of on the ground technical skills Lack of a national AF research/information sharing network and technical skills Competition with other crops
		<ul style="list-style-type: none"> No formal government AF policy/programme to support/promote the development and implementation of AF Climate change and climate variability Unpredictability of carbon markets and lack of government legal and institutional framework for carbon markets Lack of markets/incentives for ecosystem services or non-carbon benefits Maintaining positive image for voluntary carbon credits Potential risks of fire, pest and disease, theft, destruction. Insecure land tenure and land reform

D&D Stages with Basic questions	Questions	Assessment Results
Design & Evaluation	How to or what is needed to improve the systems? (Interventions)	<p>Results from the study show that the following are required to increase the success and adoption of AF in SA:</p> <ul style="list-style-type: none"> • More scientific research on AF systems • Better coordination and collaboration • The development of a policy or strategy that promotes and doesn't hinder the development, adoption and implementation of AF • Secure global carbon markets (and other environmental service markets) • Identifying the linkages of AF with conservation agriculture and climate smart agriculture • Quantifying and selling of carbon credits from AF activities • More emphasis on the other socio-economic related benefits (i.e. honey production and tourism - Increased wildlife viewing) • The provision of incentives/subsidies to promote the development and implementation of AF activities. • Establishing markets for the diverse goods and services derived from AF

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

AF is not a very well established and formally researched system in SA. There are limited published studies that have been conducted to assess the D&D of AF, and few that consider AF at the institutional level. This study was conducted to provide more information and data on AF development and implementation in a South African context. The study demonstrates that AF implementation is possible in SA, through the four assessed case studies that have been successful with promising future prospects. The multiple goods and services (economic, environmental, social, land use and cultural) derived from AF implementation confirms it as a sustainable production system. However, the requirements of the particular AF system or practice are case specific and depends on the implementation area, scale or size, level (commercial or subsistence) and management objectives. These are important and should be carefully considered and continually researched in order to ensure success of an AF project. Therefore, the successful development and implementation of AF at the national level will require most importantly an enabling environment (through a support policy and strategy), further research and development, and coordination and collaboration.

6.1 RECOMMENDATIONS

6.1.1 Recommendation 1: Developing a national AF policy and strategy and addressing the top ranking national level barriers

There are few pieces of legislation that mention AF, but none of them really provide specific and effective guidance or a mandate for the development and implementation of it. Therefore, a policy/strategy should be developed that support and incentivise the development and implementation of AF in South Africa. However, this policy should not over regulate AF; otherwise it could lead to the rejection and ultimate failure of AF as a sustainable production system. DAFF is currently developing a National AF strategy and the outcomes of this study can be integrated into that process.

There is also the issue of national level barriers (institutional, technical, social, environmental and economic) that further limit the adoption of AF in SA. It is recommended that the top three (institutional, technical and economic) national level barriers be addressed in the short to medium

term and the remaining ones thereafter (long term). A set of potential recommendations to address AF national barriers are listed in Table 53, as proposed by respondents.

Table 53: Potential recommendations to address AF top three AF national level barriers proposed by respondents

National level barrier	Proposed solutions
Institutional	<p>Current informal linkages that exist need to be strengthened</p> <p>It should be understood that AF is multi-disciplinary and involves many stakeholders</p> <p>This should be a primary focus and appropriate structures and systems need to be set up</p> <p>Suitable extension services need to be established or enhanced</p> <p>There is a need for a clear AF strategy to promote and develop AF</p> <p>The formation of a national steering committee/working group/forum or network is also important in the AF development and implementation</p>
Technical	<p>There is limited information on AF. Therefore, the need to generate adequate, reliable and up-to-date information is paramount</p> <p>Further research is required</p> <p>Research will require an information value chain to relay the information to the land user</p> <p>Best practices should be developed for AF development and implementation in SA</p>
Economic	<p>More subsidies and incentives should be made available</p> <p>On-farm research will require that funding mechanisms be established to assist land owners and to relieve them from experiments or trials</p> <p>Increased investment in AF research and development</p> <p>The issue of land reform should also be addressed</p>

6.1.2 Recommendation 2: Comprehensive assessment of AF in SA

This study took a first step in attempting to quantify the extent and distribution of AF in SA. However due to technical limitations, a lack of human resources and budget constraints, it was impossible to conduct a full comprehensive assessment of the AF projects currently being implemented. Therefore, a more sophisticated approach needs to be taken that combines surveys, remote sensing (GIS) and physical sampling. In order to cut costs this can be linked to other planned national initiatives, such as the national forest resource assessment (NFRA), which is envisaged by DAFF.

6.1.3 Recommendation 3: Quantitatively assessing the goods and services from AF

The study used a qualitative approach to identify the multiple goods and services derived from AF (economic, environmental, social, land and cultural). A total of 33 were identified across the four AF case studies. Supplementary research is required to quantitatively assess the impact of these goods and services, in order to “make a case” for the support and promote AF implementation by government and the private sector.

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APPENDIX A: NATIONAL LEVEL QUESTIONNAIRE

NATIONAL LEVEL QUESTIONNAIRE (ORGANISATION/KEY INFORMANT)

A. RESPONDENT/ORGANISATION INFORMATION

1. Date:	2. Name:
3. Organisation/Department/Affiliation:	4. Position/Occupation:
5. Gender: Male <input type="checkbox"/> Female <input type="checkbox"/>	6. Postal Address:
7. Telephone:	

B. AGROFORESTRY INFORMATION

1. Is agroforestry a formal mandate/activity/programme of your organisation? Yes No
2. If yes, at which level? National Provincial Municipal/Local
3. Does your organisation support any institution(s)/organisation(s) in the development and implementation of agroforestry?
- Yes No

Comments:

4. If yes to (3), please list the institution(s)/organisation(s) or any other institutions involved in agroforestry:

Name of the institution(s)/organisation(s)	Name of Contact Person	Email	Telephone number	Type of agroforestry & brief description; and Comments (see ANNEX)

5. Is your organisation directly involved in the development and implementation agroforestry project(s)/programme(s)/research?

Yes No

If, yes how and to what extent:

6. Please provide information on any agroforestry project(s)/programme(s)/research:

Title of Project	Type of agroforestry and brief description (see ANNEX)	Size (hectares)	Location (Area)	Starting date/Age of project	Responsible person and contacts

7. If your organisation is directly involved in developing or implementing agroforestry project(s)/programme(s)/research, will you be willing to allow an assessment thereof as a case study?

Yes No

8. Does your organisation see any value in developing or implementing agroforestry?

Yes No

Comments:

9. Are you aware of any formal policy/strategy/programme, which directly addresses agroforestry development and implementation in South Africa?

Yes No

10. If no, do you see any value and would you be willing to participate in the development of a national strategy/programme for the development and implementation of agroforestry in South Africa?

Yes No

Comments:

11. Which department/organisation/institution should have the mandate for the development and implementation of agroforestry in South Africa? _____

12. Could you please identify possible constraints/barriers in the development and implementation of agroforestry at a national level, based on the categories, and also rank the from 1-5:

Category	Constraints/Barriers	Ranking of the five categories (1 = biggest constraint; 5 = smallest constraint)	Comments
Institutional	e.g. Insufficient links and co-ordination between the various stakeholders/roleplayers and sectors; Inadequate extension services		
Technical	e.g. Unavailability of relevant information and training; Inadequate research		
Social	e.g. Lack of interest in agroforestry due to its long term nature		
Economic	e.g. Lack of sustainable funding and incentive / subsidy programs; Delayed returns on investment and under-developed markets		
Policy/Governance	e.g. Lack of a formal national policy / programme		

C. AGROFORESTRY AND CLIMATE CHANGE MITIGATION AND ADAPTATION

1. Does agroforestry have any climate change mitigation and/or adaptation benefits for South Africa?

2. Yes No

a. Please explain why and how?

ANNEX TO APPENDIX A

Use the following as a guide to describing the agroforestry system:

- **Agrisilviculture** - crops (including shrubs/vines) and trees, e.g.:
 - Improved fallow - Woody species planted and left to grow during the 'fallow phase'
 - Taungya - Combined stand of woody and agricultural species during early stages of establishment of plantations
 - Alley cropping (hedgerow intercropping) - Woody species in hedges; agricultural species in alleys in between hedges; microzonal or strip arrangement
 - Multilayer tree gardens - Multispecies, multilayer dense plant associations with no organised planting arrangements
 - Multipurpose trees on crop lands - Trees scattered haphazardly or according to some systematic patterns on bunds, terraces or plot/field boundaries
 - Plantation crop combinations:
 - Integrated multistorey (mixed, dense) mixtures of plantation crops
 - Mixtures of plantation crops in alternate or other regular arrangement
 - Shade trees for plantation crops; shade trees scattered
 - Intercropping with agricultural crops
 - Homegardens - Intimate, multistorey combination of various trees and crops around homesteads
 - Trees in soil conservation and reclamation - Trees on bunds, terraces, raisers, etc. with or without grass strips; trees for soil reclamation
 - Shelterbelts and windbreaks, live hedges - Trees around farmland/plots
 - Fuelwood production - Interplanting firewood species on or around w: firewood species agricultural lands
- **Silvopastoral** - pasture/animals and trees, e.g.:
 - Trees on rangeland or pastures - Trees scattered irregularly or arranged according to some systematic pattern
 - Protein banks - Production of protein-rich tree fodder on w: leguminous fodder trees farm/rangelands for cut-and-carry fodder h: present production
 - Plantation crops with pastures and animals
- **Agrosilvopastoral** - crops, pasture/animals and trees, e.g.:
 - Homegardens involving animals - Intimate, multistorey combination of various trees and crops, and animals, around homesteads
 - Multipurpose woody hedgerows - Woody hedges for browse, mulch, green manure, soil conservation, etc.
- **Other** (multipurpose tree lots, apiculture with trees, aquaculture with trees, etc.), e.g.:
 - Apiculture with trees - Trees for honey production
 - Aquaforestry - Trees lining fish ponds, tree leaves being used as 'forage' for fish
 - Multipurpose woodlots - For various purposes (wood, fodder, soil protection, soil reclamation, etc.)

APPENDIX B: PROJECT OR SITE LEVEL QUESTIONNAIRE

PROJECT/CASE STUDY QUESTIONNAIRE (Semi-structured)

D. RESPONDENT INFORMATION

8. Date:	9. Name:
10. Organisation/Department/Affiliation:	11. Position/Occupation:
12. Gender: Male <input type="checkbox"/> Female <input type="checkbox"/>	13. Postal Address:
14. Telephone:	15. E-mail:

E. PROJECT INFORMATION

Title of Project	Type of agroforestry and brief description (see ANNEX)	Size (hectares)	Location (Area)	Starting date/Age of project

F. BACKGROUND OR OVERVIEW OF PROJECT

Short background/history and rationale for project:

Mission & goals:

Management objectives:

Direct benefits/incentives (refer to E):

AF system/technology:

Economic feasibility/sustainability

Community involvement/Collaboration with other stakeholders:**Plans to upscale/replicate OR long term plans:****Extension/support (public or private)****G. DIRECT/INDIRECT GOODS AND SERVICES DERIVED FROM AF PROJECT**

Select or identify the main goods and services related to your project in the table below? Score the main categories from 1-5.

Main Categories	Type of Goods and Services (Tick the appropriate box, to the right or add to the list, where necessary)	Yes	Not sure	No	Scoring/ranking of main categories (1 = least important; 5 = most important) & Any Comments
Economic goods and services	• Diversification of economic/income activities				
	• Diversification of agricultural/forestry revenues				
	• Increase in yield/production				
	• Reclamation of fragile or marginal lands / Rehabilitation/ Restoration				
	• Reduction in energy and chemical inputs				
	• Bioenergy production (firewood)				
	• Energy conservation				
	• Fodder				
	• Food production				
	• Medicinal production				
	• Timber production				
	Environmental services	• Increase in biodiversity and landscape diversity			
• Decrease in wind and water erosion					
• Improvement in soil fertility					
• Improvement in soil hydrology					
• Water treatment and purification • Improved water use / management					
• Carbon sequestration and storage (Climate change mitigation); Climate change mitigation (increase in carbon sink)					

Main Categories	Type of Goods and Services (Tick the appropriate box, to the right or add to the list, where necessary)	Yes	Not sure	No	Scoring/ranking of main categories (1 = least important; 5 = most important) & Any Comments
	<ul style="list-style-type: none"> Reduction in deforestation and degradation Improvement in microclimates Climate change adaptation (increased resilience) 				
Social services	<ul style="list-style-type: none"> Job creation Food security Landscape enhancement Improvement in public opinion regarding agricultural and forestry activities Promotes secure land tenure / land ownership 				
Land use services	<ul style="list-style-type: none"> Diversified land uses Use of marginal lands (abandoned agricultural land, hill slope plots, etc.) Integrated sustainable land use management Rehabilitation/restoration of degraded land 				
Cultural services	<ul style="list-style-type: none"> Use of local and indigenous (traditional) knowledge 				
Others:					

H. SWOT ANALYSIS (Potential for AF adoption in SA)

Please select/identify the main five SWOTs related to your agroforestry project? Tick appropriate SWOTs.

Strengths (internal)	Weaknesses (internal)	Opportunities (external)	Threats (external)
Increased accessibility to firewood and other uses (i.e. timber for construction, fodder for livestock)	Management of project is remote – people on the ground needed	Global carbon market (and other environmental service markets)	No formal government AF policy/programme to support/promote the development and implementation of AF

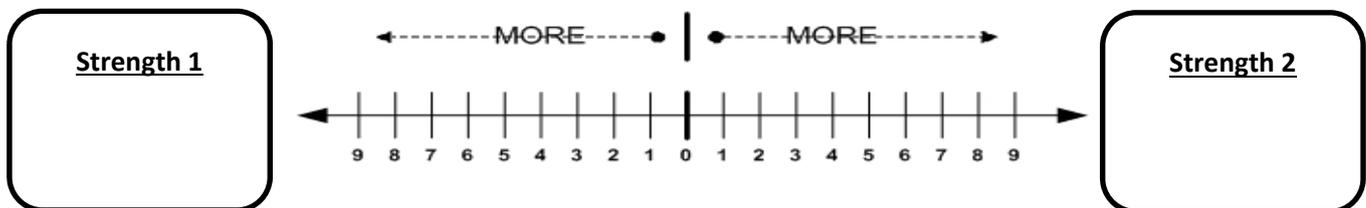
I. PAIRWISE COMPARISON OF SWOT FACTORS

Assign a value of 1-9 to indicate the relative importance of a SWOT factor over the other, using the SWOTs identified. Please see the table below for an explanation of the values:

Intensity of value	Description
1	The two factors are of equal value
3	One factor has a moderately higher value than the other
5	One factor has a strongly higher value than the other
7	One factor has a very strongly higher value than the other
9	One factor has an absolutely higher value than the other
2,4,6,8	Intermediate scales

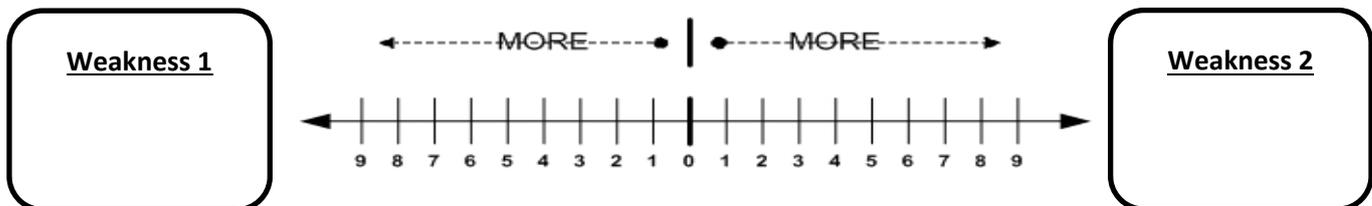
a. Strengths

1. Compare the relative importance of **Strength** to **Strength**, and circle **ONE** appropriate number:



b. Weaknesses

1. Compare the relative importance of **Weakness** to **Weakness**, and circle **ONE** appropriate number:



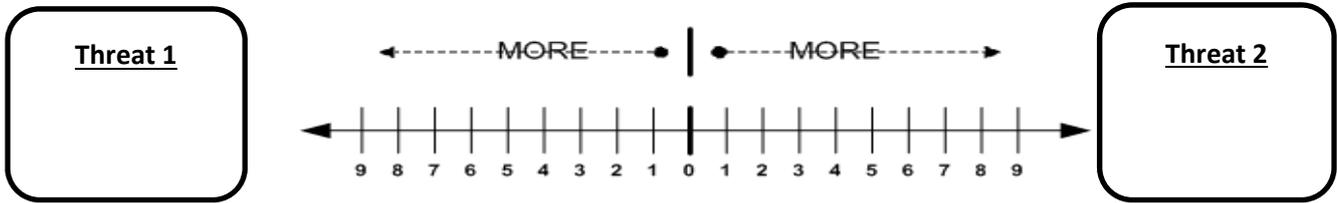
c. Opportunities

1. Compare the relative importance of **Opportunity** to **Opportunity**, and circle **ONE** appropriate number:



d. Threats

1. Compare the relative importance of **Threat 1** to **Threat 2**, and circle **ONE** appropriate number:



APPENDIX C: SITE VISIT QUESTIONNAIRE

SITE VISIT QUESTIONNAIRE (Open-ended)

1. Is there any formal quantitative/qualitative research or monitoring data that has been collected since the inception of the project? Or any analysis? Is this available?
2. Any distinct or significant physical/visual project/field features we can view? What is their significance?
3. SITE PROJECT DESCRIPTION
 - a) What was the previous land use?
 - b) What is the main land use?
 - c) Tree species/crops used?
 - d) Rationale for adopting the specific agroforestry system or systems:
 - i. Why?
 - ii. How?
4. Is the AF system for commercial/subsistence or both, please explain? Main beneficiaries?
5. Have you derived any benefits yet or when do you expect to see benefits? What are those anticipated benefits?
6. Have you performed any other trials/pilots? What were the outcomes?
7. What were your major successes or failures?
8. Future prospects or plans? Plans to upscale or diversify?
9. What are the main direct risks and costs associated to the system?
10. Practical/in-field barriers and challenges in the use of the AF system? Are there any in-field examples/features to support this?
11. Resource or technical requirements to implement or upscale project effectively and sustainably?
12. Is there any other information, in your opinion, that can potentially contribute to the outcomes of this study?

APPENDIX D: SCREENING AND SELECTION CRITERIA

