UNLOCKING BARRIERS AND OPPORTUNITIES FOR LAND-USE BASED CLIMATE CHANGE MITIGATION ACTIVITIES IN SOUTH AFRICA

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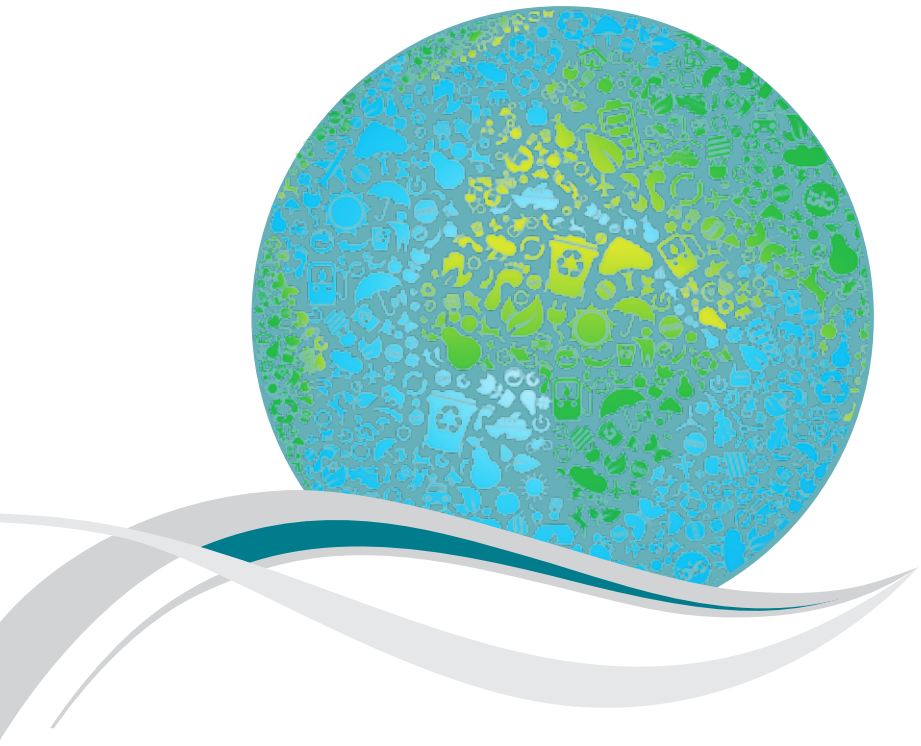

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FOREWORD

Land use and land cover change as a result of anthropogenic activities has significantly altered the Agriculture, Forestry and Other Land Use (AFOLU) sector. These changes have significantly reduced the geographical extent of many biomes around the world resulting in degradation and the release of stored carbon to the atmosphere. As a result the land sector accounts for about a quarter of the total global greenhouse gas emissions. The United Nations Framework Convention on Climate Change (UNFCCC) has established mechanisms to address these changes in a bid to inter alia enhance carbon capture and storage.

Similarly, South Africa, just like other developing countries has experienced land use and land cover change over the years. The National Terrestrial Carbon Sinks Assessment (NTCSA) published by the Department of Environmental Affairs provided initial estimates of the potential for rehabilitation in selected biomes that can enhance carbon stocks and management regimes that can significantly reduce greenhouse gas emissions. However, to make an impact rehabilitation must be implemented at national scale. Equally important is that implementation at national scale will require a concerted effort

with firm institutional and sustained financial support.

The current document provides the first ever proposal for an approach to implement rehabilitation at national scale. On the one hand, the report explores opportunities that can be harnessed through the rehabilitation of the targeted systems in this study. On the other hand, it also identifies the potential barriers and how to unlock these in pursuit of *'intact working landscapes as the foundation for the development of rural society and downstream economies'*. The proposed approach is driven by a vision that embodies the climate change mitigation and adaptation nexus.

Although the independent research and findings contained in this report do not necessarily represent the views, opinions and/or position of Government, the department believes that the information contained is critical to enhancing our understanding of the dynamics of degradation and the potential for rehabilitation to address it. Hence, the department is happy to make this work publicly available and accessible.

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ACRONYMS AND ABBREVIATIONS

AD
Anaerobic digestion

AFOLU
Agriculture, Forestry and Other Land Use

AIP
Alien Invasive Plant

CBG
Compressed Biogas

CBNRM
Community Based Natural Resource Management

CDM
Clean Development Mechanism

CEPF
Critical Ecosystem Partnership Fund

CH4
Methane

CMA
Catchment Management Association

CO_2
Carbon dioxide

CO_2e
Carbon dioxide equivalent

COGTA
Department of Cooperative Governance and Traditional Affairs

COP
Conference of Parties

CSTR
Continuously Stirred Tank Reactor

DAFF
Department of Agriculture, Forestry and Fisheries

DBSA
Development Bank of South Africa

DEA
Department of Environmental Affairs

DOE
Department of Energy

DRDLR
Department of Rural Development and Land Reform

DST
Department of Science and Technology

DWS
Department of Water and Sanitation

EPWP
Expanded Public Works Programme

ETS
Emission Trading Scheme

GCF
Green Climate Fund

GEF
Global Environmental Facility

GHG
Greenhouse Gas Emission

GIS
Geographic Information System

GJ
Gigajoule

ha
Hectare

IPCC
Intergovernmental Panel on Climate Change

IPP
Independent Power Producer

IUCN
International Union for the Conservation of Nature

km
Kilometre

M&E
Monitoring and evaluation

MJ
Mega joule

MRV
Monitoring, Reporting and Verification

MWe
Megawatt electric

MWh
Megawatt hour

N_2O
Nitrous Oxide

NFU
National Facilitation Unit

NGO
Non-Governmental Organisation

NRM
Natural Resource Management

NTCSA
South African National Terrestrial Carbon Sink Assessment

O&M
Operation and maintenance

PAMs
Policies and measures

PFM
Participatory Forestry Management

REDD+
Reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries

REIPPP
Renewable Energy Independent Power Producer Programme

SABIA
South Africa Biogas Industry Association

SAEON
South African Earth Observation Network

SANBI
South African National Biodiversity Institute

SAREC
South African Renewable Energy Council

SFM
Sustainable Forestry Management

SIP
Strategic Infrastructure Plan

SMME
Small and medium and micro-scale enterprises

SPLUMA
Spatial Planning and Land Use Management Act

TOR
Terms of Reference

UN
United Nations

UNDP
United Nations Development Program

UNFCCC
United Nations Framework Convention on Climate Change

UNREDD
United Nations programme aimed at REDD

USD
United States Dollar

VCS
Verified Carbon Standard

WfE
Working for Energy

ZAR
South African Rand

EXECUTIVE SUMMARY

INTACT WORKING LANDSCAPES AS THE FOUNDATION FOR THE DEVELOPMENT RURAL SOCIETY AND DOWNSTREAM URBAN ECONOMIES

Ninety-two percent of South Africa's land surface is rural land, which delivers most of the country's food, water and energy resources. Yet, perhaps due to a historical bias towards urban development, this area of 1.1 million km^2 is often under-appreciated in terms of the services it provides to local residents as well as to downstream urban populations and economies. The management of landscapes is often seen as a separate matter, distinct from mainstream development and not a pivotal national priority.

In practice, intact functioning landscapes are fundamental for providing access to affordable food, water and energy: the cornerstones of economic development.

Landscape restoration is therefore a means of achieving several of the goals listed in South Africa's National Development Plan. In addition to meeting Outcome 10 – protecting and enhancing our environmental assets and natural resources – it can fulfil a far broader suite of national development, security and social stability goals. It could make substantial contributions to: Outcome 4 (employment through

inclusive economic growth), Outcome 5 (skill development), Outcome 6 (infrastructure – water) and Outcome 7 (equitable and sustainable rural communities contributing to food security for all).

The restoration of natural landscapes, and the development of associated opportunities in the form of livestock production, biogas digesters, biomass-energy and others, is a mechanism through which to foster rural development and achieve the broad set of outcomes listed above. It not only restores the natural assets of the country (e.g. in the form of functional fertile soils), but also creates industries and related employment and skills development in remote rural areas where such opportunities are often rare.

However, this will only be realised if a markedly different implementation approach is adopted. Internationally, the nature of these activities has changed considerably in response to years of trial and error. The principle shifts have been in the form of scale and institutional support; with a move from small, isolated projects developed by private sector entities, to landscape or even national-scale projects facilitated by government.

In South Africa, the few existing formal reforestation projects operate at a local-scale on private land. There is no larger-scale implementation on communal lands that could deliver a broader suite of socio-economic, climate change adaptation and ecosystem service benefits (Figure E1). Similarly, biogas developers have focused only on the financially attractive opportunities associated with commercial feedlots and dairy operations, rather than developing projects that operate at the rural household or village-scale.

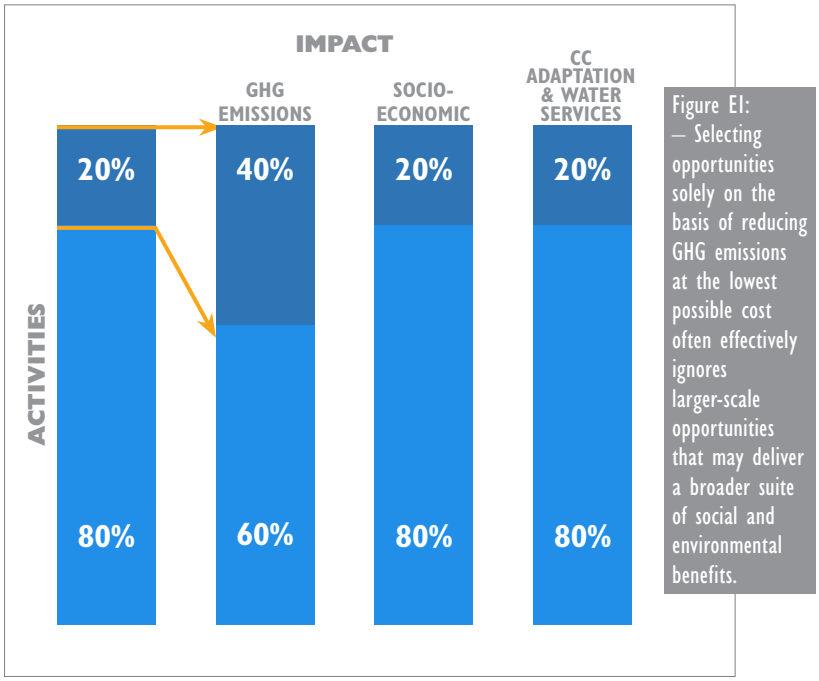


Figure E1: – Selecting opportunities solely on the basis of reducing GHG emissions at the lowest possible cost often effectively ignores larger-scale opportunities that may deliver a broader suite of social and environmental benefits.

Significantly, this strategy document seeks to expand the implementation of four principle land-use based climate change mitigation options in the country beyond narrow low-cost and risk options, to a larger vision that allows for the realisation of broader national-scale social and environmental outcomes. A fundamental change in strategy, implementation, financing and monitoring is required if implementation is to occur in a more inclusive manner at scale, with:

- A focus that is expanded to include the full potential for grassland, thicket and forest restoration together with bioenergy and livestock production opportunities.
- The aim of not only achieving emission reductions, but also a broader suite of social development and ecosystem service benefits.
- Governmental leadership as the principle planning, coordination and facilitation entity (as opposed to previous models of private sector implementation driven by market demand for carbon offsets).
- Cost-efficiency and effectiveness resulting from the joint consideration of a full suite of activities at a larger-scale.
- Integration of mitigation activities, where each is part of a greater rural value chain with opportunity to promote rural industries (Figure E2).
- The development of new incentive models where income is drawn from carbon markets as well as the public sector and emerging climate change funds.

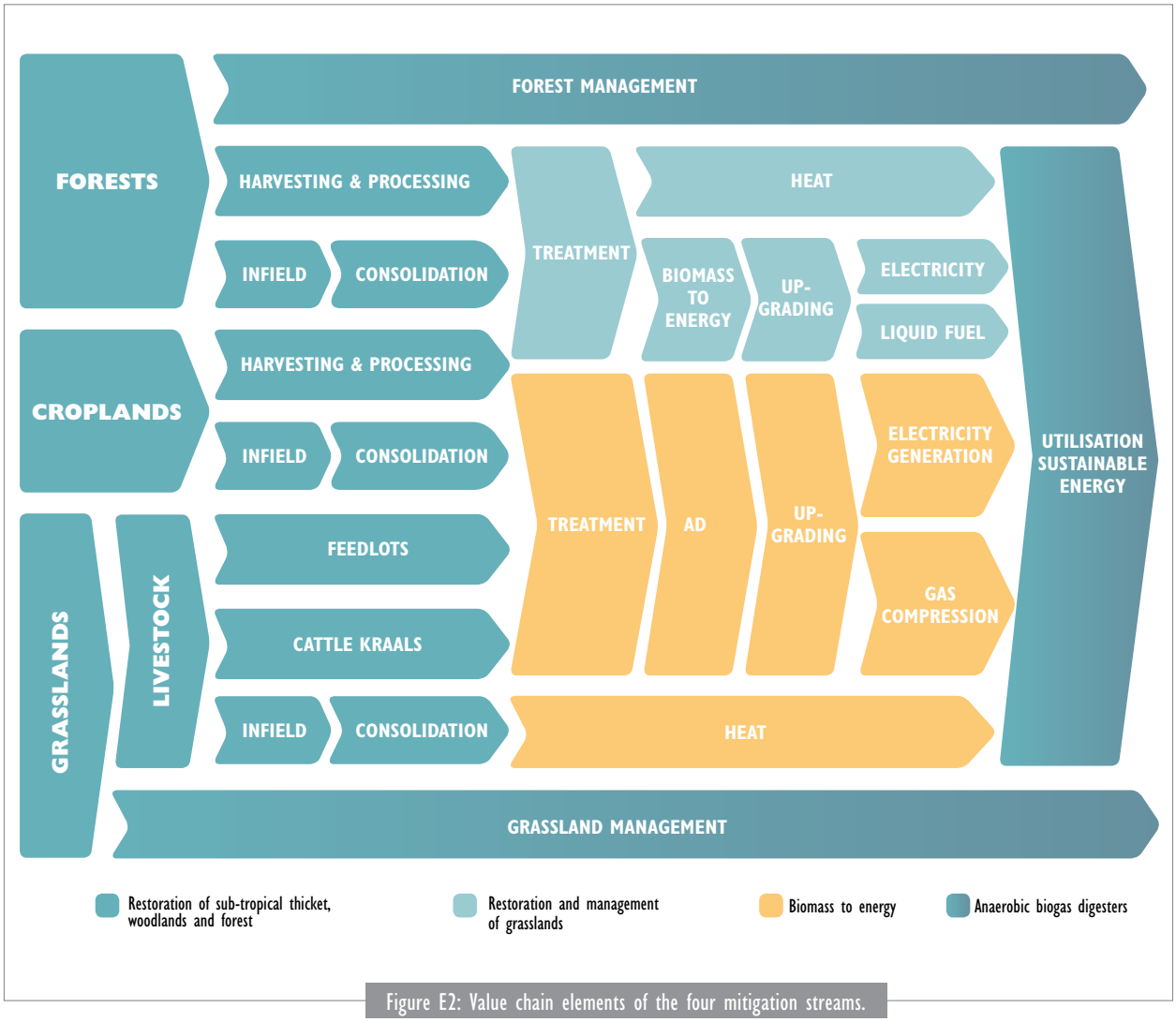


Figure E2: Value chain elements of the four mitigation streams.

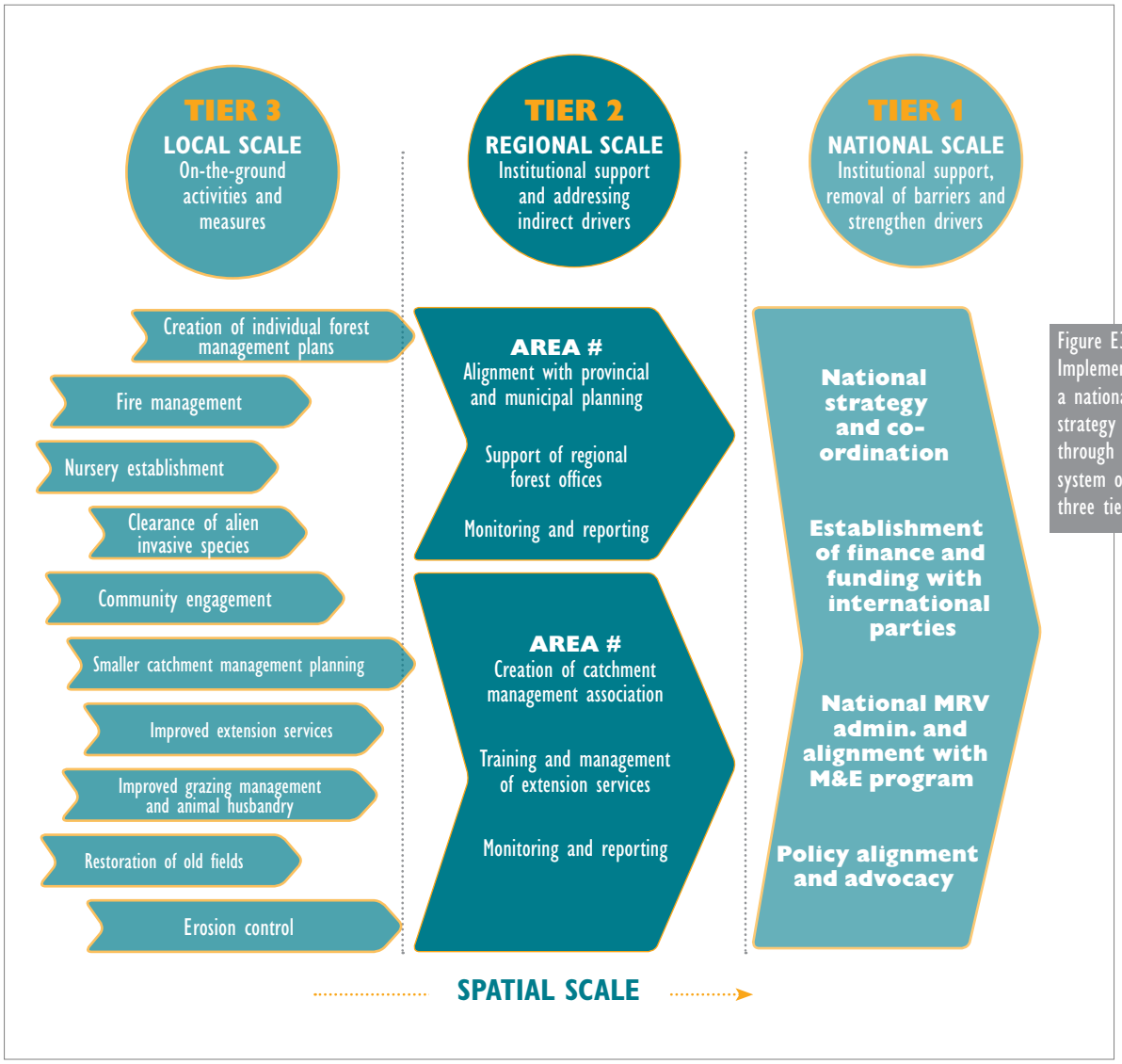


Figure E3: Implementing a national strategy through a system of three tiers

The structure consists of three tiers defined by an increasing need for context specificity (Figure E3):

- **Tier 1: National scale** – Measures that need be addressed at a national scale: these may include national strategy and co-ordination, championing and advocacy, establishment of a national MRV system, alignment with climate change adaptation and associated policy frameworks, and application to international climate change funds, among other required activities.
- **Tier 2: Regional scale** – possibly catchment or provincial This tier consists of two primary components:(i) the provision of the institutional support required to initiate, manage and sustain Tier 3 operations over time, this may include strategy development for a catchment or region, awareness and support services, research development, and (ii) measures required to address the indirect drivers associated with landscape degradation (e.g. empowering local forest and agriculture management offices to govern permits and access in an adequate manner).
- **Tier 3: Local scale** – The set of on-the-ground activities required to address direct drivers of degradation, enable the restoration of grasslands, sub-tropical thicket and forest, and facilitate the implementation of small-scale biogas and biomass-to-energy opportunities.

THE STRUCTURE CONSISTS OF THREE TIERS

(Defined by an increasing need for context specificity)

TIER 1

NATIONAL SCALE

Measures and enablers that need be addressed at a national scale may include national coordination, championing and advocacy, establishment of a national MRV system and alignment with national monitoring and evaluation (M&E), alignment with climate change adaptation and associated policy frameworks, and application to international climate change funds, among other required activities.

TIER 2

REGIONAL SCALE.

Possibly catchment or provincial. This tier consists of two primary components:

- Provision of the institutional support required to initiate, manage and sustain Tier 3 operations over time, which may include strategy development for a catchment or region, awareness and support services, and research development.
- Measures required to address the indirect drivers associated with landscape degradation, which may include reforming policy, facilitating the SPLUMA process or empowering local forest and agriculture management offices.

This support would not be mitigation type specific (that is, only for reforestation or grassland initiatives), but would rather provide integrated support for all activities and measures within a greater landscape.

It is suggested that a suite of regional pilot areas be developed initially, based on the location of early Tier 3 initiatives.

TIER 3

LOCAL SCALE

A set of on-the-ground activities is required to address direct drivers of degradation, enable the restoration of grasslands, subtropical thicket and forest, and facilitate the implementation of small-scale biogas and biomass-to-energy opportunities. Many key elements are not well understood at this scale (for example, costs of implementation, broader business plans or the socio-economic benefits of different implementation models) and research and development through early implementation is required. This is not plausible at a full national scale and therefore a set of early pilot areas that are located so as to best inform future national-scale roll-out is suggested.

TIER 3: CONSIDERING ON-THE-GROUND IMPLEMENTATION OF EACH ACTIVITY

1. Grassland restoration and management

The grassland biome dominates the central and eastern parts of South Africa, covering almost one third of South Africa's land surface, and extending through much of the Free State, Eastern Cape, Mpumalanga and KwaZulu-Natal provinces. Grasslands are a vital national asset, and their protection, rehabilitation and sustainable use is a national priority. Other than their intrinsic value, grasslands provide valuable natural solutions to the challenges posed by poverty, unemployment, and climate change.

In terms of implementing a national grassland restoration programme, the physical process of restoring grasslands is well known, but the total extent of degradation across the biome as well as required capacity and cost elements are less well understood. A systematic approach, working at a landscape-by-landscape scale, would need to be taken to understand the true opportunity for restoration together with costs and implementation capacity needs. A general process and method for rollout is described that includes required institutional capacity and support.

2. Restoration of subtropical thicket

The thicket biome extends over large areas of the Eastern Cape, covering an area of nearly 42 000 km. Almost 60 % of this vegetation has been severely degraded, with only 11 % still in pristine condition, and around 7.3 % totally lost.

During the course of engagement with stakeholders and seasoned implementing agencies, parties noted that the opportunity to restore thicket is defined both by the spatial extent of degradation and the willingness of land owners to restore areas of indigenous thicket. A land restoration process developed through many years of trial and error is described, but it does need to be preceded by a systematic and substantial upfront engagement process with land management to assess if parties would like to restore degraded areas to sub-tropical thicket. In many cases, the custodians of areas of land do not wish to have them restored to an intact thicket state, but would rather keep areas open for alternative land-use practices. Providing an estimation of the real spatial extent of potential restoration prior to the completion of this process is therefore difficult.

Whereas there are certain non-governmental organisations undertaking this process in isolated areas, a biome-scale engagement process is required to understand the true opportunity. An existing- or a new form of extension service could lead this.

3. Restoration of indigenous forests

South African forests are restricted to frost-free areas, forming an archipelago of patches scattered along the eastern and southern escarpment mountain ranges and coastal lowlands of South Africa.

They provide a wide range of services to neighbouring residents in the form of food, fibre, fuel, medicines and building materials. However, there is limited information on the status of South Africa's indigenous forests at a national scale. Local-scale assessments in the Eastern Cape note that although the total area of forest cover may not have decreased significantly, under canopy forest degradation is a cause for concern where overharvesting and exploitation has led to a decrease in carbon stocks and the abundance of certain species.

In terms of restoration, although a comprehensive assessment of drivers has not yet been commissioned, a general process can be recommended, based on the input of local experts and the project team's prior experience. This may include:

- Strategy development – establishment of forest and fire management plans, forest zonation, the identification of potential buffer zones and creation of community forestry management plans if necessary.
- Resource use control – Law and management plan enforcement
- Forest management– control of alien invasive plants, implementation of fire management plans, implementation of erosion control measures.
- Reforestation – nursery, establishment and forest management over time. This may include the establishment of high-production buffer zones.

4. Anaerobic Digestion

Biogas digesters make use of anaerobic bacteria producing gas under oxygen free conditions from various organic substances. This process commonly referred to as anaerobic digestion, comes

in various shapes and sizes with on-farm facilities using manure as feedstock being one of the most common globally. With a total estimated GHG mitigation potential of 3.6 million tCO_2, biogas from farm manure was identified in the South African Terrestrial Carbon Sink Assessment as one of the largest climate change mitigation opportunities within the land-use sector.

During the course of engagement it became apparent that there is significant opportunity for anaerobic digesters at a farm scale that remains to be unlocked. Although potential for biogas use in rural households exists, in practice uptake is limited to households currently not using electricity for cooking and heating. It was suggested that the required change is more inhibited by social factors than by cost.

5. Biomass to Energy

Four sources of biomass were considered – invasive alien plants (IAPs), bush encroachment, bagasse and plantation forestry residues. Although the total amount available is significant (22.2 million tonnes), its sparse geographical distribution and associated distance to generation units was identified as the principle barrier for the utilisation of this energy source. This is particular pertinent to IAPs and bush encroachment where biomass is often distributed in a sporadic, inconsistent manner across remote landscapes that can be costly to access.

Bagasse and forestry residues are already transported to central processing locations providing good potential to generate energy in an efficient manner. If an economically viable model can be developed to utilise this biomass, these sources can easily be unlocked.

TIER 2: REQUIRED CAPACITY AT A REGIONAL SCALE

Two broad outcomes that would need to be achieved at a Tier 2 level:

1. **The provision of the institutional and operational support required to initiate, manage and sustain Tier 3 operations** – this may include: strategy development for a catchment or region, engagement with relevant Government departments (national and provincial), operational support and governance of payment mechanisms, awareness and support services, primary ecological, social and economic

research development, alignment with regional policy and similar environmental programmes and initiatives. In the context of biogas development, a strong industry base and institutional capacity remains to be developed that addresses inhibitory factors currently limiting rollout.

2. **Measures required to address the larger-scale indirect drivers associated with landscape degradation** – measures may include providing capacity to undertake regional land-use planning process, empowering local forest and agriculture governance offices to manage permitting and access to resources in an appropriate manner, creating market access for livestock and crops, creating economic incentives for restoration, and so forth.

TIER 1: REQUIRED INSTITUTIONAL SUPPORT

The tasks that need to be provided by Government and other parties to establish and sustain the implementation models and measures over the long-term - these would include:

- A national institutional home, champion and strategy lead
- National co-ordination and management
- Strategy development
- Facilitating roll-out: Area identification and early landscape development team
- Continued extension and support services
- The implementation of a cost efficient national MRV system
- Income creation and management
- Incentive mechanisms and disbursements
- Alignment with national and international policy
- Research development

PARTICULAR TO ANAEROBIC DIGESTION OPPORTUNITIES

The national biogas platform and industry association (SABIA) is relatively well developed. However:

- Input and collaboration from industry is largely based on voluntary collaboration. A dedicated budget could strengthen institutional capacity making working groups more effective in delivering results in a shorter period of time.
- SABIA needs to grow a paying membership base to ensure its long-term financial viability.
- SABIA needs to join SAREC, thereby joining the more dominant larger scale renewables representatives (wind, solar PV) with a voice from the smaller scale bio-energy industry.

PARTICULAR TO BIOMASS ENERGY OPPORTUNITIES

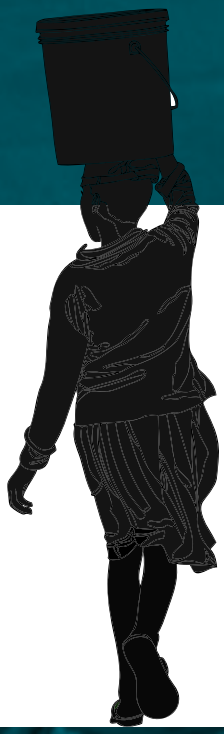
From an international perspective, the bio-energy sector cannot currently compete well with low electricity prices and no free access to the national grid. The industry is in need of a mechanism (other than the complex and not well suited for small scale IPP programmes) that can provide access and a better price to sustain implementation at scale. An option is to develop a temporary measure for the first ten years to allow the industry to standardise and develop and de-risk lower cost solutions.

Several governmental incentive mechanisms seem to favour larger scale or non-bio energy renewables. To unlock the potential for biomass to energy, existing incentives should be reviewed, including the 12L energy efficiency tax incentive of small scale Renewable Energy Independent Power Producer Procurement programme (REIPPP) and the below 1MW one year depreciation exception for solar PV. By including bio-energy options into these incentives, a more level playing field can be created thereby enabling implementation at scale.

FINANCE AND FUNDING

Perhaps the most important element in a project development process is the identification of a source of payment for initial project development and especially the long-term sustainable implementation of all activities. Financial support for projects can be divided into two separate types of support: funding and finance. There are several multilateral funds supporting climate change adaptation and mitigation, with some dedicated REDD+ funds. Important multilateral funds to consider are the Green Climate Fund (GCF, USD 10 billion), Forest Carbon Partnership Facility – Carbon Fund (FCPF-CF, USD 750 million), GEF 6 Trust Fund (USD 1,101 million) and the BioCarbon Fund (USD 354 million).

South Africa is planning to implement a carbon tax pricing mechanism for all the larger emitting economic sectors in 2017. In November 2015, National Treasury published a draft Carbon Tax Bill, which calls for a levy of R120/ tCO_2e. A carbon offset mechanism is included in the Bill, which allows for GHG emission reduction units to be created in sectors not covered by the carbon tax, which in the first period of the carbon tax, includes the agriculture, forestry and other land use (AFOLU) sector. As such, the offset mechanism could form a principle source of revenue for landscape restoration projects in the near term.



SECTION ONE

DEVELOPING A NATIONAL VISION FOR THE SOUTH AFRICAN AFOLU SECTOR

1

WORKING LANDSCAPES AS THE FOUNDATION OF RURAL SOCIAL DEVELOPMENT AND STABILITY

Ninety-two percent of South Africa's land surface is rural land, which is home to 19 million people – approximately 35% of the national population (Stats SA, 2009). It is an area that delivers most of the country's food, water and energy resources, and contributes meaningfully to the recreational and spiritual needs of the nation's residents (van Jaarsveld et al., 2005). Yet, perhaps due to a historical bias towards urban development, this 1.1 million km^2 area is under-appreciated in terms of the services it provides to local residents as well as to distant urban populations and economies. The management of intact rural landscapes is generally seen as a side-line conservation or environmental issue, separate to mainstream development, and not a pivotal component of national development and stability. Furthermore, there is a perception that the services provided by intact landscapes could be substituted by engineered solutions, such as replacing natural catchment functions with the construction of additional dams. The under-appreciation of our rural environment and the belief that we can replace it with engineered solutions will ultimately lead to irreversible degradation of vital national resources and services.

In practice, intact functional landscapes are fundamental for

providing access to affordable food, water and energy: the principle cornerstones of economic development (Blignaut, 2009). A lack of access to these primary services, especially in remote rural areas, leads to a decrease in human well-being, disquiet and an increase in potential for social instability at scales ranging from local to national. This primary link between intact working ecosystems and social stability and well-being has been repeatedly demonstrated as being a crucial factor in the rise and fall of societies over time (Diamond, 2005, Scholes and Scholes, 2013).

The restoration of natural landscapes, and the development of associated opportunities in the form of improved water security, livestock production, biogas digesters, biomass-energy and others, are mechanisms to foster and maintain national economic development. These not only restore the natural capital on which development depends (the natural assets of the country, which include functional fertile soils, grasslands, woodlands and forests), but also create sustainable rural industries with related employment and skills development. A national rural restoration programme requires planning, implementation, governance, policy, research and monitoring – stimulants for extensive capacity development and sustainable rural jobs.

Ecosystem restoration has typically been constrained to a narrow definition in South Africa's National Development Plan, being seen primarily as a means of meeting Outcome 10 – protecting and enhancing our environmental assets and natural resources. However, ecosystem restoration can realistically fulfil a far broader suite of national development, security and social stability goals, contributing to: Outcome 3 (safety), Outcome 4 (employment through inclusive economic growth), Outcome 5 (skill development), Outcome 6 (infrastructure – water) and Outcome 7 (equitable and sustainable rural communities contributing to food security for all).

1.1 INTEGRATION AT SCALE TO ENSURE EFFICIENCY, EFFECTIVENESS AND EQUITY

Land-use based climate change mitigation activities provide an opportunity to restore a significant fraction of South Africa's landscapes and to develop rural industries that contribute to local and national energy needs. However, this will only be realised if a markedly different implementation approach is adopted, compared to current approaches. Internationally, the nature of these activities has changed considerably in response to years of trial and error, and the gradual development of international climate change policy. The principle shift has been one of scale; with a move from small, isolated projects developed by private sector entities, to landscape- or even national-scale projects facilitated by government.

Previously, under the Clean Development Mechanism (CDM) and similar early frameworks, climate change mitigation measures were generally confined to the project scale with each type of activity considered in isolation. This was because the CDM and voluntary initiatives only recognised certain types of activities within the AFOLU sector and required extensive documentation and auditing processes beyond the means of most landowners.

Further, the majority of CDM implementers were private sector entities that required commercial viability and low investment risk. This generally constrained implementation to pockets of private land that met the numerous constraints, with limited rollout at a larger scale, especially in areas under communal land-tenure (see Appendix A for a list of existing projects registered through the Verified Carbon Standard (VCS) and CDM projects).

In the past, private sector developers found that restoration projects in indigenous African

woodlands and grasslands required a minimum scale of 50,000 to 100,000 ha to be financially viable (Knowles, 2011). The relative costs of administration, implementation and 'monitoring, reporting and verification' (MRV) are only financially viable at larger spatial scales, making the relatively high fixed costs of human capacity and logistics less per unit area (DEA, 2015). The emergence of 'reducing emissions from deforestation and forest degradation' (REDD+) as a recognised form of climate change mitigation, required a broader consideration of degradation drivers outside the immediate project boundaries. Implementers were often forced to consider a broader suite of regional activities and measures to halt deforestation. This was beyond the capacity of individual projects and required national government support.

Evolving international climate change policy has also been a pivotal driver in the shift from local to landscape or national-scale implementation. Early local-scale activities in developing countries were principally developed for registration through the CDM, which allowed parties to the Kyoto Protocol to reach their emission targets in a more flexible and cost-efficient manner. This context promoted concise, financially attractive, low-risk ventures that would generate emission reduction units for trade through international carbon markets. It largely ignored landscape or national-scale environmental, economic and social development issues.

International climate change policy has moved towards national-scale implementation and nationally determined responses to climate change. Recent policies allow countries to self-determine their contributions to climate change mitigation, and, importantly, to align them with the broader social and environmental development agenda of the nation. Such a nationally determined climate change mitigation system is gradually being developed through the formulation of Nationally Appropriate Mitigation Actions, Desired Emission Reduction Outcomes and Nationally Determined Contributions.

In the past, private sector developers found that restoration projects in indigenous African woodlands and grasslands required a minimum scale of 50,000 to 100,000 ha to be financially viable

(Knowles, 2011)

Previously, driven by the need to deliver emission reduction units at a low cost and low risk, project developers tended to focus only

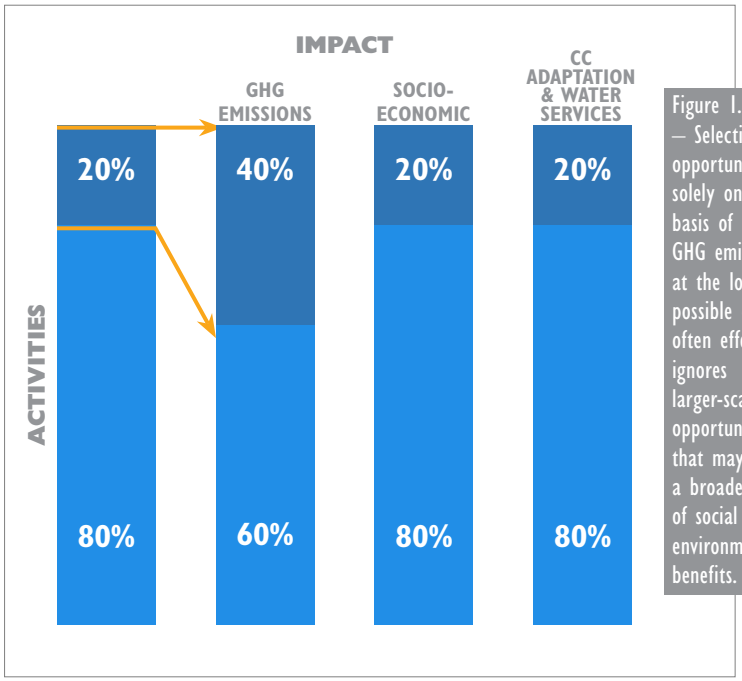


Figure 1.1: – Selecting opportunities solely on the basis of reducing GHG emissions at the lowest possible cost often effectively ignores larger-scale opportunities that may deliver a broader suite of social and environmental benefits.

on a fraction of the potential opportunities that deliver substantial GHG emission reductions (Figure 1.1). Significantly, the current strategy to develop four mitigation options has expanded the emphasis on traditional narrow low-cost and low-risk GHG emission reductions to a larger vision that includes national-scale social and environmental outcomes. The full potential of larger-scale mitigation has not yet been realised, because of low emission reductions or perceived risk.

In South Africa, the few existing formal reforestation projects operate at a local-scale on private land. There is no larger-scale, communal focus, or implementation that could deliver a broader suite of socio-economic, climate change adaptation and ecosystem service benefits.

In South Africa, the few existing formal reforestation projects operate at a local-scale on private land. There is no larger-scale, communal focus, or implementation that could deliver a broader suite of socio-economic, climate change adaptation and ecosystem service benefits. Similarly, biogas developers have focused only on the financially attractive opportunities associated with commercial feedlots and dairy operations, rather than on developing projects that operate at the rural household or village-scale.

To realise larger-scale mitigation opportunities with a broad suite of social and environmental benefits, a fundamental change in strategy, implementation, financing and MRV is required, with:

- An expanded focus that includes the full potential of larger-scale mitigation opportunities.
- The aim of achieving not only emission reductions but also a broader suite of social stability, development and ecosystem service benefits.
- Government as the principle planning, coordination and facilitation entity (as opposed to previous models of private sector implementation driven by market demand for carbon offsets).
- Cost-efficiency and cost-effectiveness resulting from a joint consideration of the full suite of AFOLU climate change mitigation opportunities at the larger scale.
- Integration of related mitigation activities that form part of a greater rural value chain that promotes rural industries and delivers broader socio-economic benefits (Figure 1.2).
- New incentive models where income is drawn from carbon markets as well as the public sector, emerging climate change funds, and potential payment-for-ecosystem-service markets (for example, watershed protection).

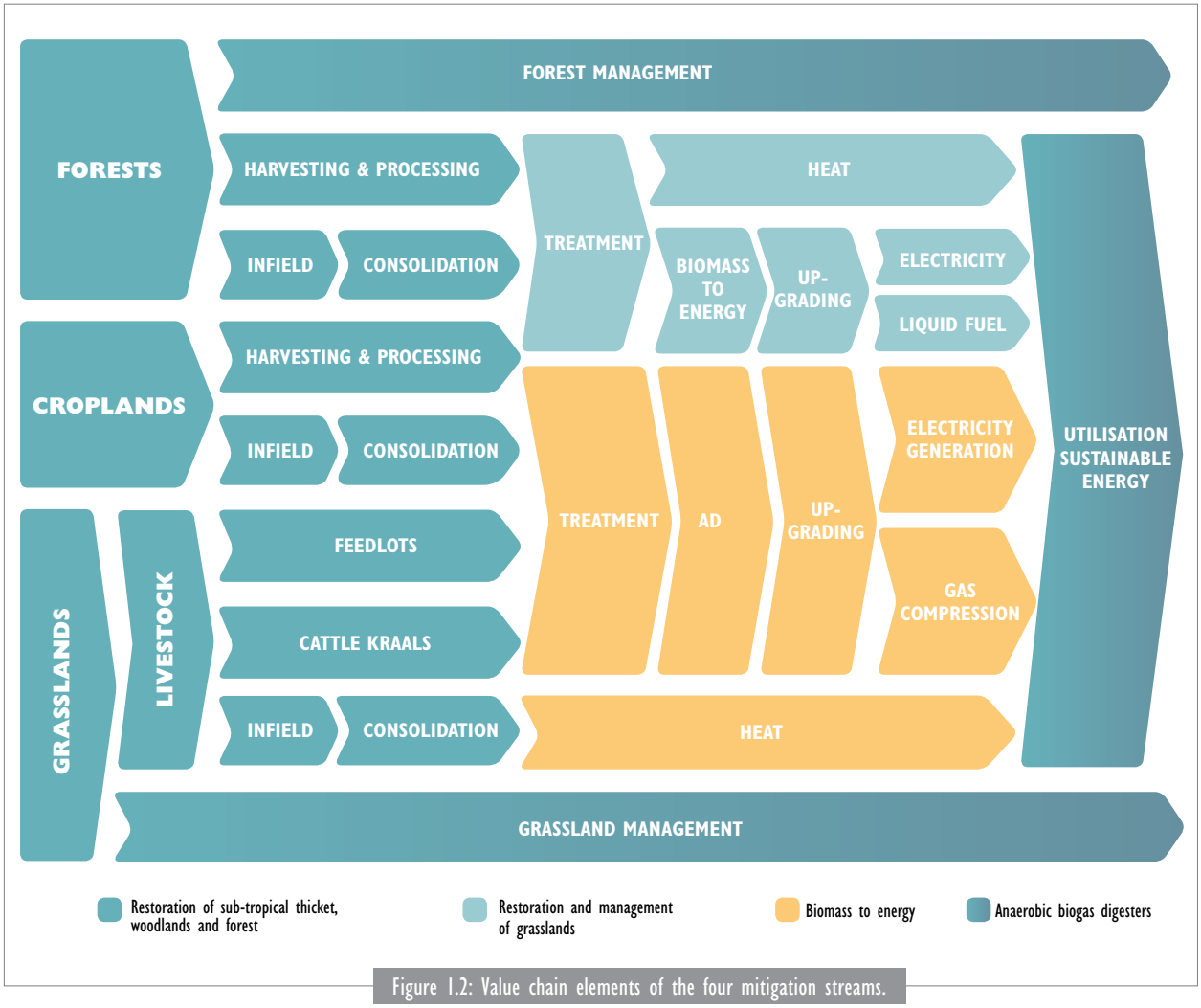


Figure 1.2: Value chain elements of the four mitigation streams.

VISION & INTRODUCTION | **TECHNICAL SCOPE** | **FORM OF IMPLEMENTATION** | **FINANCIAL FEASIBILITY**

VISION

Intact working landscapes as the foundation for the develpment of rural society and downstream urban economies

INTRODUCTION

Explanation of the rural supply-chain within the private commercial and communal subsistence contexts

FOUR ELEMENTS

1. INTRODUCTORY BRIEF

- Scope and nature of the opportunity at a national scale in South Africa.
- Current national programmes as well as CDM, VCS or GS projects.

2. DEFINING THE GAP – STATUS QUO VS. NATIONAL-SCALE READINESS

Description of the potential scope, forms of implementation, business case and required MRV, with analysis of the following states and the gap between them:

- The desired state of readyness (i.e. everything is in place to start implementation)
- The current state (i.e. the status quo in the country)
- The gap (i.e. the scope of work is required to close the gap between current state and state of readyness)

3. ANALYSIS OF RELATIVE READINESS AND IMPORTANCE

A comparative analysis that shows the relationship between relative readiness and relative importance of various activities, which aims to help prioritise activities

4. STRATEGY TO CLOSING THE GAP – WHAT, WHEN, WHERE, WHO AND AT WHAT COST?

A detailed description of what is required to close the gap, with a focus on the scope of work, location, timing, responsibilities and budgets

Repeated for grasslands, reforestation, anaerobic biogas and biomass-to-energy

1.2 A STRATEGY TO REALISE OPPORTUNITIES AND ADDRESS BARRIERS

This assessment of the barriers to, and opportunities for, larger-scale mitigation has been structured to analyse the requirements for a broader suite of social and environmental benefits. Each principle element – technical scope, forms of implementation, financial feasibility, institutional capacity and monitoring, reporting and verification – is assessed in terms of what is required for implementation at a national-scale (Figure 1.3). Each activity is described separately followed by a consideration of finance and funding options as well as analyses of potential institutional structures through which implementation can be realised.

After identifying the gaps between the desired and current states of implementation, how can these gaps be closed in an efficient, orderly and structured manner? Some gaps can be addressed immediately based on existing experience and data (for example, mapping forest cover or applying for international funding). Others are

Figure 1.3: The process of developing a strategy

highly context-specific and poorly understood, possibly requiring, for example, field experience to understand the financial feasibility of implementation, the application of progressive MRV techniques or the social outcomes of differing implementation models. Estimates of costs and outcomes based on generic models can be used at the early stages of opportunity identification (for example, Section 2 of the National Terrestrial Carbon Sink Assessment), but informed planning and implementation requires a detailed understanding of the economic, operational, ecological and social aspects across the full range of contexts found nationally. A national-scale assessment of such finer-scale elements is likely to be prohibitively expensive and therefore an alternative form of development phase may be required.

A common problem with many large-scale national programmes is 'how and where to start'? This is particularly pertinent in the context of establishing large-scale programmes that need to be implemented in their entirety to be viable. A 'chicken-and-egg' dilemma may emerge, as is illustrated in the example from the green transportation industry (next page). Here, consumers are cautious to buy-in to green vehicles if the supply-chain and institutional support are not in place. At the same time, industry is unlikely to invest in developing the supply-chain if demand from consumers is not evident. In this type of situation, government intervention may be vital in establishing early 'push' and 'pull' stimuli at either end of the system.

Such a conceptual model pertains to land-use based climate change mitigation activities in South Africa.

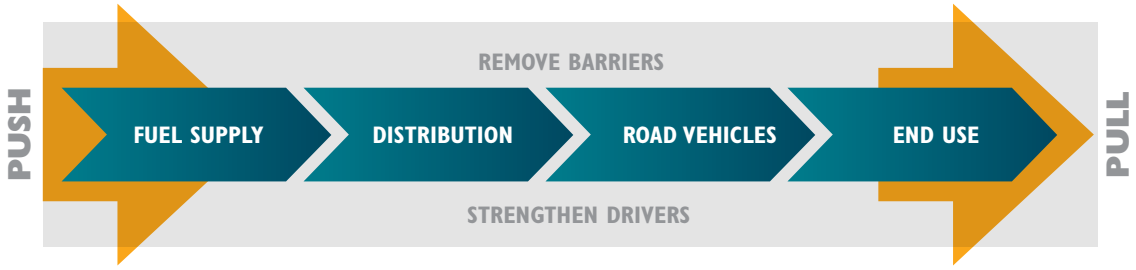
- **Private landowners and communal land users** are typically risk adverse and require 'proof of concept' prior to investing finances, committing land or changing their management systems.
- **Governing bodies** are unlikely to invest scarce resources in new institutions without clear evidence of probable viability.
- **Funders** may be hesitant to invest considerable sums in full national-scale implementation without some 'proof of concept' of all key elements at an initial smaller scale.

Government support, possibly funded through international climate change related funds, may be necessary to establish an initial set of demonstration implementation areas or projects, together with principle institutional support elements. Immediate full-scale implementation may thus not be practical, financially viable nor advisable. Many interviewed stakeholders and experts noted that while the broad principles of implementation are relatively well-known, early pilot testing is required to optimise processes and methodologies prior to full-scale implementation. Likewise, early initiatives can be used to better understand and improve on the social and biodiversity dynamics and outcomes.

PUSH / PULL MODEL EXAMPLE

- Without the requisite supply and distribution infrastructure in place, consumers are wary of buying green vehicles, while without sufficient levels of consumer demand, there is little incentive to set up a local supply, distribution and production infrastructure – the so-called 'chicken-and-egg' dilemma. Government could be key to resolving this dilemma by implementing simultaneous 'push' and 'pull' measures, to kick-start the market and allow it to grow to a competitive and sustainable scale (OECD, 2013; Nooteboom, 2006; UNSW, 2014).
- To stimulate green road transport effectively, a coherent package of policy measures needs to be defined and aligned with the current overall road transport policy framework. To promote green road transport, preference needs to be given to emerging green transport alternatives, removing barriers and strengthening drivers and enablers.
- When designing and implementing a package of measures, barriers need to be removed, and drivers and enablers strengthened. With a working supply chain, the market can be up-scaled through market push measures stimulating supply, thereby resolving the 'chicken-and-egg' dilemma.

Model for developing a package of policies promoting green transport



The various policy options identified in terms of the model:

- Optimisation measures addressing barriers, enablers and drivers.
- Push policy measures creating supply.
- Pull policy measures creating demand.

THE STRUCTURE CONSISTS OF THREE TIERS

(Defined by an increasing need for context specificity)

TIER 1

NATIONAL SCALE

Measures and enablers that need be addressed at a national scale may include national coordination, championing and advocacy, establishment of a national MRV system and alignment with national monitoring and evaluation (M&E), alignment with climate change adaptation and associated policy frameworks, and application to international climate change funds, among other required activities.

TIER 2

REGIONAL SCALE.

Possibly catchment or provincial. This tier consists of two primary components:

- Provision of the institutional support required to initiate, manage and sustain Tier 3 operations over time, which may include strategy development for a catchment or region, awareness and support services, and research development.
- Measures required to address the indirect drivers associated with landscape degradation, which may include reforming policy, facilitating the SPLUMA process or empowering local forest and agriculture management offices.

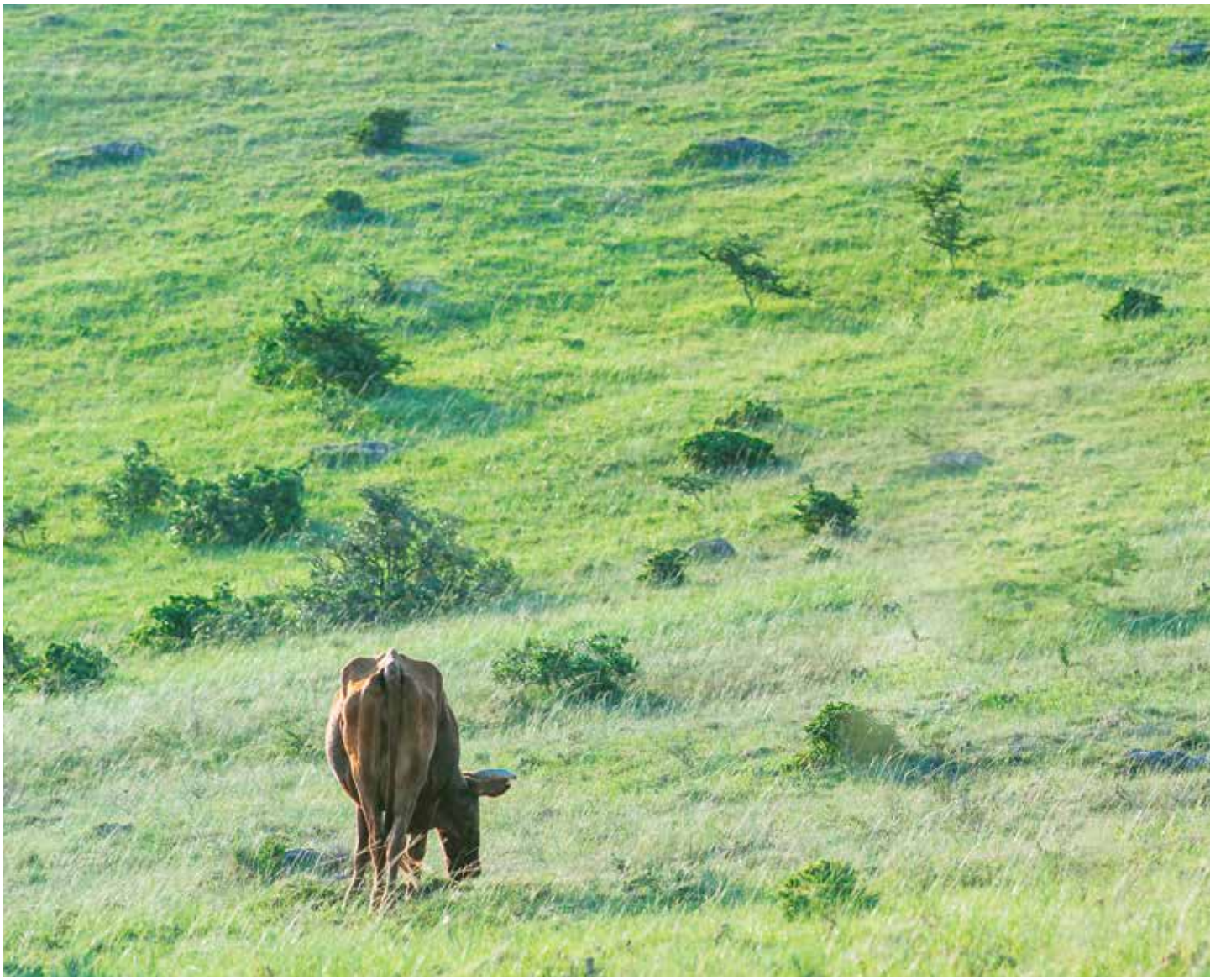
This support would not be mitigation type specific (that is, only for reforestation or grassland initiatives), but would rather provide integrated support for all activities and measures within a greater landscape.

It is suggested that a suite of regional pilot areas be developed initially, based on the location of early Tier 3 initiatives.

TIER 3

LOCAL SCALE

A set of on-the-ground activities is required to address direct drivers of degradation, enable the restoration of grasslands, subtropical thicket and forest, and facilitate the implementation of small-scale biogas and biomass-to-energy opportunities. Many key elements are not well understood at this scale (for example, costs of implementation, broader business plans or the socio-economic benefits of different implementation models) and research and development through early implementation is required. This is not plausible at a full national scale and therefore a set of early pilot areas that are located so as to best inform future national-scale roll-out is suggested.



A solution may be a multi-scaled tiered approach that focuses on the entire set of elements. Whereas certain nationally generic components can be developed immediately at scale, a small initial suite of pilot areas would be used to test and develop context specific components, for example, cost, implementation and MRV models (Figure 1.4).

The effective and efficient development of Tier 2, and to a certain extent Tier 1, is based on the scope of Tier 3 being well understood and defined. The tiers are therefore introduced in a reverse 'bottom-up' manner. Because there are currently different levels of understanding of forms of implementation for each biome, Tier 3 is approached and described in a different manner for each project type. For example, in the subtropical thicket biome, the form of implementation required is well known and can be closely described. In comparison, the form of implementation required across the entire grassland biome is less well known and therefore a broader process is described, from which detailed implementation can be developed.

In addition, the concept of direct and indirect drivers is adopted. Initially conceived in the context of REDD+ project development, this concept can be used to identify and articulate the broad range of elements to be considered, at a range of scales, to ensure successful and sustainable implementation.

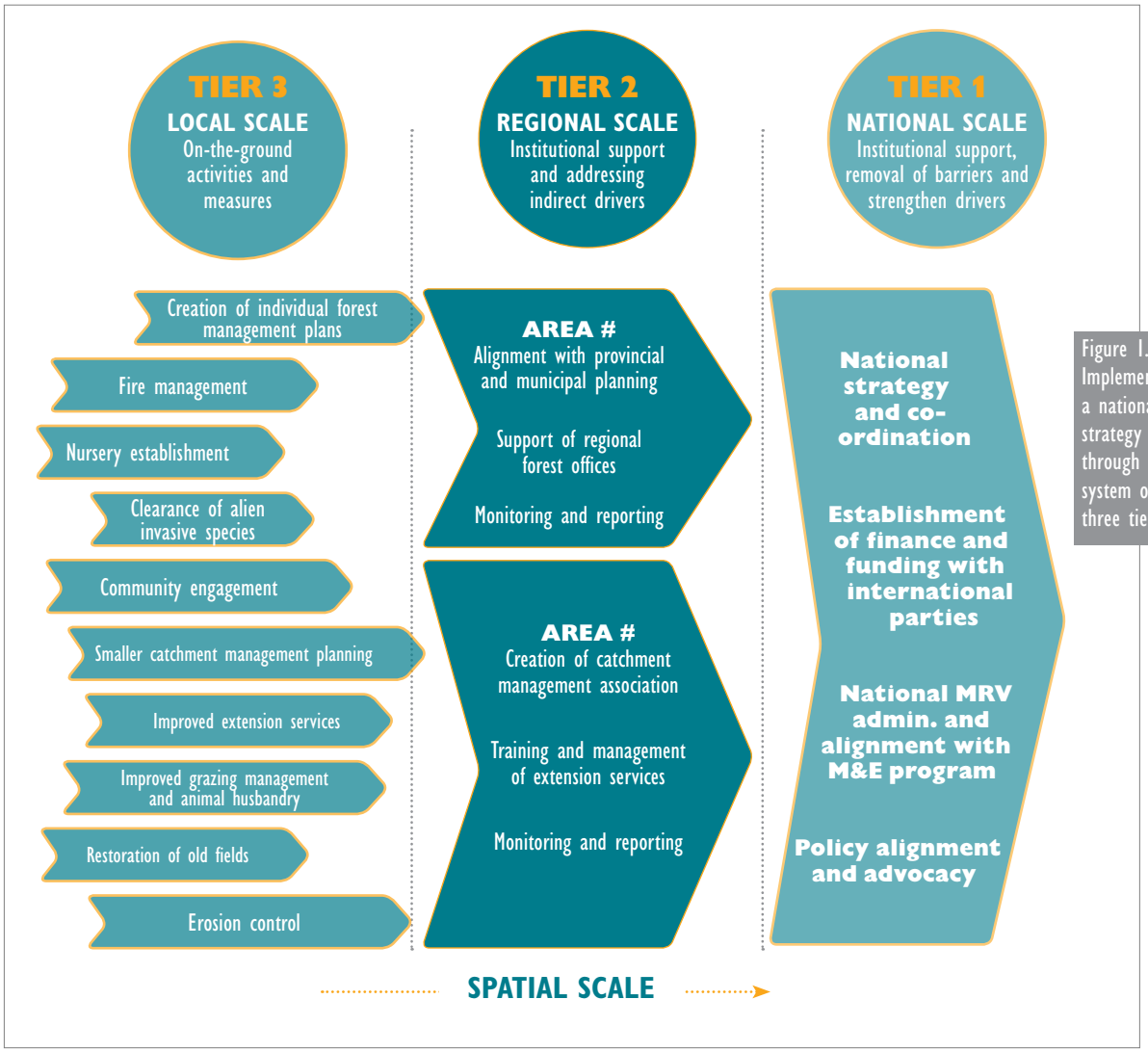


Figure 1.4: Implementing a national strategy through a system of three tiers

1.3 DRIVERS, ENABLERS, ACTIVITIES AND MEASURES

1.3.1 Direct and indirect drivers

Current land cover and land use in a particular area is the result of many drivers interacting across multiple scales. These include basic abiotic drivers that broadly define the current vegetation or agriculture (for example, soil type and climate), as well as human drivers that may directly or indirectly influence land use (for example, beef markets, grazing strategies and fire management).

Direct drivers are observable actions that directly affect a landscape, for example, ploughing land, burning grasslands, harvesting forests or collecting fuelwood. Indirect drivers are generally not observable, yet still have a profound influence on land use in an area, for example, land-use policies or demand for fuelwood and agricultural commodities.

The distinction between direct and indirect drivers is widely used in the development of land-use based climate change mitigation activities to identify and address required elements in an orderly manner. For example, in the case of a project

aimed at reducing emissions from deforestation and forest degradation (REDD+), the developer would seek to identify all direct and indirect drivers that lead to deforestation within a landscape. This may be through engagement with local experts and residents, through policy and market analysis, or historical land-use trend analysis from remotely-sensed data. Thereafter, the implementer would attempt to address all the drivers in a systematic manner to halt forest degradation and avoid offsite 'leakage'. Certain drivers, especially indirect drivers such as regional demand for inexpensive fuelwood, may not be solvable at a local scale, but could be communicated to regional or national authorities mandated to address them at an appropriate scale.

The drivers concept is adopted in this analysis of barriers and opportunities, particularly for programmes focused on restoration of landscapes and prevention of further degradation (Sections 2 to 4) as it enables systematic identification of all drivers across all tiers. Thereafter, appropriate activities and measures can be developed and implemented to address them comprehensively and efficiently.

1.3.2 Activities and enablers

- '**Activities'** are on-the-ground actions that address observed **direct** drivers (for example, livestock management or the implementation of sustainable wood harvesting regimes).
- '**Enablers**' are additional elements required to enable a programme to occur (for example, implementation or monitoring capacity or the creation of an incentive mechanism). Although not drivers in themselves, enablers are added to the list of drivers in certain sections and are addressed through suggested

activities and measures. Different parties generally implement activities and measures at different scales or tiers. The clear separation of activities and measures allows parties in different implementation tiers to understand their role and how it forms part of a greater integrated programme (Section 7 expands on these management and governance aspects).

1.3.3 Required measures

'Measures' are those initiatives required to resolve the **indirect** drivers that inhibit the roll-out of landscape restoration in a sustainable manner. Measures may include:

- **Reform of policy or market incentives** that lead to land degradation.
- **Integrated land-use planning** that includes the restoration and long-term management of landscapes (the realisation of SPLUMA).
- **Creation of a national focal point** that leads a national-scale programme, including the development of strategy, income streams, incentive mechanisms and required monitoring, reporting and verification support.

Whereas many of the measures are implemented at national Tier 1 level, several measures are required at a Tier 2 or Tier 3 level to address indirect drivers. These may include local-scale land-use planning and negotiation, law and regulatory enforcement, and the creation of agricultural extension support services.

Each of these measures is described in the exploration of tiers that follows.

1.4 IMPLEMENTATION MODELS AND INSTITUTIONAL SUPPORT

Following the full articulation of drivers, enablers, activities and measures, appropriate implementation models need to be developed and supporting institutional capacity needs to be identified. Implementation models are the structures through which enablers, activities and measures can be realised. Such models may include established public or private-sector entities (for example, private landowners or the Expanded Public Works programme) or new entities designed to address areas that are not under the remit of current programmes.

Institutional support, provided by government and other parties, helps establish and sustain the implementation models over the long term. These may include

awareness and education, extension services, research and development, funding and finance management, as well as monitoring, reporting and verification. Although principally led by government, external parties such as private sector or NGO service providers may be commissioned to implement activities in the short term and the early trial of implementation and monitoring models.

Each mitigation activity is described in detail in Sections 2-6. However, they often have common institutional support requirements at a Tier 1 and Tier 2 level. To avoid repetition in the document, Tier 1 and Tier 2 are each discussed in more detail once, rather than for each of the biomes. Similarly, a single description is given under Tier 3 for the landscape restoration and management opportunities within the three biomes –grassland, subtropical thicket and forest biomes. The nature of implementation for the two energy-related projects differs in some respects. For these activities, a separate description of Tier 3 implementation is included in Section 5 (biogas digesters) and 6 (biomass-to-energy), together with further Tier 2 and Tier 3 considerations.

1.5 EXPLORATION OF **TIER 1**: NATIONAL SCALE

Various tasks need to be carried out by government, associated departments and other agencies to establish and sustain implementation models and measures over the long term, for example awareness and education, extension services, research and development, funding and finance management, and MRV.

1.5.1 A national institutional home, champion and strategy lead

An appropriate institutional home for a national AFOLU sector mitigation programme will need to be developed internally by government. Initial indications are that it may need to be a multi-departmental working group that includes representatives from DEA, DAFF, DWS, DOE and other entities. This would not only be a caucus that meets at regular intervals – it would be a formally mandated entity that has the capacity and staff to champion the national programme and provide strategic leadership. The intention here is to understand the scope of tasks that the national entity would need to undertake, and the associated capacity requirements.

- **National coordination and management**: Operational support is required at a national scale. The majority of field operations will likely be implemented at Tier 3 and Tier 2 levels, but a programme management unit and secretariat may be required to provide oversight and coordination, national legal and policy reviews, human resource management, financial management, funding, and annual reporting at a national scale.
- **Strategy development**: Two broad levels of strategy development are required. The first level focuses on the long-term vision of the programme and roll-out, and strategic alignment with other

government programmes, ecological infrastructure and development efforts, and government policies and priorities. The second level focuses on the realisation of this vision, and how to strategically entrench that vision in a long-term roll-out plan informed by that vision. It is anticipated that the first level of strategy (the long-term vision and direction of the programme), will be undertaken with guidance from a steering committee, including members of Treasury, DWA, DAFF, and other relevant entities within government as well as the private and NGO sectors. The second level of strategy (operational strategy) would be developed with entities in each landscape.

- **Facilitating roll-out – Area identification and early landscape development team**: The process of identifying and establishing Tiers 2 and 3 needs to be undertaken by the Tier 1 entity. An initial team goes into each catchment or landscape and develops the programme from the ground up. This not only has ecological and technical elements, but also requires substantial local government, industry, private land-owner and community engagement to create awareness of the opportunity, and negotiate buy-in in a stepwise manner (one portion of land at a time).
- **Continued extension and support services**: It is anticipated that a form of extension service will be provided where extension staff provide a suite of activities to land-owners and communities on the ground.
- **The implementation of a cost efficient national MRV system**: One of the main obstacles to the roll-out of projects to date has been the high transaction costs associated with MRV through international standards. To address this, a robust and transparent MRV system would need to be created for each of the principal implementation options These MRV structures should dovetail with the national MRV programme currently being developed by DEA, and support existing capacity where possible. An extension officer or established industry structures would undertake the initial monitoring of activities in the field. Taking pertinent monitoring and verification standards for land-use based activities established in 2015 into account, the principle focus for climate change mitigation reporting in future should be operational aspects and the actual implementation of a monitoring framework. An understanding of institutional capacity and governance elements is required to progress towards an efficient system. To date the focus has been narrow and very much on the net change in atmospheric carbon dioxide resulting from

project activities. In future, a broader set of social and biodiversity safeguards may need to be monitored. At the same time, a working monitoring system (comprising remote sensing, field measurements, data-entry, and data-housing and reporting components), provides a potential framework and the capacity to monitor a broader suite of climate change adaptation, ecosystem service, socio-economic, landscape production and degradation parameters, which are required for national reporting to UNFCCC as well as for regional and national strategy development.

- **Economic instruments/ incentives**: Economic instruments and incentives already exist for nature reserves declared on private land through Section 23 of the National Environmental Management: Protected Areas Act (Act No. 57 of 2003). Section 37D of the Income Tax Act (Act No. 58 of 1962) allows a landowner to deduct 4% of the value of the land declared each year over a 25-year period, thus allowing for the full value of the land to be deducted over that period. Section 17 of the Local Government: Municipal Property Rates Act (Act No. 6 of 2004) provides for municipal property rates exemptions on land declared as a nature reserve in terms of Section 23 of the Protected Areas Act. These economic instruments could be further developed and enhanced to enable landowners who declare their land and implement land-use practices that promote the sequestration and storage of carbon to be incentivised and rewarded.
- **Income creation and management**: Further to the economic incentives noted above, the Tier 1 entity needs to pursue and develop a comprehensive funding and financing programme based on an analysis of funding and finance opportunities (Section 7). An understanding of the full scope of work is required, together with the human and institutional capacity that will be required over the long term, including consideration of an appropriate institutional home. In addition, an entity is required to manage the trade of generated emissions reductions that are generated from the programme as a whole, as well as to secure additional, alternative sources of revenue, for example payment for other ecosystem services (water), bilateral funding, national fiscus, accessing new international payment systems for climate change mitigation (Nationally Appropriate Mitigation Action

– NAMAs), and government grants. In terms of location, this would be based within the NFU and would probably require the recruitment of at least one, if not more, Commercial Directors or Fund Managers.

- **Incentive mechanisms and disbursements**: Once income is secured, an effective, cost-efficient, yet flexible disbursement and incentive mechanism is required. An entity to manage the cost-efficient and effective disbursement of generated income to implementation agents on the ground would need to be established.
- **Alignment with national and international policy**: Section 3 of the National Terrestrial Carbon Sink Assessment provides a comprehensive review of the relationship between existing policies and land-use based climate change mitigation measures. The review notes that while there is generally good alignment with policy, there are two principle contentious areas:
  – Consideration of areas under bush encroachment, where climate change mitigation policies may not align with climate change adaptation as well as land degradation, biodiversity and ecosystem service policy.
  – Consistency of agriculture, urban and plantation expansion policies and climate change mitigation and adaptation goals. The Tier 1 entity would be responsible for this coordination to avoid conflicting activities and measures over the long term.

Importantly, areas that have considerable potential for carbon sequestration should be prioritised in policy instruments, and potentially conflicting activities that lead to the loss of carbon stocks must be addressed. This relates more broadly to the protection of ecological infrastructure in general. For example, strategic water source areas are of immense strategic socio-economic importance to South Africa, both for water production and the provision of other ecosystem services, including the sequestration and storage of carbon, and policy should be implemented to ensure that compatible land uses are applied within these areas.

- **Research development**: Practitioners noted that despite some early successes, there is a crucial need for further research into the ecological, operational and monitoring elements of implementation. It is suggested that a scientific unit be located within Tier 1, focusing on hydrology, ecology and socio-economics.

1.6 TIER 2: REGIONAL SCALE (CATCHMENT OR PROVINCE)

For landscape restoration activities, a number of broad outcomes need to be achieved at a Tier 2 level:

1.6.1 The provision of institutional and operational support required to initiate, manage and sustain Tier 3 operations

- This requires an understanding of necessary institutional support as well as barriers and enablers that need to be addressed.
- Beyond merely listing the tasks that need to be fulfilled at a Tier 2 level, an understanding of the operationalisation aspects is required, including consideration of an appropriate home (existing provincial conservation agencies, EPWP regional offices or a new institutional entity), as well as required human resources, logistics and costs.
- Institutional and operational support at a Tier 2 level may include: strategy development for a catchment or region, engagement with relevant government departments (national and provincial), operational support and governance of payment mechanisms, awareness and support services, primary ecological, social and economic research development, alignment with regional policy and similar environmental programmes and initiatives.

1.6.2 Measures required to address the larger-scale indirect drivers associated with landscape degradation

- Following initial gap definition, measures to be implemented may include providing capacity to undertake a regional land-use planning process, empowering local forest and agriculture governance offices to manage permits and access to resources in an appropriate manner, creating market access for livestock and crops, creating economic incentives for restoration, and so forth.
- **Agricultural extension support**: In the past, agricultural extension forums, such as farmer study

groups that collaborated to implement accepted best practices, were widespread in the agriculture sector in South Africa. Through these mechanisms, accepted best practices based on empirical assessments of, for example, veld condition, were well known and widely implemented. Such practices have largely fallen away and empirical assessments are no longer widely undertaken. They are required, however, if farm planning targeted at livestock grazing practices is to be effective. Together with tools such as the SANBI Grazing and Burning Guidelines (Lechmere-Oertel, 2014), practices that promote compatibility of biodiversity conservation and livestock production should be pursued. This requires the re-establishment of professional agricultural extension services that allow for sustainable rangeland management in both commercial agricultural environments and on communal land, following the types of approaches that Conservation South Africa has developed through their Meat Naturally programme.

- **Land-use planning**: The protection of ecological infrastructure, which relates to the protection of carbon stocks and the ability to adapt to climate change, should be embedded in all land-use policy. Furthermore, issues such as carbon sequestration potential and regions of potentially high carbon stocks should be identified in spatial planning instruments such as regional and provincial conservation plans, which may then be translated into bioregional plans as identified in Section 40 of the National Environmental Management: Biodiversity Act (Act No.10 of 2004). As the bioregional plans form the basis for environmental planning in district and local municipal planning instruments such as spatial development frameworks, this will enable areas of high potential carbon stocks to be identified and captured in appropriate national, provincial and local planning instruments, such as the municipal Integrated Development Plans and Spatial Development Frameworks. Such areas should be identified specifically in planning instruments formulated in terms of the Spatial Land Use Management Act (SPLUMA) to ensure that appropriate land uses are applied in areas of high ecological infrastructure importance that will also be important for the protection of carbon stocks.

1.6.3 Regulation and law enforcement

- Regulation and law enforcement should focus largely on existing instruments and ensure that they are appropriately implemented, but efforts should also be made to ensure that conflicting legislation is not undermining efforts to protect carbon stocks. For example, legislation related to the control and eradication of alien invasive plants (AIP) requires that landowners take responsibility and undertake measures to address AIP infestations, but in many instances there is little or no compliance with such legislation.

This is true of many government entities that own and are responsible for land such as provincial and national road and rail authorities. It is incumbent on government to set the example in addressing issues such as invasive alien plant control, which poses a significant threat to carbon stocks and ecological infrastructure in general.

- Potentially conflicting legislative imperatives, which may lead to loss of biodiversity and ecological function with little or no socio-economic benefit, should be addressed. Examples of potentially conflicting legislation include some aspects of the Preservation and Development of Agricultural Land Bill, which seeks to promote the conversion of virgin land to arable land, which may lead to considerable loss of important biodiversity and ecological infrastructure, and ultimately to further loss of soil carbon stocks within grasslands.

1.6.4 Identification of broad areas of interest and specific pilot projects

The intention is not to choose sites that will optimise carbon benefits, but rather a suite of locations that will provide insight into the nature of implementation across the entire country in terms of operational requirements, costs, MRV, climate mitigation and adaptation benefits, as well as social, ecological infrastructure and other non-carbon outcomes.

Pilot projects need to be broadly applicable (that is, scalable) and not once-off examples selected just because they will deliver immediate returns. They will be selected because they cover the range of variation for activities, required implementation models, payment mechanisms, MRV processes, and so forth.

Factors to be considered include:

- Vegetation type, rainfall and geology.
- Carbon stocks, type and level of degradation or threat.
- Type of land tenure.
- Potential activities and associated implementation models.
- Socio-economic indicators (poverty and resource dependency).
- Co-benefits – important areas for water, biodiversity and ecological infrastructure.

A spatially explicit model could be used to identify broad candidate

areas based on existing data and simple GIS-based prioritisation methods. Once the broad areas have been delineated, the identification of pilot projects will require a logical evaluation framework that considers the following principles:

- The public must be made aware of the project, especially those people directly affected.
- Social benefits to the people who live in the area are essential.
- Local residents should be empowered to manage their landscape, rather than having outside teams coming in to do the work.
- An integrated landscape approach must be applied, rather than attempts to restore individual components of the landscape. For example, in a sub-catchment, grasslands, forests and wetlands should be restored together as their ecological functionality is linked.
- Where appropriate, mutually-beneficial partnerships with existing projects should be arranged. Rather than establishing new 'green fields' pilot programmes, collaboration with existing projects may be more expedient, cost-efficient and allow for leverage of existing data and longer-term estimates of outcomes. For the existing initiative, it provides an opportunity to benefit from inclusion in a possible future national programme.

Tier 2 initiatives would be established at each of the Tier 3 pilot landscapes:

- At the start, a set of guiding principles could be applied across all landscapes to facilitate efficiency, effectiveness, completeness, robustness and sustainability over the long term. A suite of regional pilot areas should be developed initially, based on the location of early Tier 3 initiatives.
- To ensure efficiency and effectiveness, Tier 2 capacity should be developed in response to the required list of activities, measures and barriers listed in the inception phase – a bottom-up, context-appropriate response, but leveraging existing capacity and institutions where possible.

1.7 TIER 3: LOCAL SCALE – GRASSLANDS, SUBTROPICAL THICKET AND FORESTS

On-the-ground activities are required to:

- Address direct drivers of degradation.
- Enable the restoration of grasslands, subtropical thicket and forest.
- Facilitate the implementation of small-scale biogas and biomass-to-energy opportunities.

As many local-scale dynamics are poorly understood (for example, costs of implementation, broader business plans or the socio-economic benefits of different implementation models), strategic research and development through early implementation is required. This is not plausible at the outset at a full national scale and therefore a set of early pilot areas that are strategically located to inform national-scale roll-out should be identified.

The establishment of pilot areas will allow for developing and testing approaches and activities that will inform regional- and national-scale implementation.

The success or failure of different implementation approaches and specific rehabilitation activities often

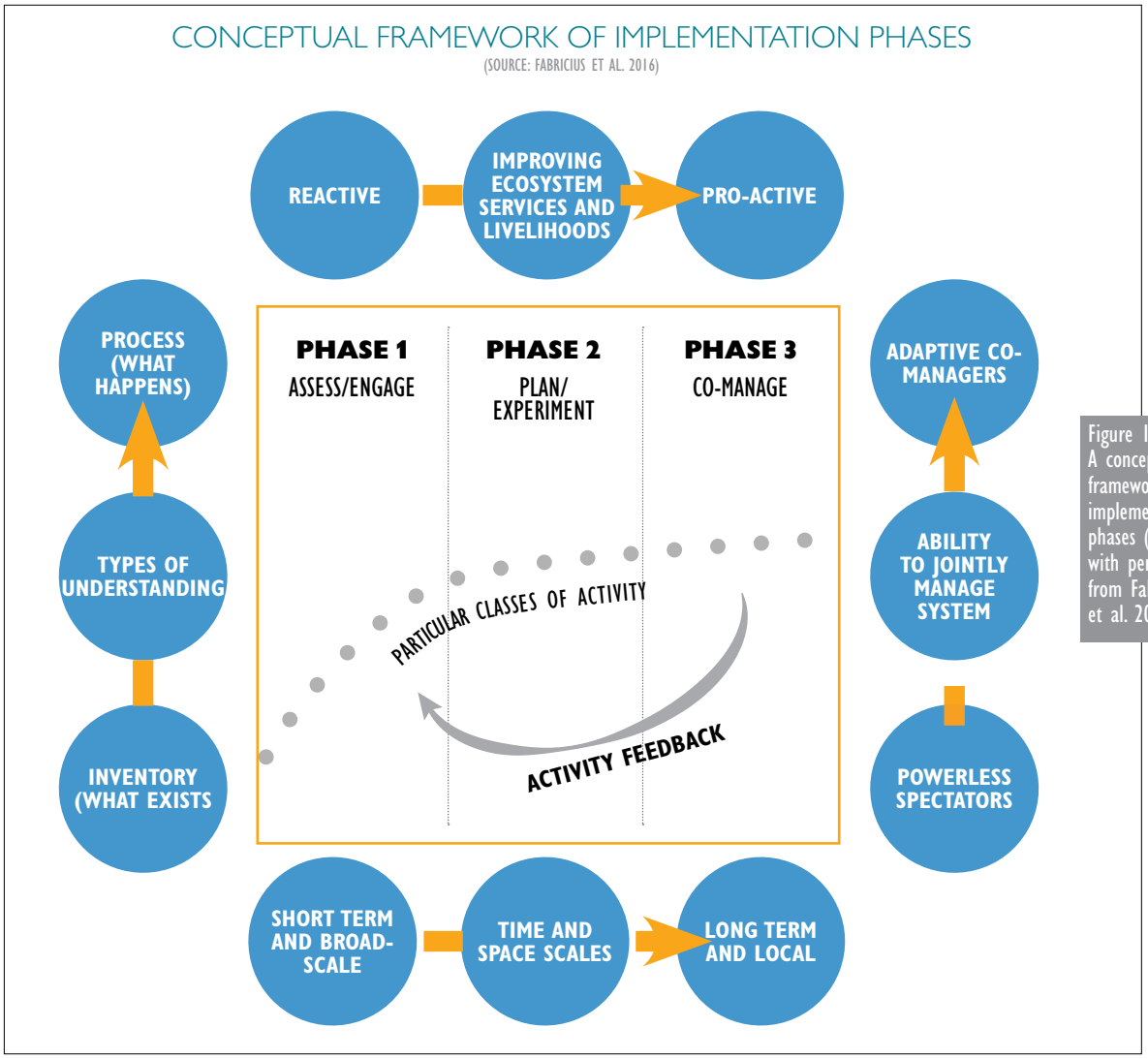


Figure 1.5 A conceptual framework of implementation phases (sourced with permission from Fabricius et al. 2016)

only emerges once implementation is quite far advanced, and it is thus helpful to learn these lessons early on, prior to larger-scale implementation.

1.7.1 The vision, objectives and planning

The restoration objective for a specific area is influenced significantly by what society (especially the local people) considers future landscape desirability, resilience and functionality. Unclear restoration objectives lead to frustration and inefficient use of resources. Determining a restoration objective should be a process that involves local people, that establishes a restoration culture and an underlying ethic of care, and that develops leadership and political support. The example of this process provided by Fabricius et al. (2016) could be adopted and further developed during the course of creating pilot programmes (Figure 1.5). The planning stage should also include an understanding of the broad suite of social and ecosystem service benefits and losses due to implementation, and how these could be addressed within the project time frame. Such planning requires considerable time and financial resources, but it should not be ignored.

1.7.2 Technical scope

A more accurate understanding of the potential scope for halting further degradation and effecting restoration is required for detailed project planning, especially for resource budgeting. Initial estimates can be made based on remote sensing and preliminary models, but these need to be calibrated using field measurements and more accurate models to inform implementation and estimation of climatic and non-climate benefits

adequately. Not all aspects are known and therefore this stage may include a description of future research on the potential for restoration and associated carbon sequestration rates.

1.7.3 Implementation

An understanding of the full suite of potential activities and associated implementation models is needed to ensure the appropriate methods are used. Supporting activities and measures need to be provided to implementing agencies to ensure viability and sustainability over the long term, for example, initial awareness and project development, extension officer services, regional coordination and management, monitoring and reporting
The choice of implementation model will be driven by the type of functions required as well as the particular land-tenure and socio-economic contexts in which they occur. The form of land tenure – state, private or communal – is fundamental to determining the type of implementation structure that will be effective.

An initial set of potential implementation models suggested by experts and stakeholders includes:

- Participatory forest management committees (PFMC).
- Expanded Public Works programmes ('Working for' programmes).
- DAFF regional offices.
- Non-profit organisations.
- Private forestry companies.
- Private farmers.
- Consultants.

Several of these models could be implemented through the regional offices of DAFF or the Expanded Public Works Programme (EPWP, Table 1.1).

The appropriate implementation model will need to be chosen on a case-by-case basis, in a bottom-up manner, dependent on the particular context of operations. The full list of functions – ranging from the initial development of integrated forest and fire management plans, to the day-to-day management of the forest, and then period monitoring – may need to be undertaken by a number of separate entities, but should be coordinated by a local regional office.

1.7.4 Development of restoration pilot projects

Restoration is a long-term process that aims to restore the character (diversity, structure and functioning) of a damaged area. It always requires multiple and divergent activities, as opposed to a specific action, and is only successful if the underlying reasons for degradation are understood and addressed. Any restoration process that only deals with the symptoms of degradation (for example, soil erosion), but ignores the drivers (for example, overgrazing) or the landscape-scale ecological dynamics (for example, the hydrology) is

Table 1.1: Potential implementation models under current Expanded Public Works Programme umbrella

IMPLEMENTING MODEL	COMMENTS
National implementing agents using SMMEs	National DEA office working through implementing agents such as SANParks/Isimagiliso etc. using contractors.
NRM region plus implementing agents using SMMEs	Provincial DEA offices working through implementing agents using contractors (dominant in WC, EC, KZN) – working through cooperative partnerships with traditional authorities, working through parastatals (e.g. through SANParks or Ezemvelo KZN Wildlife – Land-use incentives.
NRM region plus land-user incentives using SMMEs	Provincial DEA offices working through land owners who use small-scale contractors – Working through cooperative partnerships with traditional authorities – Land-use incentives.
NRM region plus land-user incentives using direct employment	Provincial DEA offices working through land owners who uses own labour – Working through cooperative partnerships with traditional authorities – Land-use incentives.
NRM regional using SMMEs	Provincial DEA offices working directly with small-scale contractors (dominant in FS, Lim, NC, MP).
National implementing agent with direct employment	National DEA office working through implementing agents such as SANParks/Isimagiliso etc. using own/direct labour – Public private partnerships (PPP, e.g. Working on Fire).
Regional SMMEs and Regional IS	Private contractors –- Land-use incentives.

doomed to failure. It is imperative that a systematic and integrated landscape approach to restoration is followed. Furthermore, in most rural landscapes, the underlying drivers of degradation are almost always related to human activities, and it is important to involve the local people affected by the restoration process to ensure they become empowered custodians of their landscape as opposed to powerless observers of a well-intended but ultimately futile intervention.

Technically, restoration of ecosystem structure, resilience and functionality integrates several activities over a period of time and can almost never be achieved with a single activity. Grassland restoration will often include activities such as improving grazing and fire management, clearing invasive alien plants, soil stabilisation, and the localised re-establishment of plants through re-seeding or re-planting.
It is thus important to consider the following when developing a restoration project:

- **Vision and plan**: Clarity of vision of why and how restoration should take place, including how the land will be used after restoration, is essential for long-term sustainability. This vision must form the basis for a clearly-articulated restoration plan.
- **Technical scope**: An accurate understanding of the scope for restoration can be made based on remote sensing and models, calibrated using field measurements.
- **Implementation**: There is a significant knowledge base concerning every aspect of restoration of grasslands, including project models and management, human resources and technical knowledge. This prior knowledge must be taken into consideration.
- **Resources**:
  - **People**: Restoration requires people with wide-ranging skill-sets, including people with local knowledge, restoration practitioners, social scientists, the local community and land-owners or users.
  - **Time**: The time needed to properly restore a degraded landscape is often under-estimated and most project time-frames are too short to achieve meaningful success.
  - **Money**: The amount of money required to restore a degraded landscape is also often under-estimated and most project budgets are too small to achieve meaningful success. The more degraded a site is, the more expensive it is to restore.
  - **Monitoring, reporting and verification (MRV)**: Measurement of success will depend on baseline data, appropriate monitoring and then clear reporting. In some cases, independent verification of the results may be appropriate.

SECTION TWO

GRASSLANDS RESTORATION AND MANAGEMENT

2 GRASSLANDS: INTRODUCTION

2.1 WHAT AND WHERE ARE THE GRASSLANDS?

The Grassland Biome dominates the central and eastern parts of South Africa, covering almost one third of South Africa's land surface, and extending through much of the Gauteng, Free State, Eastern Cape, Mpumalanga and KwaZulu-Natal provinces. Grassland also occurs as a mosaic with other vegetation types in other biomes, such as the Indian Ocean Coastal Belt and the Savanna Biome. Unsurprisingly, grasslands are visually dominated by various species of indigenous grass. However, in terms of species composition there is often also a very high diversity of non-grass plants, especially bulbs and soft-leaved herbaceous plants (collectively called forbs) and ferns. Scattered trees or tree clumps may also be present, but their canopy cover is negligible.

Grasslands span an altitudinal range from sea level to more than 3,000 m, and include highly varied topography – from the sandy coastal plains and rolling hills adjacent to the coast, through the steep slopes, valleys and ridges of the sub-escarpment, up onto the peaks and plateaus of the high escarpment and into the rolling plains of the Highveld. This topographic variation is underlain by significant changes in geology and soils, and further influenced by significant climatic gradients – all of which lead to an incredible diversity of grassland vegetation types distributed across these complex environmental gradients. The grassland biome

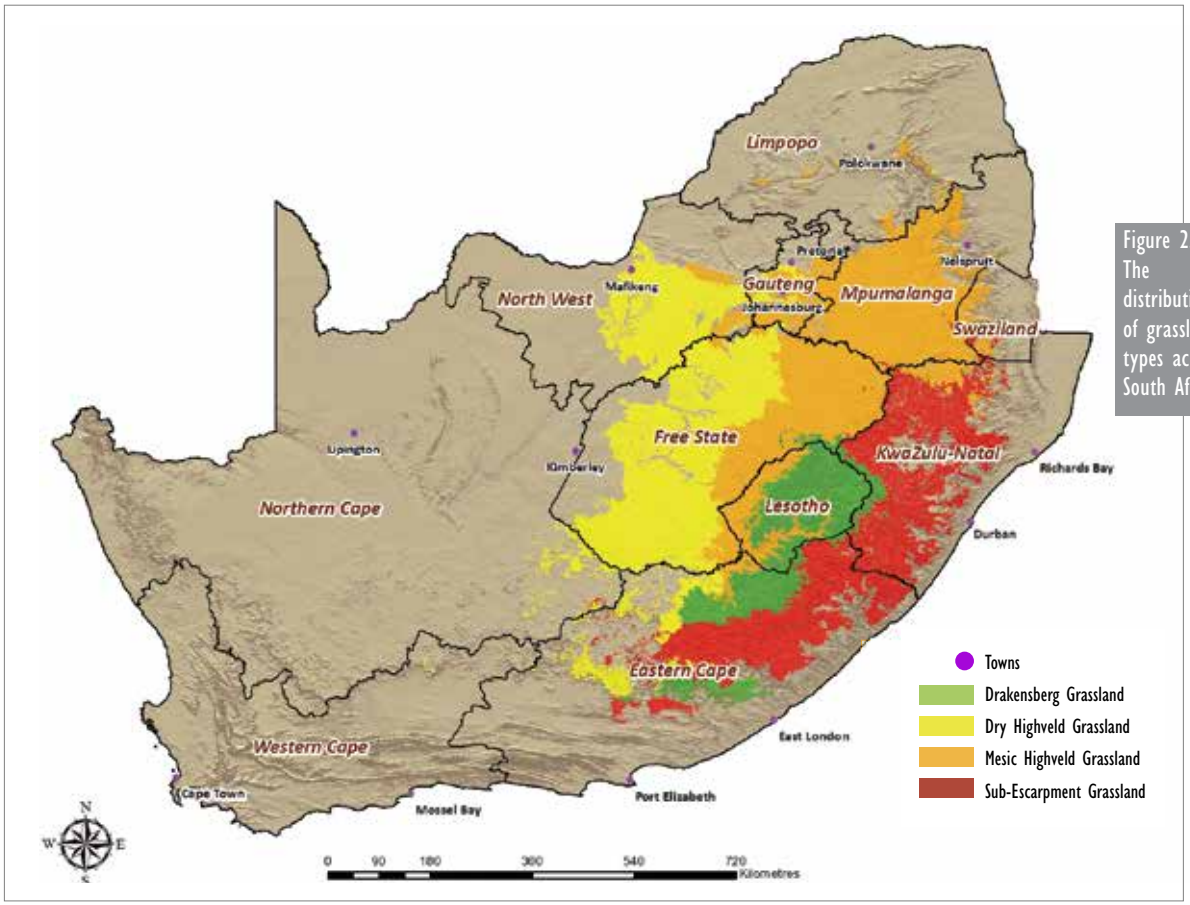


Figure 2.1: The distribution of grassland types across South Africa.

includes 72 grassland vegetation types, differentiated by shifts in species composition that result from the interplay of these environmental variables. The environmental patterns influence other ecological driving processes, such as grazing and fire that give rise to further differentiation of grassland vegetation types.

Grassland vegetation types can be arranged into five broad groups based on the species composition, community structure, abiotic (that is, 'non-living') environmental factors, and ecological characteristics:

- Dry Highveld Grassland.
- Mesic Highveld Grassland.
- High Altitude Grassland.
- Sub-escarpment Grassland.
- Coastal Grassland.

Within each broad grassland ecosystem group, the plant communities share similar structure and species composition, and are maintained by similar ecological processes. This means that they can be expected to respond similarly to the land uses that take place within them and so have similar planning and management requirements.

Many grasslands have separate but integrated ecosystems that are present as a mosaic within the grassland landscape, such as wetlands, rivers, and indigenous forest patches. These often have related ecological processes that cannot meaningfully be separated from the matrix grasslands. For example, wetland and riparian dynamics are often determined by the state of, and processes in, the catchment grasslands. Similarly, forest patches are not ecologically isolated from their surrounding grasslands, especially regarding the prevalence and nature of fire.

The average consumption of wood for fuel in South Africa is estimated at 4.5 tons per household per annum. This estimate was based on a study published by the Programme for Basic Energy and Conservation, a regional

(Damm and Triebel, 2008)

2.2 WHAT IS THE VALUE OF GRASSLANDS?

Grasslands are a vital natural asset, and their protection, rehabilitation and sustainable use is a national priority. Other than their intrinsic value, grasslands provide valuable natural solutions to the challenges posed by poverty, unemployment, and climate change. Their rich store of biodiversity, diverse ecosystems and abundant ecological infrastructure provides the foundation for economic growth, social development and human well-being.

Grassland landscapes are home to:

- 40% of South Africa's human population.
- 60% of the country's commercial crops and 50% of subsistence croplands.
- 45% of the country's cattle and 30% of its sheep.
- 92% of the country's commercial plantation forestry.

South Africa's grasslands are an irreplaceable biodiversity asset of global significance, and grassland ecosystems are also home to many of the country's rare, endangered and endemic animal species, including 52 important bird areas, one third of South Africa's 107 threatened butterflies, 15 endemic mammals and nearly 3,500 plant species.

Grasslands are critically important water production landscapes and provide the natural resources and ecological infrastructure that supports most of South Africa's important economic activities, and millions of rural livelihoods. Some of the most important

ecosystem services provided by grasslands include:

- **Water production, water purification and flood attenuation**. Grasslands are particularly important for water security, playing a vital role in maintaining the quality and quantity of water entering rivers, streams and aquifers. The above and below ground nature of grassland vegetation is optimal for capturing water, maximising infiltration, limiting erosive run-off and reducing soil loss. In this way, grasslands account for almost half of the Strategic Water Source Areas of the country – areas that cover less than 5% of South Africa's land surface, but that receive most of its rainfall, and yield more than 80% of all water run-off. Many major river systems have their headwaters in grasslands, and 43% of the country's remaining wetlands occur in grassland landscapes.
- **Good quality forage for animal production**. Grass-fed livestock plays a very important role in the formal and informal agricultural economy, with the national herd comprising over 15 million cattle and 25 million sheep (FAO database, 2006). Grasslands are the foundation upon which this industry exists.
- **Nutrient-cycling and carbon sequestration and storage**. Natural grasslands provide a massive service towards the cycling of nutrients and storing of carbon, hence the importance of this project. (Details of carbon storage are elaborated upon later in this document).
- **Support for local livelihoods**. Although largely unquantified, many families living in communal areas rely heavily on grasslands for food and medicinal plants as well as natural products that are used in their daily lives, such as for building, thatching and weaving.
- **Cultural, heritage and recreational amenities, often with significant tourism value**. South Africa's grassland landscapes are an important part of our national heritage and they provide many opportunities for the nature-based tourism economy. Examples include the world-famous uKuhlamba-Drakensberg Park World Heritage Site (KwaZulu-Natal), Mountain Zebra National Park (Eastern Cape), and Songimvelo Nature Reserve (Mpumalanga).

2.3 PEOPLE IN GRASSLANDS

Grasslands generally occur in areas that are very amenable to human habitation. Grasslands are a rich source of resources for addressing economic, job creation and social upliftment challenges, but many of the current land-use practices in grasslands are unsustainable, and grassland ecosystems and resources are coming under increasing pressure from a variety of competing land uses. Such pressure has resulted in 40% of the grassland biome being irreversibly modified. Some 60% of remaining grassland areas are threatened – vital aspects of their composition, structure and functioning are deteriorating. This influences their ability to deliver essential services such as fresh water, soil formation, climate regulation and reduction of disaster risk. With less than 3% of grasslands under formal protection, remaining grassland landscapes, and the biodiversity and ecosystems they support, are critically at risk.

South Africa has a relatively complex landownership context, with four broad categories of land tenure making for very different approaches to implementing land restoration work.

- 70% of the country is privately-owned farmland under freehold tenure. Freehold farms are characterised by clear boundaries, exclusive rights of use, and commercial farming objectives. The landowners can trade with their properties and use their title as collateral security.
- 14% of land in South Africa is communally-managed state land characterised by open access rights to grazing areas and subsistence agriculture. Individuals or families are granted rights by a traditional authority (such as a tribal chief) to occupy and use a portion of the land, but they do not have title for the land and hence cannot sell, trade or access capital using the land. Within such grasslands, degradation is often likely to occur because of variations of the tragedy of the commons dynamic. Deteriorating traditional leadership in some areas is leading to abuse of communal grazing lands and their subsequent degradation. Land tenure issues can hamper the introduction and adoption of improved management practices.
- 5% of land that was under private ownership has been restituted to the families or communities that originally occupied it prior to the large-scale resettlements that occurred during the apartheid era. These land-restitution areas are generally managed in a communal manner, and will be considered as such in this document.
- 10% of land in the country is owned and formally conserved by the State as national and other parks. Other entities and state departments, such as Public Works, Housing, and various municipalities also own land, which is used for a variety of purposes.

2.4 DRIVERS OF DEGRADATION IN GRASSLANDS

Understanding the dynamics that drive ecosystem degradation and species loss in grasslands is important to planning or implementing rehabilitation efforts. Direct drivers are those that affect the land and vegetation in themselves, while indirect drivers are often 'unseen' dynamics that cause a cascade of other effects that result in a direct driver occurring.

DIRECT DRIVERS

Poor range management practices dominate direct processes, although the following all have an impact:

- Non-sustainable farming practises (no crop rotation, over-fertilisation, inefficient irrigation, etc.).
- Shifting slash-and-burn subsistence cultivation.
- Subsistence or commercial use of medicinal plants.
- Inappropriate fire use.
- Poor grazing practices (over-, under- or selective-grazing).
- Bush-encroachment.
- Exposure of soil leading to soil erosion.
- Spread of invasive alien species.
- Encroachment by karroid species.
- Habitat loss or fragmentation due to modification by urban development, increased game fencing, roads, and other infrastructure.

INDIRECT DRIVERS

Indirect drivers may include:

- Poor regulation and control of cultivation on virgin land.
- Poor government extension services to promote sustainable agriculture.
- Poverty leading to increased reliance on natural resources for survival, with few alternatives or incentives.
- Poor enforcement of existing laws and policy.
- Economies of scale trends in agriculture forcing farmers to expand their operations.

Many of these indirect drivers also apply to other biomes, and can only be addressed at a regional or national scale. More detail is provided in Section 1 (Tiers).

Prior and significant initiatives within the grasslands biome

EXISTING INITIATIVES	DESCRIPTION
SANBI Grasslands Programme https://www.sanbi.org/biodiversity-science/science-policyaction/mainstreaming-biodiversity/grasslands-programme	Partnership between government, non-governmental organisations and the private sector to mainstream biodiversity into the grassland biome, with the intention of balancing biodiversity conservation and development imperatives in a production landscape. The programme was catalysed through an $8.3 m investment from the Global Environment Facility (GEF), managed by the United Nations Development Programme (UNDP) and implemented by the South African National Biodiversity Institute (SANBI) and approximately 26 partner organisations. The programme relies on partnerships to mainstream biodiversity objectives into the major production sectors that operate in the grassland biome. These include agriculture, forestry, coal mining, and urban economies, as well as the enabling environment. The programme was launched in 2008 and closed in December 2013 with the end of the UNDP-GEF investment.
Enkangala Grasslands Programme	Programme run by WWF-SA focused on the escarpment areas in the Free State, KwaZulu-Natal and Mpumalanga, all within the grassland biome. Strong focus on the protection of remnant habitat within agricultural landscapes and a particular focus on the protection of strategically important water resource areas. Uses biodiversity stewardship as the primary mechanism to secure land. Has led to the creation of a number of newly declared protected environments and nature reserves.
uMngeni Ecological Infrastructure Partnership www.sanbi.org/news/umngeni-ecological-infrastructure-partnership-ueip-strengthening-collaborative-water-governance	Partnership between a range of organisations from the NGO, research, local, provincial and national government sectors. The efforts of the partnership are closely related to SIP 19 with a strong focus on securing the strategically important water resources that are fundamental to the economy and human livelihoods in the main urban and economic centres of KwaZulu-Natal. The UEIP will play a key enabling role in implementing SIP 19.
GEF 5 Programmes – Mainstreaming www.thegef.org/project/mainstreaming-biodiversity-land-use-regulation-and-management-municipal-scale	Programme focused on four district municipalities in South Africa: Cape Winelands District Municipality in the Western Cape, Amathole District Municipality in the Eastern Cape, Ehlanzeni District Municipality in Mpumalanga, and uMgungundlovu District Municipality in KwaZulu-Natal. The last three municipalities all contain significant areas of grassland. The focus of the mainstreaming programme is to better integrate biodiversity and related issues such as climate change into municipal policy and planning.
GEF 5 Programmes – Protected Areas	Programme focused on improved management effectiveness of key national parks and their buffer areas in South Africa. In some instances, this means consolidating the protected areas in an effort to secure key ecological processes. For instance, securing strategic water source areas in the escarpment grasslands of Limpopo and Mpumalanga provinces, which form the primary watersheds of a number of the large rivers that flow through the Kruger National Park. The areas are being secured through the Protected Areas Act using biodiversity stewardship.
GEF 6 Programme www.thegef.org/country/south-africa	This programme will succeed the GEF 5 Programme, and will focus on land degradation, climate change and biodiversity. Approximately US$46 million has been indicatively allocated to South Africa for the programme.
Biodiversity Economy/ Bioprospecting	In 2016 the Department of Environmental Affairs (DEA) and the Department of Tourism held a six-week Biodiversity LAB aimed at unlocking South Africa's biodiversity economy, which focused primarily on the wildlife ranching sector and bioprospecting. This built on the South African Biodiversity Economy Strategy developed by DEA, which seeks to transform the wildlife ranching sector, transferring ownership of wildlife ranches and game to previously disadvantaged black communities. Bioprospecting focuses on unlocking opportunities to develop new medicines and pharmaceuticals from plants and other natural resources used as traditional medicines. Although a number of plants in traditional medicine originate in grasslands, there is limited potential for the wildlife ranching industry within the Grasslands Biome because many of the large charismatic species are confined to the Savanna Biome. Nevertheless, opportunities to develop the wildlife ranching industry in suitable grassland areas, with suitable wildlife species, may be pursued through this programme.

EXISTING INITIATIVES	DESCRIPTION
Maputo-Pondoland-Albany Subtropical Hotspot www.cepf.net	The Critical Ecosystems Partnership Fund (CEPF) funded a five-year biodiversity conservation programme, focused on the Maputo-Pondoland-Albany Subtropical Hotspot, which covers much of the north-eastern part of the Eastern Cape, most of Kwazulu-Natal, parts of Mpumalanga, Swaziland, and the southern part of Mozambique. The areas covered includes extensive areas of grassland. The CEPF project used biodiversity stewardship as the primary tool to secure land, leading to the creation of a number of new protected areas in the grassland biome, which covered a range of grassland types from coastal grasslands in the Pondoland Centre of Endemism to high altitude grasslands in the Drakensberg.
Offset programmes – For example, N2 and Spring Grove Dam	An offset being implemented in the grassland biome is the newly-established Spring Grove Dam, which has been constructed by the Department of Water Affairs and Sanitation to enable an inter-basin transfer from the Mooi River catchment into the uMngeni River catchment. As part of the environmental authorisation for the dam, an offset was required to compensate for the loss of grasslands, wetlands and river channels. The offset is being secured using biodiversity stewardship to create new protected areas. Over 1,800 ha of grasslands will be protected through this mechanism. Landowners are incentivised to enter the offset through the provision of financial support for wetland restoration and improved livestock grazing practices, which include the realignment of fences and relocation of water points. The offset envisaged for the proposed N2 development through the Eastern Cape will provide the opportunity to secure several important areas of remnant grassland within the Pondoland Centre of Endemism.
Conservation South Africa's Meat Naturally Programme www.conservation.org/publications/Documents/CI_South-Africa_CSA_Meat-Naturally-Sustainable-Farming_Factsheet.pdf	Programme focused on enabling rural communities to develop opportunities to breed and sell cattle commercially while improving historically damaging communal grazing practices that have led to overgrazing and the degradation of grasslands. The programme is based on the use of herders to control grazing practices and allow for the rotational rest and recovery of areas that have been utilised for grazing. The flagship project for the programme is the Umzimvubu Demonstration Project, being implemented in more than six villages. Cattle gained weight and condition through the improved livestock management applied in this programme and several community members received relatively substantial amounts for the sale of their cattle on auction. The programme provides a model for improved communal rangeland management that has significant potential to improve rural livelihoods through sustainable livestock production.
Research – SAEON and NRF http://gfw.dirisa.org	Tertiary institutions such as universities are conducting a range of relevant research on grassland ecology and conservation in South Africa that is being coordinated at a national level, for example, research by the South African Environment Observation Network (SAEON) and the National Research Foundation (NRF) on the Grasslands-Forests-Wetlands Node. The objective of the node is to create and maintain integrated observation platforms that provide long-term, rare parameter data sets on the hydrological, energy balance and carbon cycles, and the interlinked processes within these. SAEON intends to use the long-term observation platforms to facilitate improved process understanding research through collaboration with academic partners, to reduce uncertainty surrounding the impacts of human-induced global change on ecosystem services at regional scales. The nodes COSMOS Probes are located at Mike's Pass in the Cathedral Peak region of the Drakensberg.
SIP 19	Programme focused on the protection of strategically important water resources that play a critical role in supporting human livelihoods. One of the focuses of SIP 19 is on securing the ecological infrastructure within the uMngeni River Catchment, which is fundamental to the water security of Pietermaritzburg and eThekwini Municipality (Durban). SIP 19 will focus on protecting remnant habitat, and implementing ecological restoration and rehabilitation efforts in an effort to ensure properly functioning grasslands and wetlands to ensure the protection of water resources.

3

GRASSLANDS: DEFINING THE GAP – STATUS QUO VS NATIONAL READINESS

3.1 LAND USES AND REQUIRED ACTIVITIES

GRASSLAND CONTEXTS

Grasslands can be described in a variety of ways, but in terms of this work it is best to view them as being in one of five contexts:

- Grasslands in protected areas.
- Grasslands on communally-managed land.
- Grasslands under state (but not conservation) management.
- Grasslands under private management.

The context will influence the timing, responsibility and type of activities that should be applied to the various land-use or mitigation scenarios.

Within the significant heterogeneity of South Africa's Grassland biome, stakeholders and experts identified a set of common land-use types that cover most of the biome, and a set of activities that are required to achieve the national readiness. The activities may apply to any number of the land-use types. Each land use and activity is described in more detail in Table 3.1.

GRASSLAND LAND-USE TYPES

- Arable – current fields (within 10 years of last use).
- Arable – old fields (last use more than 10 years ago so successional recovery to grassland has started).
- Natural grassland (across a gradient from pristine to degraded, including over-sown or 'improved' grasslands).
- Heavily eroded areas – sheet erosion.
- Heavily eroded areas – gulley erosion.
- Areas heavily invaded by alien invasive woody plants such as bramble, wattle or gum.

GRASSLAND ACTIVITIES

Control of Alien Invasive Plants (AIP)

Alien invasive plants are not a new problem in South Africa and considerable research into their ecology and control has been undertaken over the past fifty or so years. The national Agricultural Research Council as well as several university-led programmes have had a strong emphasis on research into AIP control. Although there is always scope for further research, lack of information and understanding is not generally the limiting factor in AIP control in South Africa. One exception may be the poor understanding of manipulating natural successional

processes over time to out-compete AIP, as opposed to more active (and therefore expensive) eradication and follow-up control that is currently practiced.

The methods of active control, including follow-up work, are well understood but not always well implemented. Currently there are strong government (such as EPWP – Working for Water) and NGO programmes (for example, WWF Water Balance) that tackle invasive plants in grasslands, focusing on the local eradication of water-thirsty invasive trees such as wattle, eucalyptus and pine. The biggest problem seems to be the lack of follow-up work, so areas that were cleared become re-infested, often making the problem worse. The rehabilitation of recently-cleared areas can also be a problem, especially in areas that were once heavily invaded. Clearing AIP exposes the soil surface, which can lead to catastrophic erosion if there is no attempt to revegetate the area. There is a lot of scope for ensuring these initiatives are strategic in terms of their geographic interventions, and that adequate follow-up is done.

Burning and grazing (range management)

Burning and grazing have many inter-related dynamics and cannot meaningfully be treated separately. The ecology of fire in South Africa's grasslands is reasonably well understood, although there are some areas of contention among the academic and agricultural specialists. Fire protection is a significant issue in South Africa and legislation obliges landowners to protect against unplanned fires. In many parts of the country Fire Protection Associations exist to help landowners implement the fire protection requirements. However, judicious burning can make a significant contribution to improving grassland condition, especially when used as part of a coherent management plan that includes good grazing practice. The use of fire for active rehabilitation and manipulation of grasslands towards a desired state is currently the focus of several university research programmes, and there are very promising understandings and methods emerging from these.

The key to good grazing practice is understanding what the limits of use are for any particular grassland landscape. The carrying capacity of grassland can be estimated using relatively simple techniques, and it is extremely bad for grasslands to have on-going grazing pressure that exceeds this limit. There are various rotational grazing systems that can be applied for livestock, and although they each have pros and cons, the key factor is ensuring that there is a full season's rest every 3–4 years.

A significant limiting factor for better rangeland management is the lack of extension services to help farmers and communities design and implement good grassland management plans. Although there are several guidelines for good burning and grazing practice, there is no 'one size fits all' management system for all grassland types and farming situations. Unavoidably, a locally applicable management plan needs to be designed by a specialist agricultural grassland ecologist and implemented by extension officers. This is particularly the case in communal areas, which may require ongoing management input to achieve the desired management goals.

Anti-erosion structures

The control of erosion is a vital part of grassland protection and restoration. Without the top

soil layers in place, it is difficult to restore grasslands or to sequester any carbon. The key to soil protection is preventing it from eroding in the first place, especially in relatively intact grasslands. The primary reason soil erosion (which is a natural process) is sometimes accelerated in grasslands is the reduction of basal plant cover, mostly in response to overgrazing and poor fire management. Thus the control of grazing, and the concurrent use of fire, is fundamentally important in preventing accelerated soil erosion.

In areas where basal cover has already been lost and sheet and gulley erosion has started, there is a need to prevent or slow down the erosion process artificially. The various options for erosion control structures are well understood, but using the correct methods in a specific area requires an understanding of topography, soil, climate and local conditions. Re-establishing some form of vegetation cover is an important part of the process.

Revegetation

In grassland landscapes the sequestration of carbon into the soil relies on a functional grass sward. Where basal cover has been reduced or lost, it is vital to re-establish vegetation as this will help prevent soil erosion and infestation by alien plants. The goal of revegetation needs to be clear and it is important to have the site under good management control prior to initiating any work. For example, all efforts to revegetate an area can be completely undone if grazing is permitted too soon, which is sometimes a risk in areas under communal management.

Options for revegetation vary according to the goals and scale of the project. There is considerable knowledge of and experience in using various commercially available grass species, such as Vetiver or Eragrostis, to revegetate areas that are actively eroding. More complex and less understood is revegetation using local indigenous species, although there have been some attempts to do this. Revegetation programmes require significant initial investment in specialist technical planning to ensure that the landscape has been correctly interpreted and that the various revegetation methods are correctly matched to the goals.

Conservation agriculture

In those parts of the Grassland Biome that have been converted to timber or arable fields, the original grassland vegetation has been entirely replaced with a mono-culture crop. It is not possible to retain biodiversity in such areas, but there are several good practice principles that can be applied to improve the protection and water and nutrient (including carbon) status of the soil. A significant amount of information on zero tillage, mulching and not burning, using push-pull animal pest control, and other such principles is available. As with the grazing and burning plans, the issue is not a lack of knowledge but rather a lack of extension facilities and staff to convey existing information to farmers (especially communal farmers). Such capacity needs to be created and sustained over the long term and have adequate institutional support.

Table 3.1: Potential grassland restoration activities that could be impl

LAND USE ACTIVITIES
Arable – Current fields (<10 years of last use)
Arable – old fields (Last use >10 years ago)
Natural grassland (Gradient from pristine to degraded, including over-sown or 'improved' grasslands)
Heavily eroded areas Sheet erosion
Heavily eroded areas Gulley erosion
Areas heavily invaded by AIP

emented in each form of land use.

	ALIEN INVASIVE PLANT (AIP) CONTROL	BURNING	GRAZING	ANTI-EROSION STRUCTURES	REVEGETATION	CONSERVATION AGRICULTURE
	n/a	n/a	n/a	n/a	n/a	Apply appropriate techniques to improve soil health, such as zero-till, contouring, mulching, not burning residues, reduced fertilisation.
	Annual cut/spray to prevent establishment of AIP infestations (only if follow-up is guaranteed, or the problem becomes worse). Alternatively, a directed successional approach can be adopted in some circumstances.	Aim for periodic hot fires (every 4–5 years) to prevent bush encroachment.	Aim for a non-selective grazing regime with a full season's rest every three years followed by a hot burn.	Use appropriate technology and structures to prevent sheet or gulley erosion in areas where the soil is exposed.	Sow indigenous grass seeds on larger areas. Plant indigenous grass plugs in smaller areas. Withhold grazing until grasses have properly established.	Establish a thick mulch layer to protect soil and prevent the germination of weed and AIP seeds.
	Annual cut/spray to prevent establishment of AIP infestations. Prioritise new or expanding AIP infestations.	Develop a fire management plan to prevent grassland becoming moribund, and which prevents bush encroachment.	Aim for non-selective grazing pressure with 1 full season rest every 3–4 years.	Use appropriate technology and structures to prevent gullies forming in localised areas such as livestock paths, water troughs and feedlots.	Plant indigenous grass plugs in areas where localised destruction of grassland has occurred, such as around water points.	Apply SANBI burning and grazing best practice guidelines to all grazing lands.
	Annual cut/spray to prevent establishment of AIP infestations.	Withhold fire until fully re-vegetated.	Where appropriate, use high intensity short-duration grazing to promote the ecological dynamics that assist re-vegetation.	Use appropriate technology and structures such as rock lines, logs, brush-strips, hollows, mulching, or geomats.	Plant rows of vetiver grass along the contours. Sow indigenous grass seeds on larger areas. Plant indigenous grass plugs in smaller areas. Withhold grazing until grasses have properly established.	Establish a thick mulch layer to protect the soil and prevent the germination of weed and AIP seeds.
	Annual cut/spray to prevent establishment of AIP infestations.		Where appropriate, use high-intensity short-duration grazing to promote the ecological dynamics that assist re-vegetation.	Use appropriate technology and structures such as reshaping, gabions, brush packs, etc., to prevent further head erosion and to stabilise the gully walls.	Plant vetiver grass to stabilise the walls and floors of the gulleys. Plant hardy indigenous trees to help stabilise the gulleys. Withhold grazing until grasses have properly established.	n/a
	Design a landscape-scale clearing plan prioritising newer infestations that has sufficient emphasis on rehabilitation of cleared areas.	Use hot fire to control woody invasive plants and stimulate mass germination of AIP seeds which can then be killed with chemicals.	Under certain conditions use livestock to help crush dense infestations of AIP, especially bramble. This should be followed by active rehabilitation.	Use appropriate technology and structures to stabilise the exposed soil, such as rock lines, logs, brush-strips, hollows, mulching, or geomats.	Plant rows of vetiver grass along the contours. Sow indigenous grass seeds on larger areas. Plant indigenous grass plugs in smaller areas. Withhold grazing until grasses have properly established.	Following clearing, establish a thick mulch layer to protect the soil and prevent the germination of weed and AIP seeds.

3.2 GRASSLANDS: NATIONAL AND PROVINCIAL-SCALE MEASURES (TIER 1 AND TIER 2)

When all the activities and land-use scenarios detailed above have been considered, several key requirements need to be in place for restoration of grasslands to be implemented at a national, regional or local scale (Table 3.2).

Table 3.2: National requirements for grassland restoration and management

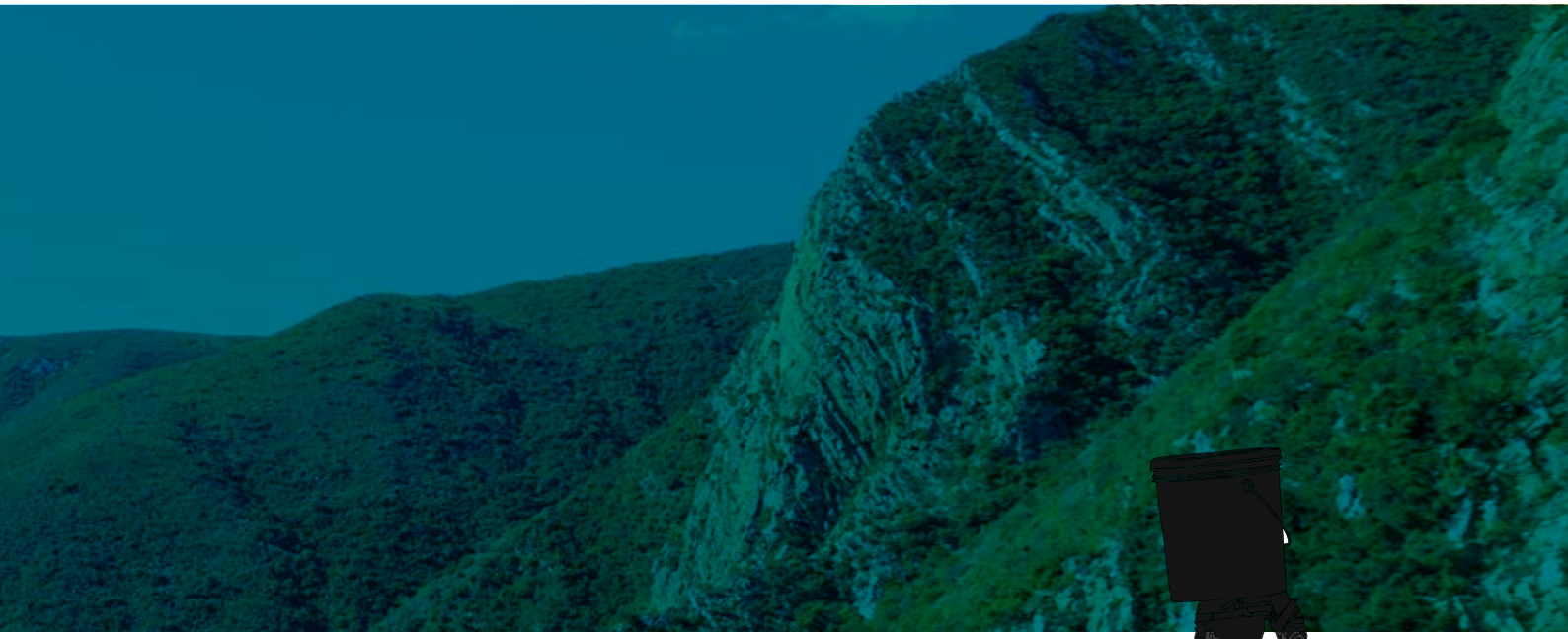
REQUIREMENT	STATUS QUO
A clear spatial plan for grassland biome vegetation types, and conservation value and priority.	Reasonable maps exist for the current distribution of grasslands types, and there has been prioritisation of these (at a national, provincial and regional level). Essential local information is needed to identify suitable project sites.
The distribution of AIP is well mapped, and each administrative region has clarity on their priority clearing goals. All institutions that have part responsibility for AIP control are coordinating their efforts in grasslands. Regional AIP control budgets reflect the state of priority in that region.	Although reasonable maps do exist for AIP distribution in grasslands, they are quite dated. Clearing efforts to date have been ineffective because of lack of coordination between departments and poor follow-up, often as a result of a lack of resources.
Strong provincial and national conservation authorities that are mandated, resourced and able to ensure effective grasslands conservation and restoration.	The national and provincial conservation departments are generally under-staffed and under-funded and largely ineffective in their management (with some exceptions).
Implementation of relevant conservation, agricultural and land care legislation.	Understanding and enforcement of the existing laws is ineffective. Very limited capacity to police the huge areas of grasslands. Little political will to enforce some of the laws in communal areas.
Strong support and incentives to develop nature-based economies in grasslands, such as grass-friendly beef and ecotourism.	Some strong support from NGOs for local projects. Weak support from relevant government departments. Limited funding and finance opportunities. Confusion and administrative obstacles to the establishment of small-businesses.
Clear land tenure in freehold areas and strong traditional authorities in communal areas.	Most grassland occurs in communal areas and there is often unclear traditional authority jurisdiction or lack of traditional leadership authority to enforce any management plan. Many privately-owned areas are currently subject to land claims, so future ownership and authority structures are unclear.
Monitoring, reporting and verification of carbon stocks and fluxes (MRV ability).	Poor capacity within state departments to do MRV. Technical capacity exists in tertiary and research institutions (e.g. SAEON), but capacity and funds are limited.
Good understanding of succession and recovery dynamics of grasslands.	Considerable research and practical experimentation has achieved a measure of success in understanding the management and restoration dynamics of grasslands. Further research will improve on this knowledge base, especially in terms of restoring a large suite of biodiversity.
Strong support for community-based carbon mitigation projects.	Little extension support available.

3.3 GRASSLANDS: INDICATIVE FIELD IMPLEMENTATION COSTS

The cost of grassland restoration is highly site specific and very difficult to predict accurately. Published costs of restoration are not easily understood as some only provide aggregate costs, and others only capital or labour costs. Scale adds another level of complexity, as the relative costs vary according to the size of the area. Some studies only report direct costs, while others also include in-kind or indirect costs. The costs also vary as a function of the specific ecosystem, the degree of degradation, the goals and specific circumstances in which restoration is carried out, and the methods used. Such complexity makes it difficult to extrapolate between projects or to make predictions for future projects accurately. For comparative purposes, and to demonstrate the range, some published restoration costs are provided (adjusted for 2015 prices):

- Restoring grasslands in the Drakensberg (Blignaut et al., 2010):
  - R20/ha for improved fire management.
  - R10,000/ha for re-seeding after intensive grazing.
  - R90,000/ha for restoring gullies.
- Restoring vegetation after mining (Crookes, 2012)
  - R31/ha for bio-control.
  - R70,000/ha for re-seeding and fertilisation after mining.

Despite the uncertainty associated with restoration budgeting, it is important to develop a standard budget model that can be used to provide a best estimate.



SECTION THREE

SUBTROPICAL THICKET RESTORATION AND MANAGEMENT

4

SUBTROPICAL THICKET: INTRODUCTION

4.1 WHAT AND WHERE IS SUBTROPICAL THICKET?

Subtropical thicket has strong biogeographical links to both savanna and Karoo vegetation types, and has previously been classified within each of these biomes. It leans towards being a dense savanna (Rutherford and Westfall, 1986; 1994; Rutherford, 1997; Scholes, 1997), but it is dominated by dwarf shrubs and succulent plant forms that are more reminiscent of the Karoo. It has recently been given its own status as a biome (Low and Rebelo, 1996) because of its unique combination of growth forms and species compositions. Structurally, Subtropical Thicket comprises an overstory component of evergreen hard-leaved shrubs (Everard, 1987), with a mix of subtropical forest and savanna tree species (Holmes and Cowling, 1993), and an understory comprising grasses, forbs and low-growing succulents (Acocks, 1953).

Subtropical thicket is characterised by a very dense, almost impenetrable tangle of slow-growing trees and shrubs (Pierce and Cowling, 1984) with a high proportion of spiny and semi-succulent plants. The canopy can reach up to 5 m high and it is generally a very stable vegetation, with a high standing biomass

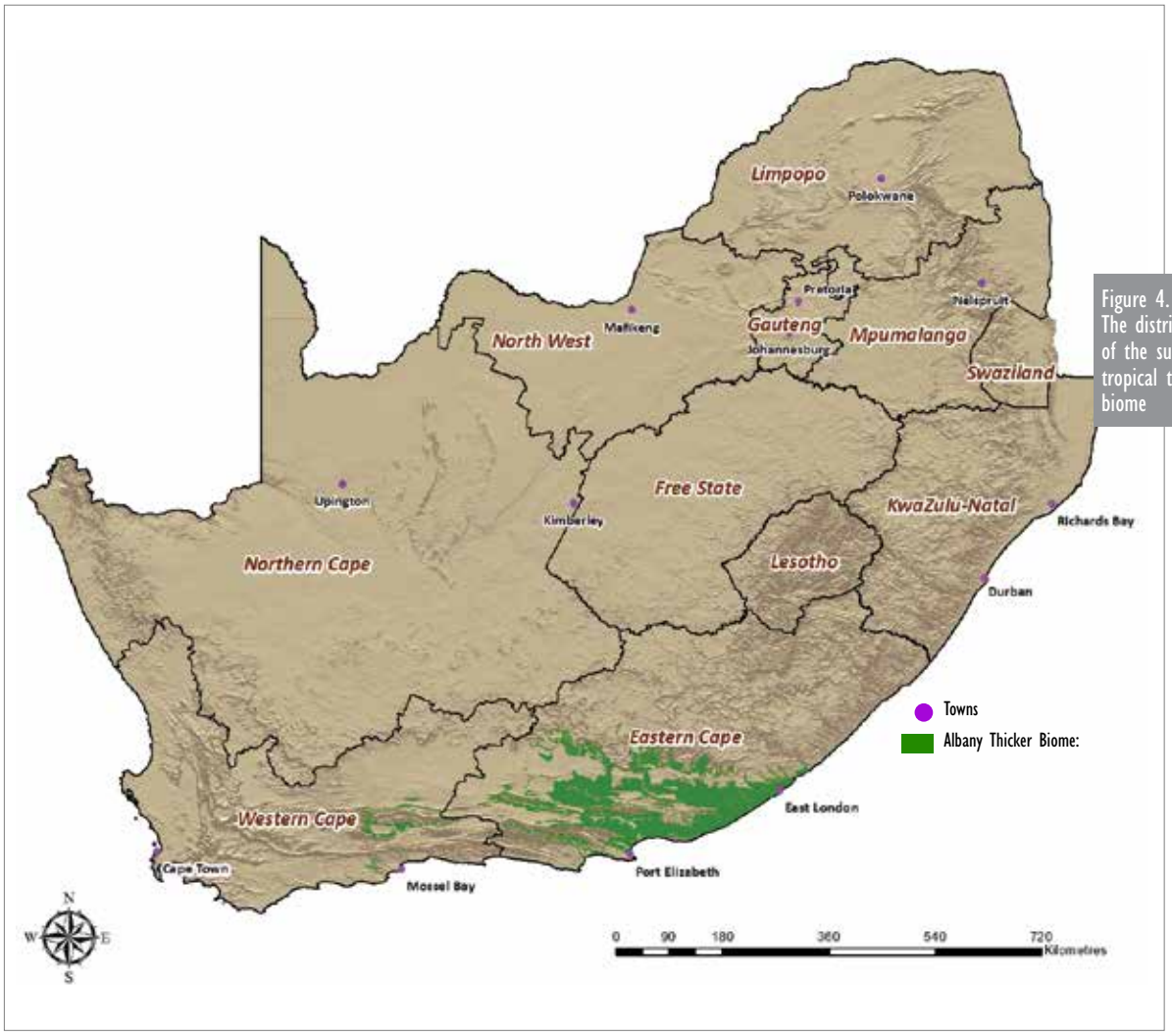


Figure 4.1: The distribution of the sub-tropical thicket biome

and very low fluctuations in biomass, despite occurring in areas characterised by frequent drought (Aucamp and Tainton, 1984). Subtropical thicket covers an area of nearly 42,000 km^2, concentrated in the southern interior of the Eastern Cape (Everard, 1987; Low and Rebelo, 1996; Vlok et al., 2003) (Figure 4.1), but also extending into the Western Cape and up the east coast to a limited degree. Recent attempts to classify and map the individual thicket types have shown that there are strong, but complex, influences between the abiotic factors like climate, fire, geology, soils and topography, and biotic factors like competition and herbivory (Vlok et al., 2003). Climate, in particular, is an important determinant of thicket distribution, and the various types are distributed over a significant range from 200 mm yr-1 (in inland arid areas) to 1,050 mm yr-1 (in south east dune areas). Importantly, subtropical thicket is restricted to areas where at least 20% of the annual rain falls during winter (Vlok et al., 2003). It grows under a wide range of temperature regimes, and some types are capable of surviving even extreme heat (up to 50°C) and frost. The underlying geology and soils also have a marked influence on the distribution of thicket types, with different types occurring on soils ranging from infertile quarzitic sands to nutritious mudstone clays and calcareous substrates.

Recent attempts to classify and map the individual thicket types have shown that there are strong, but complex, influences between the abiotic factors like climate, fire, geology, soils and topography, and biotic factors like competition and herbivory

(Vlok et al., 2003)

4.2 WHAT IS THE VALUE OF SUBTROPICAL THICKET?

Historically, subtropical thicket supported a wide range of indigenous mammalian herbivores from the megaherbivores, such as elephant and black rhinoceros, to a variety of antelope, such as kudu, bushbuck, grysbok and duiker. Subtropical thicket still harbours a greater diversity of indigenous herbivores than all adjacent vegetation types, even today (Le Roux, 2002). The abundance and diversity of indigenous herbivores in thicket combined with the fact that plant species are well defended with physical (such as thorns and spines) and chemical defences (such as toxins and latex) has led scientists to conclude that herbivory has been the largest evolutionary pressure acting on subtropical thicket.

Currently, subtropical thicket is used primarily to support commercial herbivores, both indigenous game and livestock, mostly in the form of goats. Although game farming is generally quite sustainable in that the vegetation doesn't undergo major structural changes in response to the herbivory, the same cannot be said of livestock farming. Over the past several decades, large areas of subtropical thicket have been completely transformed by high-intensity goat farming. Typical changes include an almost complete loss of all woody vegetation, a very marked change in the micro-climate, accelerated soil erosion, and the dominance of pioneer grasses. This change represents something close to the definition of desertification, and it has very significant implications for the carbon stocks in the area.

Arable lands in subtropical thicket are restricted to relatively small areas, often associated with river valleys or in areas where irrigation can be achieved – there is a significant citrus fruit industry associated with some of the large river systems, from which irrigable water is obtained. Ecotourism, mostly in the form of game viewing, outdoor adventure and hunting, has grown significantly in the past decades, and is now a major contributor to the regional economy. More recently, the value of subtropical thicket in regulating the climate has come to the fore (Mills and Cowling, 2006; Powell 2009).

4.3 PEOPLE IN SUBTROPICAL THICKET

Other than urban centres such as Port Elizabeth and East London and a few rural towns, the area associated with subtropical thicket has a relatively low density of people, typical of extensive rural agriculture and game farming. There are two main types of land tenure systems in the rural Eastern Cape – private freehold and communal.

The farming activities, especially livestock in the form of goats, has had a massive impact on the subtropical thicket. Almost 60% of subtropical thicket has been severely degraded, with only 11% still considered in pristine condition, and around 7.3% totally lost (Mucina and Rutherford, 2006). The mesic thicket, which has the highest levels of endemism and species richness, is under the greatest pressure. More detailed analyses by Lloyd et al., (2002) and Vlok and Euston-Brown (2002) provide figures on levels of severely degraded and moderately degraded thicket for each vegetation sub class. These analyses shows that with the exception of the Mainland Montane thicket and Coastal Dune thicket, all of the vegetation units described show high levels of severe degradation, ranging between 31% and 88% of the particular vegetation type (Table 4.1).

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(Mucina and Rutherford, 2006)

More than 70% of all subtropical thicket units are moderately to severely degraded. This is of particular importance as vegetation types differ in their conservation importance and degree of degradation. For conservation and carbon sequestration opportunity value, priority areas should include those vegetation types that are of highest conservation value and that have been most degraded.

Subtropical thicket types that have been especially degraded and modified by overgrazing in the past century are those rich in the succulent and nutritious spekboom (Portulacaria afra). There is evidence that even in the short space of a decade, heavy browsing, especially by mohair-producing angora goats, can convert dense shrublands into a desert-like state. The dominant palatable species such as spekboom are poorly adapted to browsing from small stock, but are better adapted to use from large wild herbivores such as elephants and kudu that utilise the top of the plant rather than eating sensitive growth points from underneath the plant (Stuart-Hill, 1991).

Of 16,000 km^2 formerly covered in spekboom-rich subtropical thicket, some 46% has undergone severe degradation and 34% moderate disturbance. This is predominantly from overgrazing, although clearing for arable use is another major threat to the subtropical thicket. Land has been cleared along the rivers, and lucerne and other crops are grown under irrigation. Land has also been cleared for orange orchards in the Addo region. Unfortunately, removing livestock and resting subtropical thicket from browsers does not lead to natural recovery of the vegetation, as fundamental changes in microclimate and soil health preclude the recruitment and establishment of the indigenous plants. Thus, restoration of subtropical thicket requires active intervention to overcome these biophysical barriers until a reasonable canopy has been re-established to moderate the microclimate and protect the soil.

Table 4.1: The areas (km^2) and percentages of modification and degradation for each type of subtropical thicket (data from Vlok et al., 2003)

THICKET TYPE	PRISTINE THICKET	%	MODERATELY DEGRADED	%	SEVERELY DEGRADED	%	MODIFIED	%
Dune thicket	6,219	28.3	11,609	52.8	1,451	6.6	2,695	12.3
Valley thicket	206,681	22.9	367,341	40.7	290,432	32.2	38,351	4.2
Arid thicket	62,606	7.9	240,057	30.3	484,053	61.2	4,561	0.6
Thicket mainland-montane	119,821	40.9	121,687	41.5	38,144	13.0	13,267	4.5
Thicket mainland-basin	10,987	46.9	7,878	33.6	4,561	19.5	-	-
Total	**406,314**	**20.0**	**750,645**	**36.9**	**818,640**	**40.2**	**58,874**	**2.9**

4.4 DRIVERS OF DEGRADATION IN SUBTROPICAL THICKET

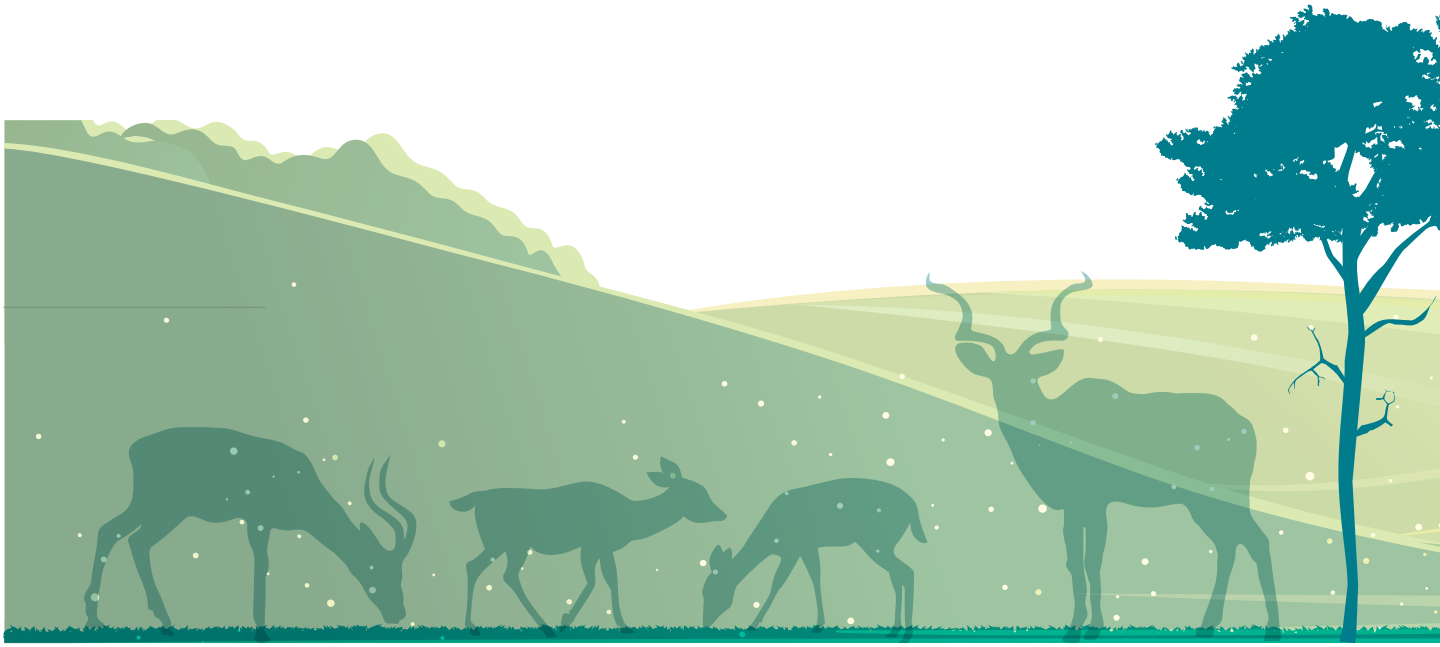
One of the greatest challenges in preventing further loss and restoring degraded areas in subtropical thicket is understanding the processes that drive the patterns of change. Degradation and transformation in the thicket biome originates from several direct and indirect drivers, and an understanding of these is important for planning or implementation. Direct drivers are those that affect the land and vegetation in themselves, while indirect drivers are often 'unseen' dynamics that cause a cascade of other effects that result in direct drivers occurring.

DIRECT DRIVERS

Direct processes are dominated by excessive herbivory by domestic livestock, although the following all have an impact:

- Non-sustainable farming practise (no crop rotation, resting etc.).
- Cultivation of new lands for subsistence farming.
- Subsistence use of fuelwood and medicinal plants.
- Commercial harvesting of medicinal plants.
- Overgrazing/over browsing.
- Bush encroachment, exposure of soil leading to soil erosion.
- Spread of invasive alien species.
- Encroachment by karroid species.
- Inappropriate fire use.
- Habitat loss or fragmentation due to modification by urban development, increased game fencing, roads, and other infrastructure.

Over-use by livestock is probably the biggest driver. Degradation from livestock grazing on communal land is currently a serious threat to thicket in many areas such as the Great Fish, Keiskamma,



Buffalo and Kei river valleys, and the use of indigenous wood for fuel and dwelling construction is exacerbating rates of degradation. Efforts to replace these sources of fuel with electricity have accelerated since 1994, but do not appear to take cognisance of the economic conditions of the users and regional population trends. Many poorer people still use wood, which is essentially free, for fuel for heating and cooking, and not electricity, which must be pre-paid.
Palmer et al. (2006) identify two differing patterns of vegetation degradation that occur in mesic and xeric subtropical thicket. Degrading mesic subtropical thicket is characterised by an increase in weedy woody species such as Acacia karroo, Rhus undulata and Gymnosporia polyacantha. This change occurs primarily in response to a reduction of fire frequency, and the removal of grass biomass by domestic herbivory, with the resultant success of woody shrubs and possible carbon fertilisation (with C3 shrubs having a competitive advantage over C4 grasses, under elevated CO2 conditions).

In xeric thicket areas degradation is a decline in desirable succulent and woody shrubs primarily in response to unsustainable levels of browsing, particularly by goats.

Thicket remains under serious threat from several sources, although contemporary changes in the political and economic climate of the region have shifted the emphasis away from certain driving processes. There appears to be less of a threat to the thicket from goat production on freehold land, with a concomitant increase in goat numbers on communal rangeland. Even though the threat from goat farming had abated on freehold properties to a large extent, recent increases in mohair prices have stimulated a renewed interest in angora goat farming, providing an incentive for short term, high stocking rates, and a boom and bust farming strategy. The increase threat from invasive alien plants is likely to expand across the region.

INDIRECT DRIVERS

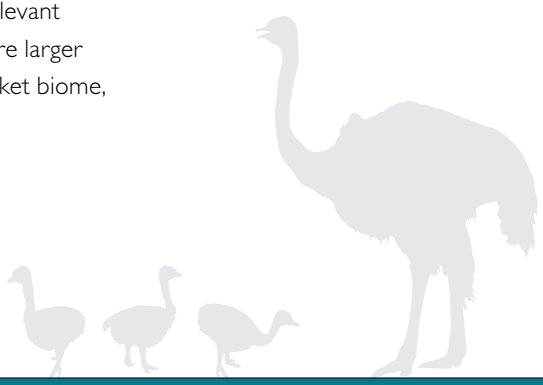
Indirect drivers are the same as those listed in the grasslands section:

- Poor regulation and control of cultivation on virgin land.
- Poor government extension services to promote sustainable agriculture.
- Poverty leading to increased reliance on natural resources for survival, with few alternatives or incentives.
- Poor enforcement of existing laws and policy.
- Economies of scale trends in agriculture forcing farmers to expand their operations.

Many drivers can only be addressed at a regional or national scale (see Section 1: Tier 1 and 2).

4.5 EXISTING INITIATIVES WITHIN SUBTROPICAL THICKET

Please also see the equivalent table in Chapter 2, which addresses relevant national initiatives that are larger than the subtropical thicket biome, but still relevant to it.



EXISTING INITIATIVES	DESCRIPTION
GEF 5 Programmes – Mainstreaming www.thegef.org/project/mainstreaming-biodiversity-land-use-regulation-and-management-municipal-scale	The mainstreaming component is focused on four district municipalities in South Africa: Cape Winelands District Municipality in the Western Cape, Amathole District Municipality in the Eastern Cape, Ehlanzeni District Municipality in Mpumalanga, and uMgungundlovu District Municipality in KwaZulu-Natal. The Amathole municipality contain significant areas of subtropical thicket. The focus of the mainstreaming programme is to better integrate biodiversity and related issues such as climate change into municipal policy and planning.
Maputo-Pondoland-Subtropical Hotspot www.cepf.net	The Critical Ecosystems Partnership Fund (CEPF) funded a five-year biodiversity conservation programme, focused on the Maputo-Pondoland-Subtropical Hotspot, which covers much of the north-eastern part of the Eastern Cape, most of KwaZulu-Natal, parts of Mpumalanga, Swaziland and the southern part of Mozambique. The areas covered include extensive areas of grassland.
Subtropical Thicket Ecosystem Planning (STEP) 2003 bgis.sanbi.org/STEP/project.asp	The Subtropical Thicket Ecosystem Project (STEP) began in 2000 with a four-year planning phase supported by the Global Environment Facility (GEF) and implemented by the Terrestrial Ecology Research Unit (TERU) at the Nelson Mandela Metropolitan University. The main aim of the planning phase was to conduct a thorough conservation planning exercise in South Africa's thicket biome with key stakeholders, and provide management guidelines for sustainable use.

5

SUBTROPICAL THICKET: DEFINING THE GAP – STATUS QUO VS NATIONAL READINESS

5.1 LAND USES AND REQUIRED ACTIVITIES

SUBTROPICAL THICKET CONTEXT

Subtropical thicket can be described in a variety of ways, but in terms of this work it is best to view it according to four tenure contexts:

- Subtropical thicket in protected areas.
- Subtropical thicket on communally-managed land.
- Subtropical thicket under state (but not conservation) management.
- Subtropical thicket under private management.

The context will influence the timing, responsibility and type of activities that should be applied to the various land use or mitigation scenarios.

There is a set of common land-use types that covers most subtropical thicket vegetation types, and a set of activities that are required to achieve the national readiness. The activities may apply equally to one or more land-use types. Each land use and activity is further explored in Table 5.1.

SUBTROPICAL THICKET LAND-USE TYPES

- Arable and orchards – current fields (<10 years of last use).
- Arable and orchards– old fields (last use >10 years ago).
- Natural subtropical thicket (spread across a degradation gradient).
- Modified subtropical thicket that has lost almost all its woody vegetation.
- Heavily eroded areas that have lost all their vegetation.
- Bush encroachment – areas heavily invaded by alien invasive woody plants or indigenous weedy trees.

SUBTROPICAL THICKET ACTIVITIES

The primary activities required in subtropical thicket are similar to those described for grasslands:

- Alien invasive plants and bush encroachment.
- Browsing and grazing management.
- Anti-erosion structures.
- Conservation agriculture.

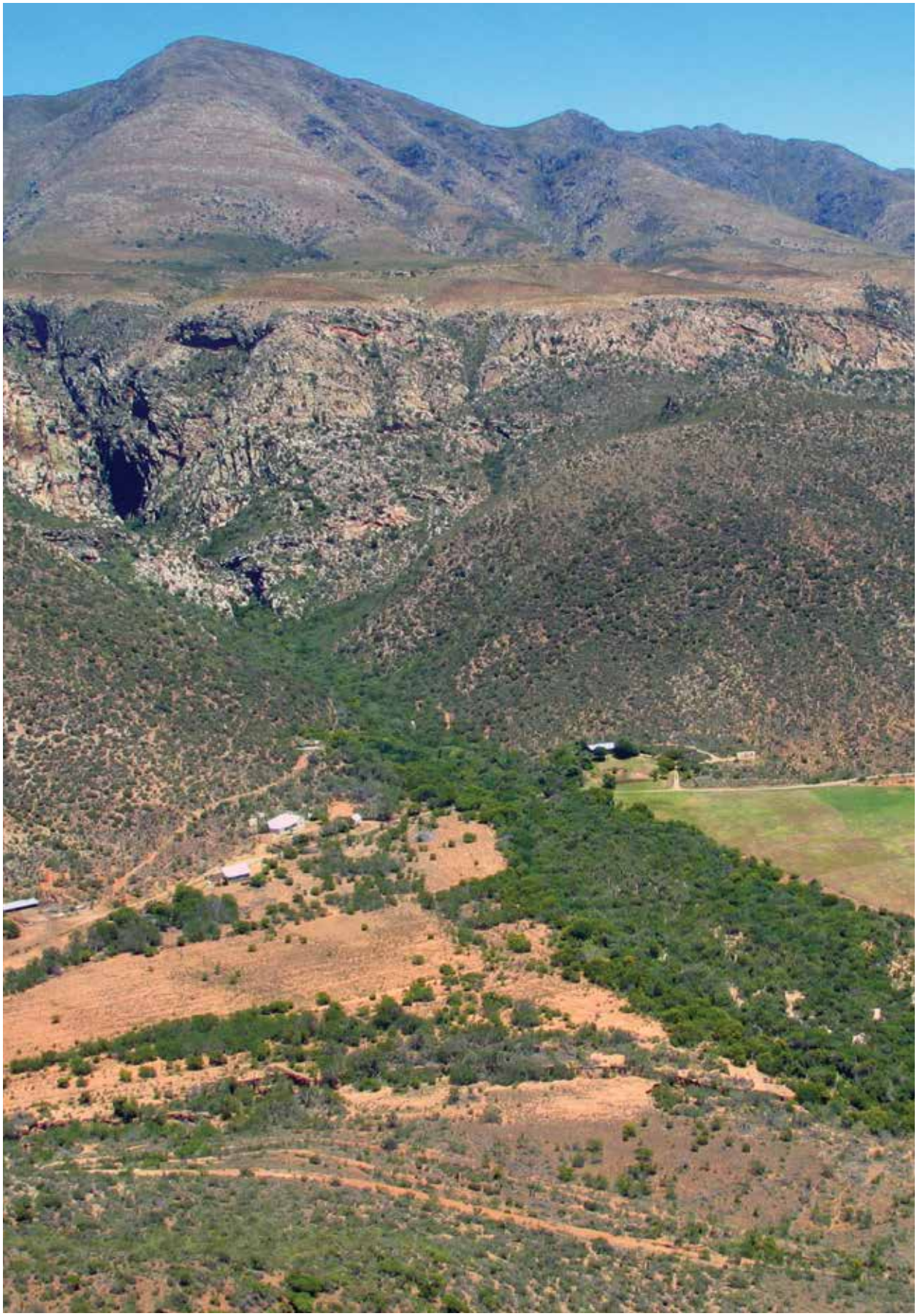
In addition, focused replanting and land rehabilitation activities are required to restore degraded areas. Although intact subtropical thicket is very resilient, it is unlikely to re-establish naturally over large degraded areas. Additional formal replanting and restoration programmes are required (described in greater detail on the next page).

In addition, focused replanting and land rehabilitation activities are required to restore degraded areas. Although intact subtropical thicket is very resilient, it is unlikely to re-establish naturally over large degraded areas.

Table 5.1: Potential subtropical thicket restoration activities that could be implemented in each form of land use.

LAND USE ACTIVITIES
Arable and orchards Current fields (within 10 years of last use).
Arable and orchards Old fields (last use more than 10 years ago) to be restored to subtropical thicket.
Natural subtropical thicket.
Modified subtropical thicket.
Heavily eroded areas.
Areas heavily invaded Alien invasive woody plants or indigenous weedy trees (bush encroachment).

	ALIEN INVASIVE PLANT AND BUSH ENCROACHMENT CONTROL	LIVESTOCK AND GAME BROWSING AND GRAZING	ANTI-EROSION STRUCTURES	REVEGETATION	CONSERVATION AGRICULTURE
	n/a	n/a	n/a	n/a	Apply appropriate techniques to improve soil health, such as zero-till, contouring, mulching, not burning residues, reduced fertilisation. Conservative irrigation systems should be used to ensure water is not wasted.
	If AIP or weedy trees are taking over the area, then a directed successional approach may be appropriate to facilitate the establishment of indigenous woody species, using the undesirable species to create a nursery environment.	Aim for very low grazing intensity to allow for a good cover of grass to establish to protect the soil. Withhold browsers unless they are being specifically used to introduce seeds or to control undesirable elements of AIP or weeds.	Use appropriate technology and structures to prevent sheet or gulley erosion in areas where the soil is exposed.	Sow indigenous grass seeds on larger areas. Investigate hydro-mulching options. Plant indigenous plugs and seedlings in smaller areas. Withhold grazing until grasses have properly established.	Establish a thick mulch layer to protect the soil and prevent the germination of weedy and AIP seeds.
	Annual cut/spray to prevent establishment of AIP infestations. Prioritise new or expanding AIP infestations.	Avoid browsing with more than the recommended intensity of animals, especially goats. Consider switching to game farming.	Use appropriate technology and structures to prevent gullies forming in localised areas such as livestock paths, water troughs and feedlots.	Plant indigenous species in areas where localised destruction has occurred, such as around water points.	Apply the SANBI burning and grazing best practice guidelines to all grazing lands. Use thicket best practice guidelines to guide browsing management.
	Annual cut/spray to prevent establishment of AIP infestations.	Where appropriate, use high-intensity short-duration grazing to promote the ecological dynamics that assist re-vegetation.	Use appropriate technology and structures such as rock lines, logs, brush-strips, hollows, mulching, or geomats.	Plant rows of vetiver grass along the contours. Sow indigenous grass seeds on larger areas. Withhold grazing until grasses have properly established.	Establish a thick mulch layer to protect the soil and prevent the germination of weed and AIP seeds.
	Annual cut/spray to prevent establishment of AIP infestations.	Where appropriate, use high-intensity short-duration grazing to promote the ecological dynamics that assist re-vegetation.	Use appropriate technology and structures such as reshaping, gabions, brush packs, etc., to prevent further head erosion and to stabilise the gully walls.	Plant vetiver grass to stabilise the walls and floors of the gulleys. Plant hardy indigenous trees to help stabilise the gulleys.	n/a
	Design a landscape-scale clearing plan that prioritises newer infestations and that has sufficient emphasis on rehabilitation of cleared areas. Annual cut/spray to prevent establishment of AIP infestations (only if follow-up is guaranteed, or the problem becomes worse). Alternatively, a directed successional approach can be adopted in some circumstances.	Aim for very low grazing intensity to allow for a good cover of grass to establish to protect the soil. Withhold browsers unless they are being specifically used to introduce seeds or to control undesirable elements of AIP or weeds. Under certain conditions use livestock to help crush dense infestations of AIP. This should be followed by active rehabilitation.	Use appropriate technology and structures to stabilise the exposed soil, such as rock lines, logs, brush-strips, hollows, mulching, or geomats.	Plant rows of vetiver grass along the contours. Sow indigenous grass seeds on larger areas. Plant indigenous grass plugs in smaller areas. Withhold grazing until grasses have properly established.	Following clearing, establish a thick mulch layer to protect the soil and prevent the germination of weed and AIP seeds.

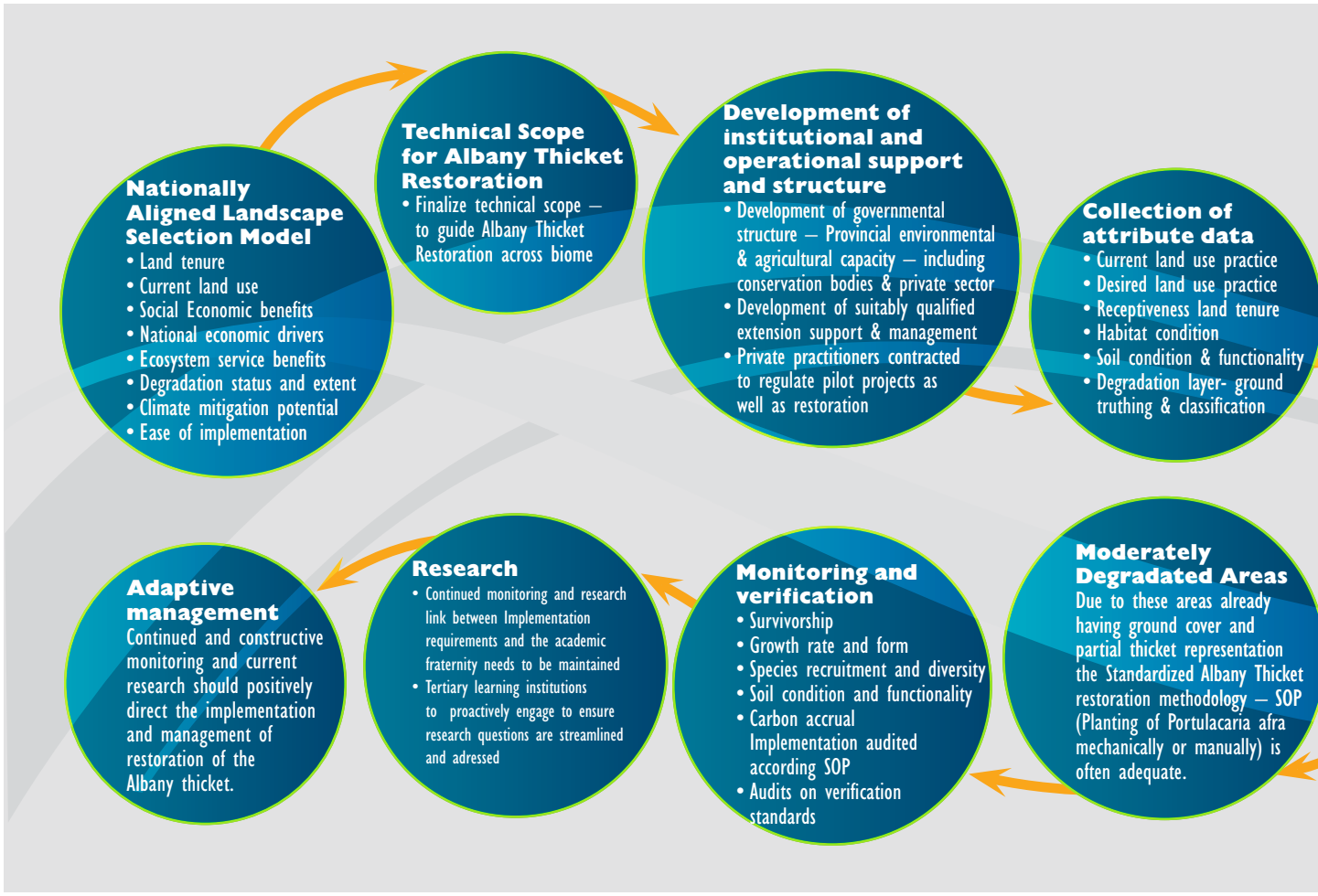


5.2 SUBTROPICAL THICKET: NATIONAL AND PROVINCIAL SCALE MEASURES (TIER 1 AND TIER 2)

After all the activities and land-use scenarios described have been taken into consideration, several additional key requirements need to be in place for restoration of subtropical thicket to be implemented at a national, regional or local scale (Table 5.2).

Table 5.2: National requirements for subtropical thicket restoration and management

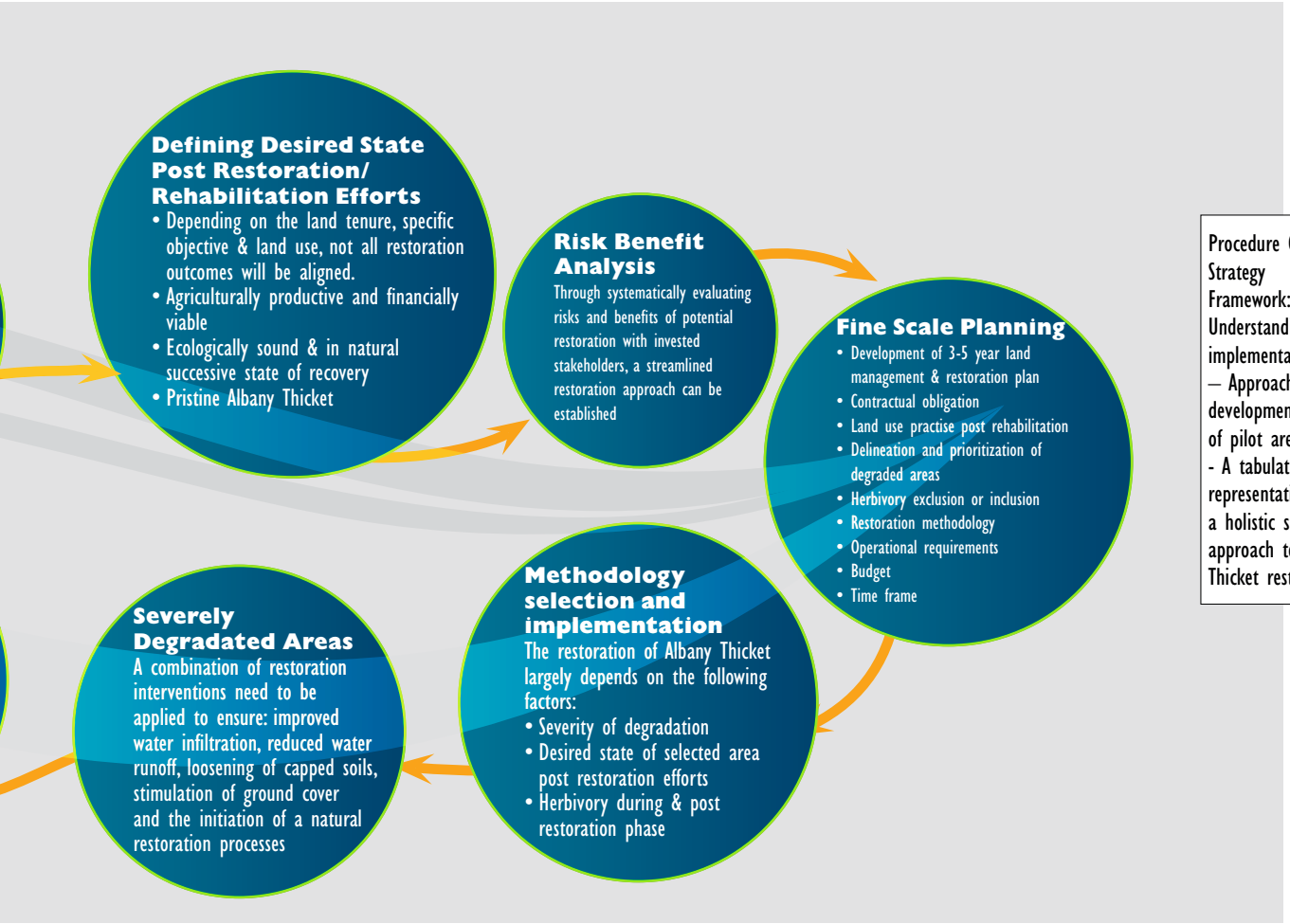
REQUIREMENT	STATUS QUO
A clear spatial plan for subtropical thicket across the region indicating historic and current boundaries, and conservation value and priority.	Reasonable maps exist for the current distribution of subtropical thicket types, and there has been prioritisation of these (STEP project). Essential local information is needed to identify suitable project sites.
The distribution of AIP is well mapped, and each administrative region has clarity on their priority clearing goals. All institutions that carry part responsibility for AIP control are coordinating their efforts in subtropical thicket. Regional AIP control budgets reflect the state of priority in that region.	Although reasonable maps do exist for AIP distribution in subtropical thicket, they are quite dated. Clearing efforts to date have been ineffective as a result of lack of coordination between departments and poor follow-up, often because of lack of resources.
Strong provincial and national conservation authorities that are mandated, resourced and able to ensure effective subtropical thicket conservation and restoration.	The national and provincial conservation departments are generally under-staffed and under-funded and largely ineffective in their management (with some exceptions).
Implementation of relevant conservation, agricultural and land care legislation.	Understanding and enforcement of the existing laws is ineffective. Very limited capacity to police the huge areas of subtropical thicket. Little political will to enforce some of the laws in communal areas.
Strong support and incentives to develop nature-based economies in subtropical thicket, such as ecotourism and hunting.	Weak support from relevant government departments. Limited funding and finance opportunities. Confusion and administrative obstacles to the establishment of small businesses.
Clear land tenure in freehold areas and strong traditional authorities in communal areas.	Most subtropical thicket occurs in communal areas, and there is often unclear traditional authority jurisdiction or lack of traditional leadership authority to enforce any management plan. Many privately-owned areas are currently subject to land claims, so future ownership and authority structures are unclear.
Monitoring, reporting and verification of carbon stocks and fluxes (MRV ability).	Poor capacity within state departments to do MRV. Technical capacity exists in tertiary and research institutions (e.g. SAEON), but capacity and funds are limited.
Good understanding of succession and recovery dynamics of subtropical thicket.	Considerable research and practical experimentation has achieved a measure of success in understanding the restoration dynamics of subtropical thicket. Further research will improve on this knowledge base, especially in terms of restoring a large suite of biodiversity.
Clear guidelines for AIP control in subtropical thicket.	Some dispute in ecological circles about the most effective and efficient ways to handle AIP.
Strong support for community-based carbon mitigation projects.	Little extension support available.



5.3 SUBTROPICAL THICKET: TIER 3 – DEVELOPMENT OF PILOT RESTORATION AREAS

Stakeholders and seasoned implementing agents working within subtropical thicket agree that the opportunity to restore subtropical thicket is defined both by the spatial extent of degradation and the willingness of land owners. A land restoration process developed through many years of trial and error is described below, but it needs to be preceded by a systematic and substantial upfront engagement process to ensure there is willingness to participate. In many cases, the land owners or managers may not wish to restore degraded or modified areas to subtropical thicket, but would rather use them for alternative land-use practices such as crop or livestock farming. Providing an estimation of the real spatial extent of potential restoration prior to the completion of this process is therefore difficult as land-owner willingness cannot be estimated prior to engagement. Although there are certain non-governmental organisations undertaking this process in isolated areas, such as the Baviaanskloof, a biome-scale engagement process is required to understand the true opportunity. An existing or a new form of extension service could lead this.

A step-wise framework through which pilot programs could be developed is described in Chart



Procedure Chart A: Strategy Framework: Tier 3 Understanding field implementation – Approach and development of pilot areas - A tabulated representation of a holistic stepwise approach to Albany Thicket restoration

A and Table 5.3. This structure is based on input from stakeholders and several years of in-field experience within the sub-thicket biome. Whereas there is certainly opportunity to develop and calibrate the framework further, this is viewed as a reasonable starting process for early pilot project development. Although it does include (and repeat) some Tier 1 and Tier 2 elements, these are included so that the reader can see how the full comprehensive process may fit together. The framework is followed by a description of replanting and practical restoration techniques that have been developed through trial and error within the biome.

Table 5.3: A tabulated representation of a stepwise approach to subtropical thicket restoration.

	STEPWISE STRUCTURE OVERVIEW	ACTION REQUIRED	RESPONSIBLE STAKEHOLDER	MEASURE
1	Nationally aligned landscape selection model based on: • Land tenure • Current land use • Socio-economic benefits • National economic drivers • Ecosystem service benefits • Degradation status and extent • Climate mitigation potential • Ease of implementation.	Development of a subtropical thicket restoration landscape matrix which will assist in the selection of suitable areas to invest in restoration.	Government, with the aid of a suitably qualified environmental practitioner if required.	Complete and functional tool aligned to other climate mitigation restoration area selection tools.
2	Technical scope for subtropical thicket restoration	Development of finalised technical scope for the restoration of subtropical thicket, using knowledge and experience gained over the last 8 to 10 years of implementation	Government to initiate, with the aid of a suitably qualified environmental practitioner if required. Stakeholder involvement to include: • Past and current implementation agencies • Scientific and tertiary education institutions • Conservation authorities • Environmental practitioners • Current landowners	Complete and functional technical scope which guides the successful restoration of subtropical thicket
3	Institutional and operational support and structure	Development of a functional institutional and operational support structure that is effective in coordinating the successful restoration of subtropical thicket: • Planning and upscaling of existing efforts • Development of legal framework • Networking – nationally and internationally • Sourcing of funding • Administrative processes • Operationalising • Supporting • Monitoring • Researching • Validating	Government to initiate with the aid of: • Private business/investors • Environmental practitioners • Legal practitioners • Implementing agents • Extension officers • Conservation authorities • Tertiary education institutions • Landowners	Fully functional institutional and operational industry built around subtropical thicket restoration with multiple benefits which can be measured accordingly: • Socio-economic benefits • Ecosystem services • Biodiversity improvement • Food security • Taxable income • Climate change mitigation
4	Collection of attribute data to be utilised prior to the development of subtropical thicket restoration projects with identified landscape	The following critical attribute data are required to be sourced prior to project development, which provide the necessary information to make a calculated judgment on the overall value of project establishment: • Current land-use practice • Desired land-use practice by the current owners/users of the land • Receptiveness to restoration across all forms of land tenure • Habitat condition • Soil condition and functionality • Degradation layer ground truthing and classification.	Government to initiate with well-constructed pilot areas across all forms of land tenure. Environmental practitioners or internal capacity could facilitate this at pilot level. This process could later be coordinated and implemented by the private sector, sourcing assistance though: • Environmental practitioners • Extension officers trained during the pilot studies. This information could also be used by the environmental and agricultural departments as national attribute data.	The quality and quantity of attribute data.

	STEPWISE STRUCTURE OVERVIEW	ACTION REQUIRED	RESPONSIBLE STAKEHOLDER	MEASURE
5	Defining desired state post rehabilitation/restoration efforts	The desired state post rehabilitation/restoration needs to be established by the relevant land tenants and contracted into agreement by the relevant investor (government or private industry, both nationally and internationally). This is important to protect initial and future investment, both financially and ecologically. The following models have been considered and can be further refined post technical scope finalisation: • Agriculturally productive and financially viable state • Ecologically sound and in a natural successive state of recovery • Pristine subtropical thicket.	Relevant land tenant and potential investor (government or private industry, both nationally and internationally).	Clearly defined outcome of rehabilitation/restoration objective along with criteria to be met.
6	Risk benefit analysis	Information gained through the attribute data collection phase to be used to undertake a risk benefit analysis. The outcome of this will guide the decision on project establishment. If the risks are too high, then these risks need to be mitigated, failing which no project will be developed within the specific area.	Joint responsibility of the following: • Neutral party (environmental practitioner) to facilitate • Investor • Land tenant	Outcomes of risk benefit analysis.
7	Fine-scale planning should be undertaken once contractual agreements are in place and a suitable area has been confirmed	Development of 3 to 5-year land management and restoration plan to be reviewed post verification process over the restoration plan cycle. • Prioritisation and delineation of specific areas aligned to desired state and restoration • Herbivory exclusion or inclusion • Methodology selection designed according to requirements • Operational requirements • Budget requirements • Monitoring requirements • Verification requirements	The land tenant is responsible for ensuring that the land management and restoration plan is developed and in place. Landowners can develop these plans themselves or outsource to the following: • Environmental practitioner • Interested and involved NGO • Extension officers	Complete and functional land management and restoration plan.
8	Monitoring and verification	A monitoring framework which highlights key indicators of restoration success is to be developed, examples follow: • Survivorship of desired species • Growth rate and form • Species recruitment and diversity • Soil condition and functionality (LFAs) • Carbon accrual • Implementation audited according to SOP • Audits on verification standards	Government to develop and initiate monitoring and verification standards. Independent monitoring team to undertake monitoring and verification – this cost to be allowed for in the scope of project.	Data collected to be consistent and reflective of on-the-ground implementation and restoration undertaken.

Table 5.3 Continued

	STEPWISE STRUCTURE OVERVIEW	ACTION REQUIRED	RESPONSIBLE STAKEHOLDER	MEASURE
9	Continued research to guide implementation and up scaling	Well-directed research needs to be directed within critical areas in order to successfully promote the up scaling of subtropical thicket restoration. Areas of focus to include but not limited to: • Landscape selection model • Technical scope • Effective institutional and operational models • Ecosystem service benefits • Stimulating local and foreign investment • Land incentive models for private engagement • Offset cost for establishment phase • Practical methodology that allows for all land tenure and utilisation models.	Government along with the tertiary educational facilities should be involved in facilitating this process. Research should be aligned to contribute directly to the successful restoration of subtropical thicket and the numerous associated benefits. Government could look towards international funding based on climate change mitigation, water and food security, carbon sequestration benefits and biodiversity improvements.	Guided research to allow for the successful restoration of subtropical thicket can be measured per research project completed or holistically as per advancement in successful restoration.
10	Adaptive management	An adaptive management process needs to be applied whereby strategies and scope are revised on the basis of lessons learnt across the sector. It is critically important for the turnaround time to be addressed as punctually as possible, thereby creating an innovative yet progressively functional programme. In addition, a central deposit for lessons learnt and programme advancement needs to be developed.	All stakeholders involved are responsible for providing feedback here. This could be housed in the newly developed institutional and operational structure which the government would be responsible for creating.	Progress and associated benefits within the restoration of subtropical thicket.

RESTORATION METHODOLOGY SELECTION AND PRACTICAL IMPLEMENTATION

A well-defined restoration methodology selection matrix needs to be established. This will guide suitable methodology according to land-use practices and desired restored state. Implementation of various restoration interventions can be undertaken by suitably skilled and developed contracting teams or the landowners themselves. The following factors need to be considered:

5.3.1 Severity of present degradation

A combination of rehabilitation and restoration interventions needs to be applied to ensure improved water infiltration, reduced water run-off, loosening of capped soils, stimulation of ground cover and the initiation of a natural restoration process. Practical rehabilitation and restoration interventions include simple soft techniques, but as each degradation site is unique, these are often applied differently in each area. Practical rehabilitation and restoration interventions include:

- Loosening of capped soils through manual or mechanical means (improved water infiltration and seedling establishment).
- Brush packing (forms a protective mulch layer – Vachellia karroo works best).
- Ponding or hollow construction (improves water infiltration and seedling establishment).
- Application of geotextiles on bare and aridified soils (retains moisture, prevents capping, improves seed establishment).
- Suitably placed sediment traps (slows down water flow and collects sediment).

Planting of Portulacaria afra truncheons 2 m x 2 m apart

(root treated/non-root treated), mechanically or manually.

5.3.2 Desired state of selected area post restoration efforts

- **Agriculturally productive land in a financially viable state.** Agriculturally productive thicket does not have all the elements of an ecologically intact thicket, but is restored to a functional and sustainable state, where landowners can utilise the thicket to make a sustainable living. Time for recovery, rotational utilisation and stocking rates need to be considered accordingly.
- **Ecologically sound thicket and in a natural successive state of recovery**. The aim here is to stimulate the restoration process through initial restoration efforts and follow-up that allows a natural successive recovery of the thicket to occur. Natural patterns and processes should be promoted.
- **Pristine subtropical thicket**. The aim here is to return the thicket into its pre-degraded state though a holistic restoration approach. This is a long term commitment, aligned to biodiversity objectives.

The average consumption of wood for fuel in South Africa is estimated at 4.5 tons per household per annum. This estimate was based on a study published by the Programme for Basic Energy and Conservation, a regional

(Damm and Triebel, 2008)

A) A severely degraded area where the soil crust is capped and standardised planting of Portulacaria afra truncheons and cuttings in isolation will not yield desired restoration results.

B) A severely degraded area where holistic rehabilitation methods such as ponding, sediment trap placement and brush packing has yielded promising results.

C) An isolated Portulacaria afra truncheon that has responded successfully due to improved water retention and reduced water run-off created by holistic rehabilitation methods.

Spekboom truncheons and cuttings planted in bare, open landscapes are exposed to extreme conditions and suffer high mortality as a result of low temperatures and frost or desiccation caused by extreme heat.

5.3.3 Herbivory

Excluded or reduced herbivory within the first 2–5 years of the restoration process has proven extremely successful throughout restoration efforts conducted in thicket-wide research plots. Although herbivory is a natural process within thicket environments, reduced utilisation of vulnerable and newly establishing plants promotes the restoration process.

Experience in practical restoration of severely degraded subtropical thicket has shown that the common practice of planting spekboom (Portulacaria afra) truncheons and cuttings in isolation does not yield optimal restoration results for the following reasons:

- The modified landscape has a very unforgiving micro-climate and eroded and capped soils prevent water penetration and retention.
- Spekboom truncheons and cuttings planted in bare, open landscapes are exposed to extreme conditions and suffer high mortality as a result of low temperatures and frost or desiccation caused by extreme heat.
- In severely degraded areas, spekboom truncheons and cuttings are often the only food source for herbivores and are thus heavily utilised. This can be avoided by excluding herbivory from the area.

D) Represents moderately degraded thicket which still has sufficient ground cover and stands of thicket to function as nursery areas.

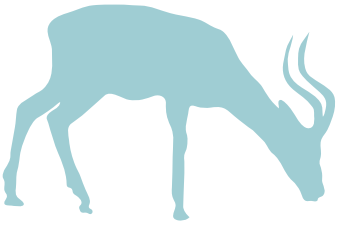
E) A severely degraded area that has been treated with holistic rehabilitation methods incl. sloping, geotextile application, brushpacking and sediment traps, with noticeable results.

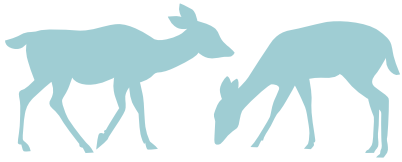
F) Reflects extensive damage on Portulacaria afra truncheons due to elephants.

Although the initial costs of holistic restoration treatment that includes multiple rehabilitation interventions are far higher than planting alone, experience has shown that the results are superior (Photo A):

- When the capped and impenetrable crust layer of the soil is broken up, water can penetrate the soil and provide the necessary moisture for plant development and species recruitment (Photo B and C).
- Creating depressions such as ponds or hollows within the landscape slows down and retains surface water, providing valuable moisture for plant development and pioneer recruitment (Photo B).
- When geo-fabrics are applied to the soil, additional moisture is retained, capping is prevented, seed recruitment is improved and soil health is enhanced (Photo E).
- Applying brush and mulch in the form of planted Vachellia karroo truncheons and cuttings protects recruited pioneers from herbivory, increases moisture retention, provides additional nitrogen and improves soil health (Photo E).

In moderately degraded subtropical thicket there is usually sufficient ground cover and enough intact thicket still standing within the landscape for the standardised planting of spekboom truncheons and cuttings to be effective. This is because the remnant subtropical thicket vegetation moderates the harsh micro-climate, and the soil conditions are generally still amenable for plant establishment (Photo D). Existing vegetation can also sustain the existing herbivores, thus herbivory damage to the new plants is reduced.





5.4 INDICATIVE COSTS OF SUBTROPICAL THICKET RESTORATION

The costs associated with the restoration of subtropical thicket are extremely varied and can be split into two main categories – indirect costs and direct operational costs:

INDIRECT COSTS

These are financial costs not directly related to the operational restoration itself and may include, but would not be limited to, the following:

- Institutional governance of programme.
- Cost of specialist development for structures, technical scope, standards, resource collection.
- Research and technical advice from consultants.
- Pilot project development.
- Legal services.
- Monitoring and verification.
- Offset cost for activities that are replaced during rest period.

DIRECT OPERATIONAL COSTS

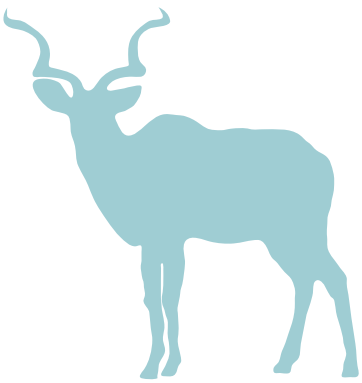
These are costs relating directly to the actual operational restoration/ rehabilitation activities. These costs are extremely varied and are still in the process of being adequately understood. The following factors indicate the complexity and variability of the costs:

- The severity of degradation to be treated.
- Methodology of restoration/ rehabilitation intervention.
- Desired state of area post restoration/rehabilitation.
- Distance from treatment area to source of operational staff.
- Distance from treatment area to source of material to be harvested.
- Working in dangerous game area.
- Presence or absence of herbivory.

Table 5.4: General restoration costs associated with methodology

RESTORATION/ REHABILITATION ACTIVITY	DESCRIPTION OF ACTIVITY	DESCRIPTION OF COST
Restoration of severely degraded areas.	Pre-treatment of basic landscape erosion control with soft intervention methodology. Standardised spekboom (Portulacaria afra) planting from harvested truncheons (mechanised).	Operational and management costs include:
		PERSON DAY (PDY) COST
		Low cost: R 270/pdy
		Moderate: R 280/pdy
		High cost: R 302/pdy
		HECTARE COST
		Low cost: R6,500/ha
		Moderate: R 8,767/ha
		High cost: R 10,327/ha
Restoration of moderately degraded areas.	Standardised spekboom (Portulacaria afra) planting from harvested truncheons (mechanised).	Operational and management costs included:
		PERSON DAY COST
		Low cost: R 250/pdy
		Moderate: R 270/pdy
		High cost: R 285/pdy
		HECTARE COST
		Low cost: R2,800/ha
		Moderate: R 3,627/ha
		High cost: R 4,500/ha

(Note that although these are realistic costs for doing the job properly, they only cover the cost of initial restoration work. Follow-up work is more cost effective, but is not included in this calculation). These costs relate directly to survival rate. Further pilot studies will refine through different applications.



SECTION FOUR

INDIGENOUS FOREST RESTORATION AND MANAGEMENT

6

FORESTS: INTRODUCTION

6.1 WHAT AND WHERE IS THE FOREST BIOME?

Forests are loosely defined as closed canopy stands of woody plants with canopies higher than 5 m (Midgley et al., 1997).

South African forests occur as an archipelago of patches scattered along the eastern and southern escarpment mountain ranges and coastal lowlands of South Africa. South African forests tend to be highly fragmented and discontinuous, and so forest stands are usually considered to be relicts of a once more widespread biome. Forest occurs in many small to medium size patches – 80% of patches are smaller than 50 hectares (Berliner, 2009), although some individual patches may exceed several thousand hectares, notably in the southern Cape, Lowveld escarpment, and the Pondoland regions.

The Eastern Cape has the most forests (c. 140,000 ha), followed by KwaZulu-Natal (c. 91,200 ha), the Western Cape (c. 60,000 ha) and Limpopo province and Mpumalanga (c. 35 000 ha each).

Forests are generally restricted to areas with mean annual rainfall of more than 525 mm in the winter rainfall region and more than 725 mm rainfall in the summer rainfall region. They occur from sea level to over 2,100 m above sea level. At least 5 forest groups and 24 distinct forest types are recognized (CSIR, 2003) (Figure 6.1). These can be split into two major sub-biomes (Mucina and Geldenhuys, 2006):

- Warm temperate evergreen forest biome (Afrotemperate forests).
- Subtropical coastal forest biome.

Forests occur within other biomes, across a very large range of bioclimatic conditions. In many non-forest areas of the country, especially in the grassland biome, the bioclimatic conditions are suitable for forests. Other abiotic factors such as changing fire regimes and historic human land-use patterns have caused a relative shrinking of the forest distribution. Such dynamics are often indicated by the very defined boundaries between forests and other biome vegetation, such as grassland.

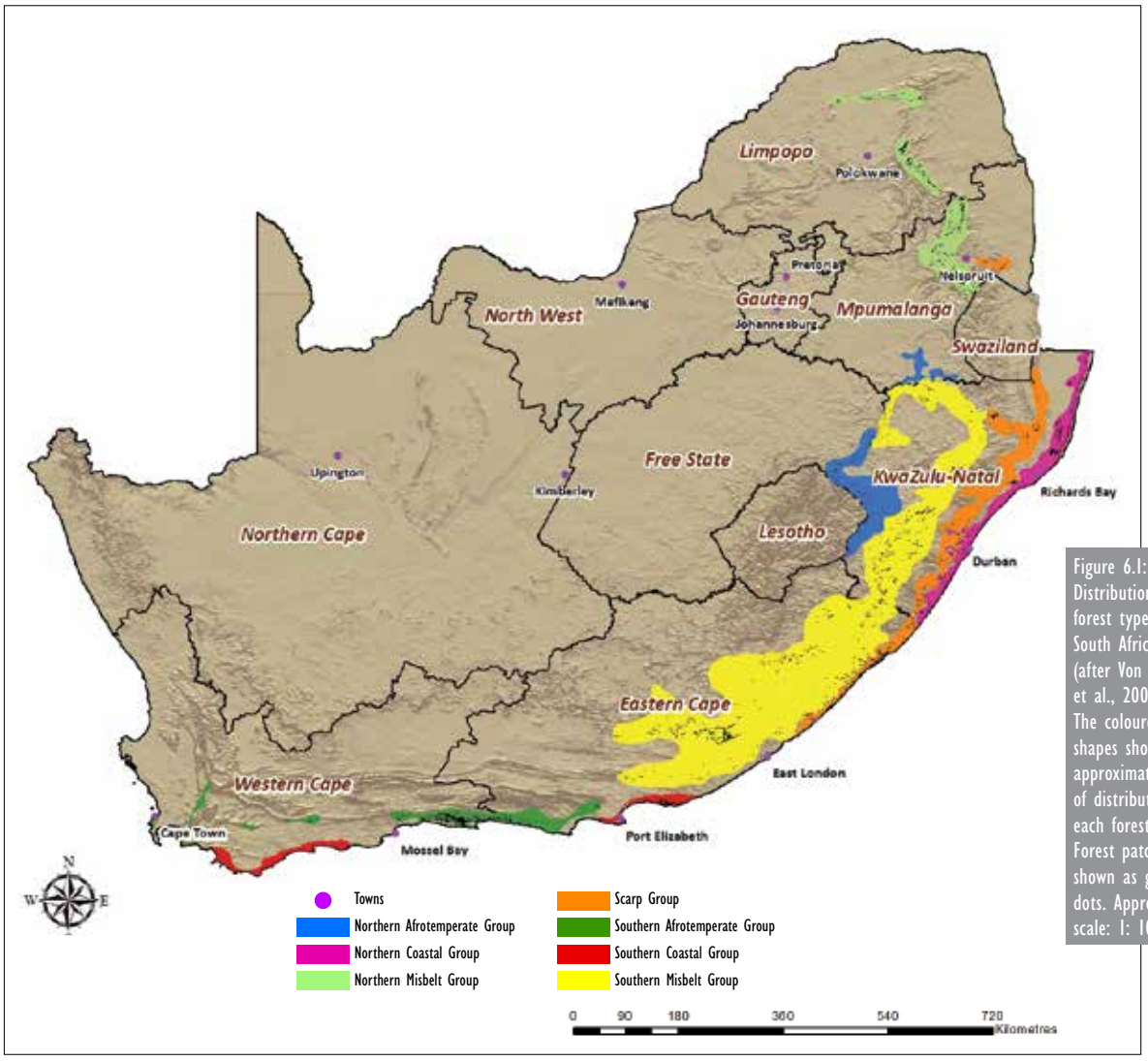


Figure 6.1: Distribution of forest types in South Africa (after Von Maltitz et al., 2003). The coloured shapes show the approximate area of distribution of each forest type. Forest patches shown as green dots. Approximate scale: 1: 10 000.

6.2 WHAT IS THE VALUE OF FORESTS?

Although forests cover only 0.4% of South Africa's surface area, they have disproportionately high conservation and intrinsic value.

BIODIVERSITY

Forest provides important habitat to a large number of plant, vertebrate and invertebrate animal species. Despite the relative small area of the biome, forest has the highest density of plant species per unit area (0.38 plant species per km^2) with the next highest being the fynbos biome (0.11 plant species per km^2). If species richness is considered per unit area of forest, South African forests have by far the highest number of tree species of any temperate forest in the world (Silander, 2001; Cowling, 2002). Forest occurs adjacent to all South Africa's major biomes, with the exception of the succulent karoo and nama karoo biomes. Forest margins and ecotones have a high diversity of plant species as they may contain species common to adjacent biomes (Mucina and Geldenhuys, 2006).

Overall, of the 56 species of vascular plants listed as IUCN red data species occurring in forests in South Africa, 2 are listed as extinct in the wild, 4 as critically endangered, 8 as endangered, 20 as vulnerable, and 22 as near threatened (Berliner, 2009). Most of the red data plants occur in coastal and scarp forest types, with just two forest types, Pondoland scarp and eastern scarp, containing more than half of all recorded forest red data plants (Berliner, 2009). Despite their conservation importance, both these types have low levels of formal protection and face increased pressure, primarily from subsistence harvesting and alien plant infestation.

Many vertebrate and invertebrate animal species make use of forests for habitat, foraging or breeding, although it is seldom exclusive. A large proportion of forest fauna, even those considered as typical 'forest species' will make use of the forest–matrix ecotone as well as surrounding areas. Surprisingly, a higher proportion of forest vertebrate species are threatened than species in other biomes. Overall, approximately 13% of all vertebrate species that depend on the forest biome for their survival are listed as threatened by the IUCN. Approximately 26% of all forest amphibians, 25% of forest mammals, 15% of forest reptiles and 11% of forest birds are threatened. The isolation of fragmented patches has given rise to highly-limited distributions of immobile species such as anthropoids, and some amphibians and dwarf chameleons. For example, the Dlinza forest pinwheel snail occurs only in the Dlinza Forest, and the Pondoland cannibal snail (Herbert, 2004) occurs only in the Ngele Forest in KwaZulu-Natal.

Although South African forest is highly-fragmented, often embedded within a variety of matrix land-use types and vegetation types, and existing where the matrix has been converted to agriculture, the forest patches have an unusually high landscape connectivity value – acting as 'stepping stones', or ecological corridors, connecting remaining intact habitat.

Many of small patches have been totally lost or are now highly degraded and should be considered as priorities for reforestation/ rehabilitation carbon mitigation projects.

Forests have a wide range of critically important ecosystem services:

- Ecosystem regulation (climate regulation, carbon storage, water production and storage).
- Socio-economic and livelihood value (food, fibre, fuel, medicines, and building materials).
- Cultural, spiritual, and recreational value.

Although South African forest is highly-fragmented, often embedded within a variety of matrix land-use types and vegetation types, and existing where the matrix has been converted to agriculture, the forest patches have an unusually high landscape connectivity value – acting as 'stepping stones', or ecological corridors, connecting remaining intact habitat.

ECOSYSTEM SERVICES

South African forests are rich in biodiversity and provide a wide range of extremely valuable ecosystem services. In the steep river valleys and gorges, the old growth forests contain some of the highest carbon densities in the world, for comparable forest biomes (Berliner, 2015). Conserving forests conserves their valuable carbon stocks, and rehabilitation projects have the potential to sequester significant additional amounts of carbon. Arresting forest degradation needs to be a priority carbon loss mitigation action. This will require an ecologically integrated and participatory approach and full implementation of existing forestry policy and principles, as provided for in the National Forestry Act, of 1998 and the White paper on Forestry in South Africa.

SOCIO-ECONOMIC AND CULTURAL VALUES

Currently, all indigenous forest in South Africa is protected from harvesting by law, except for certain permitted situations. During the colonial era, forests were heavily logged for various hardwood species and other products, and entire industries existed around this resource base. Currently, limited harvesting of individual hardwood tree is permitted under very controlled conditions in the southern Cape forests – where the trees are selected because of their imminent natural death or for some other legitimate reason, and are auctioned standing to the highest bidder. Extraction is done under very controlled conditions, sometimes even by helicopter, giving an indication of the value of the timber.

Timber and non-timber forest products are vital components of local livelihoods in many rural areas, acting as a form of livelihood safety net (Shackleton et al., 2007). People obtain food, medicines and other products from the forest when they do not have the resources to purchase them. Consequently, there is an urgent need to integrate forest conservation planning with rural development and poverty alleviation. Community-based natural resource management strategies, that promote sustainable forest resource use in conjunction with conservation management, need to be employed.

Forests patches often have a high cultural and spiritual value to people, both locally and regionally. Many local communities access forest patches for burial, ancestral worship and circumcision ceremonies.

The forests of the southern Cape are very important socio-economically, forming part of the Garden Route tourism centre, and in the Drakensberg, Karkloof and Maputaland areas many eco-tourism ventures are centred on forests.

6.3 PEOPLE AND FORESTS

LAND TENURE IN FORESTS

South African indigenous forests fall within an assortment of land ownership and land tenure regimes, and there has been considerable uncertainty regarding the management authority of many forests. Large areas of indigenous state forests in the Knysna and Tsitsikamma districts were transferred to South African National Parks in 2005, and DAFF recently devolved management responsibilities for a significant portion (26%, according DWAF, 2003) of former state forest to provincial authorities. In some cases, provincial authorities have deferred this authority down to local tribal authorities. The flux and confusion regarding management responsibility has had detrimental effects on the conservation of some forests, leading to uncontrolled access and use of resources, such as in the Gxalingwa (884 hectares) and KwaYili (404 hectares) forests in the Drakensberg foothills of KwaZulu-Natal (DWAF, 2003).

Approximately 55% of the forest estate occurs on land not directly owned by organs of the state. Of this, 22.6% is on communal land and 23.4% on private land (Table 4.1). Most of the larger forests occurring on communal land are designated as 'state forests', while many of the smaller forest patches are

considered as 'headman's forests' and controlled by the local tribal authorities. Cooper and Swart (1992) surveyed a total of 100,000 ha of forest in the former Transkei, of which 30,000 ha were designated as 'headman's forests'. Of the 91,000 ha of forest surveyed in KwaZulu-Natal by Cooper (1985), 31,671 ha was located on communal land.

Private forestry companies conserve an estimated 41,000 ha (DWAF 2003) of patches of natural forest on their land, and in some instances, these forests have been given elevated conservation status within the provincial conservation systems or biodiversity stewardship programmes.

Some 10% of South Africa's natural forested area is subject to land restitution claims (approximately 49,218 ha). A significant proportion of these areas (45%) are in existing Type 1 protected areas. These areas present a particularly important challenge to conservation and social planners alike, since it is imperative that forest conservation be achieved, not at the expensive of, but in conjunction with, improvements to rural livelihoods. Participatory models that not only improve forest conservation/restoration and carbon sequestration, but also have significant and positive impacts on livelihoods and poverty reduction, are increasingly recognised as essential to achieve this balance.

Table 6.1: Forest land ownership class for national forest estate expressed as percentage of total area (Berliner et al. 2006).

LAND TENURE	PERCENTAGE AREA OF ALL FORESTS
Communal	22.6
DWAF state forest	25.6
Private	23.4
Type 1 protected areas	17.6
Uncertain	10.8

6.4 CURRENT STATE OF FORESTS

FOREST LOSS

Relatively poor quantitative data is available for rates of change of forest cover in South Africa. In relatively recent geological time, South African forests have successively receded and expanded in response to ice ages and changes in climate, making it very difficult to use inferences from indirect data, such as pollen profiles in the soil, to build an accurate history of anthropogenic change. Limited study has been done by Berliner (2009, 2015), Bolus (2003), Mangwale (2010), and McKenzie (1989) for the Wild Coast, and by Laws (2009) for KwaZulu-Natal. Anecdotal evidence suggests that most forest destruction took place at the hands of European settlers in the period 1860–1940, (King, 1938; Laws et al., 2004). Estimates of original extent are very difficult, especially since the earliest aerial photographs in South Africa date from the late 1930s. The absence of high-resolution satellite imagery makes determining rates of loss prior to about the 1990s problematic.

A recent spike in forest destruction occurred in many communal areas between 1994 and 2000, mostly as a result of agricultural field expansion (Berliner, 2011). Since then, the rate of outright forest loss has declined, attributable largely to reduced agricultural activity (Shackleton et al., 2013). Many of these lands now lie fallow, overrun by alien plants. Overall forest loss is still difficult to determine, but in some areas, it has certainly been extensive. For example, McKenzie (1989) looked at habitat change on several plots in the former Transkei. He found that between 1937 and 1982, forest had declined by 3 and 7% for two of the plots. The same plots were re-analysed to determine loss in forest cover from 1982 to 2008, and it was found that there had been a significant acceleration in forest loss, particularly after 1994. For two of the plots, there had been a 25% and a 60% loss in total forest area since 1937 (Berliner, 2011).

Limited quantitative data is available to determine forest loss across the whole country accurately, and early

estimates of forest loss (for example, King, 1938) cannot be accurately tested. Evidence suggests that in certain areas indigenous forests were significantly larger than at present, but, for some areas, losses have been exaggerated considerably, and are likely to be only in the order of 10 to 15% loss, mainly through boundary contraction (Lawes, personal communication).

In contrast, some forests may have expanded, particularly where fires have been excluded by roads, habitat transformation or increased fire protection efforts, but this expansion is often not yet true forest, but rather forest precursor bush or woodland (Berliner, 2015). Further research is required to understand how forest regenerates, particular under continued pressure from livestock and alien invasive plants.

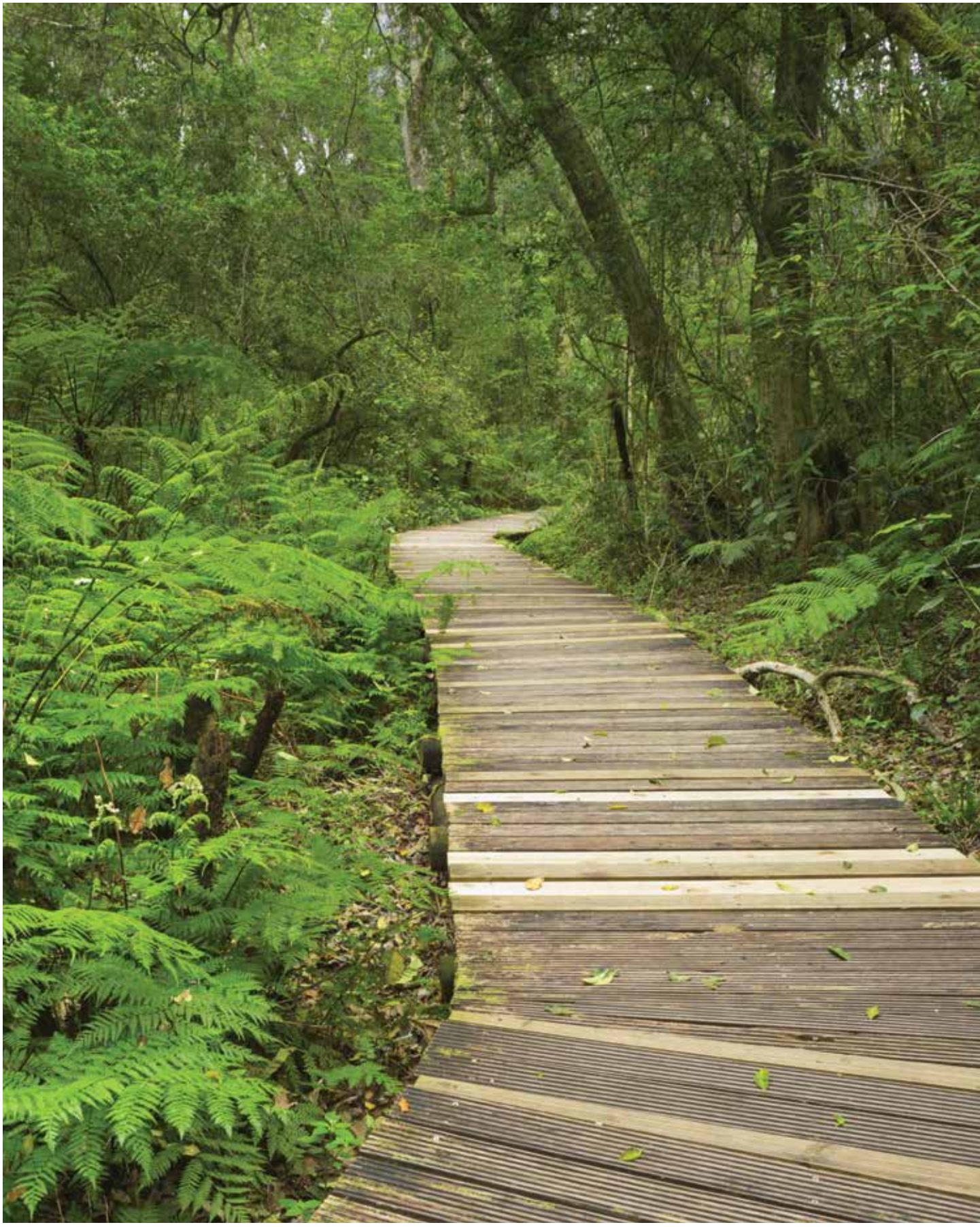
The total historical forest loss in South Africa is unlikely ever to be accurately determined, but recent advancements in remote sensing and land-cover mapping will be able to track contemporary and future changes in forest cover and carbon with far greater accuracy.

FOREST DEGRADATION

Forest degradation is much more prevalent that outright loss. Degradation, primarily from selective logging pre-1940, and the current subsistence harvesting of plants and animals for food, medicine, fire wood and timber, has altered forest structure and composition. This has in turn affected forest functioning, and food abundance for birds and other forest fauna.

Forest edges are distinctive communities –forest ecotone communities can tolerate fire and are typically higher in biodiversity than the forest interior. In many areas these ecotones have become heavily infested with invasive alien plant vegetation (Berliner, 2009). Invasive plants often invade forest edges and anthropogenic paths, and these form a seed source for movement into forest gaps. The recent infestation of forest by alien invasive plants is alarming, and is accelerating the impacts of human, livestock and fire-induced degradation. For example, gaps created in forest by illegal logging or fire are rapidly invaded by invasive species like bugweed and lantana, both extensively spread by frugivores. Where livestock are able to access forests for grazing and browsing or shelter, they can bring in alien plant seeds in their guts or on their bodies.

Although it takes many decades, disturbed forest will recover in time if natural succession is allowed to unfold, but this is not happening in many forests in communal areas of South Africa (Berliner, 2011, 2014, 2015). Typically, where invasive alien plants are prevalent, and free ranging livestock is allowed to roam in forests, natural forest regeneration is prevented. This is a now a common situation in the communal areas of the Eastern Cape and KwaZulu-Natal.



While rates of deforestation (complete loss of forest cover) have declined substantially in South Africa over the last 20 years, forest degradation has rapidly accelerated. This is due to several direct and indirect drivers (see below), but is primarily a result of non-sustainable harvesting and the spread of invasive alien plants. Although this is hard to quantify at a national scale, expert estimates suggest that, depending on forest type, approximately one third to half of all forests in South Africa may be degraded (Berliner, 2009) (Table 4.2).

Bird populations are good indicators of ecosystem health, and recent research shows significant range declines in half of South Africa's forest-dependent and forest-associated bird species, particularly in the Eastern Cape, between 1990 and 2015. Forest loss (17%) and degradation, as well as changes in the surrounding matrix, are thought to be causing these declines (Cooper, 2016' Cooper, et al. in prep).

Because South African forests are inherently fragmented, they have a high edge-to-interior ratio and are highly exposed and vulnerable to impacts originating from surrounding lands, such as fire, livestock, alien plants, illegal harvesting and agricultural pressure. The importance of adopting an ecologically integrated landscape approach to forest conservation, with strong local population participation in planning and management., is essential.

Table 6.2: Expert estimations of forest loss and degradation from 1900, and from 1990. The conservation status is derived through a multi-criteria assessment (Berliner, 2009)

Forest Type	Estimated Loss Since 1900 (%)	Estimated Loss Since 1990 (%)	Remaining Area (Ha)	Estimated Degraded (%)	Conservation Status
Albany	15-35	3	22 046	10	NT
Amatole Mistbelt	< 15	3	64 221	10	E
Drakensberg Montane	< 15	3	1 926	30	NT
Eastern Cape Dune	< 15	5	10 941	10	NT
Eastern Mistbelt	15-35	5	41 842	30	E
Eastern Scarp	15-35	10	33 750	30	VU
KwaZulu-Natal Coastal	35	10	21 089	50	VU
KwaZulu-Natal Dune	35	15	12 396	30	CE
Licuati Sand	15-35	2	24 276	30	CE
Limpopo Mistbelt	< 15	2	5 323	10	E
Lowveld Riverine	15-35	2	11 401	50	NT
Mangrove	35	15	2 393	30	CE
Mpumalanga Mistbelt	< 15	5	32 772	10	CE
Northern KwaZulu-Natal Mistbelt	< 15	5	19 204	30	CE
Pondoland Scarp	35	10	12 284	30	CE
Southern Cape Afrotemperate	< 15	3	74 848	10	VU
Swamp	< 15	2	3 022	50	CE
Transkei Coastal Platform	35	10	61 484	30	CE
Transkei Mistbelt	15-35	5	30 250	10	E
Western Cape Afrotemperate	< 15	2	4 731	10	NT
Western Cape Milkwood	15-35	5	2 500	10	E

6.5 DRIVERS OF DEGRADATION IN FORESTS

Causative agent of forest loss and degradation are seldom isolated but act in concert and are compounded. For example, a breakdown in resource use control encourages poaching and land clearing, and this in turn opens up gaps in the forest and margins. These are rapidly invaded by alien plants, which tend to be highly flammable, promoting fires that eat at forest margins.

Causes of forest loss and degradation need to be understood systemically, and solutions need to address both root causes, and their secondary effects.

INDIRECT DRIVERS

Indirect drivers (or root causes) are often socio-economic in origin and mostly beyond the scope of the individual site or project to respond to. These include:

- Poor resource management control.
- Increasing population pressure.
- Poverty, resulting in increased dependency on natural resources.
- Culturally-acceptable non-sustainable agricultural practices (shifting agriculture and field abandonment).
- Increased demand from urban centres for medicinal plant and animal products.

Commercialisation, modernisation, social change and the breakdown of traditional authority structures and introduction of inappropriate policies, all contribute to upsetting the equilibrium that once existed between traditional communities

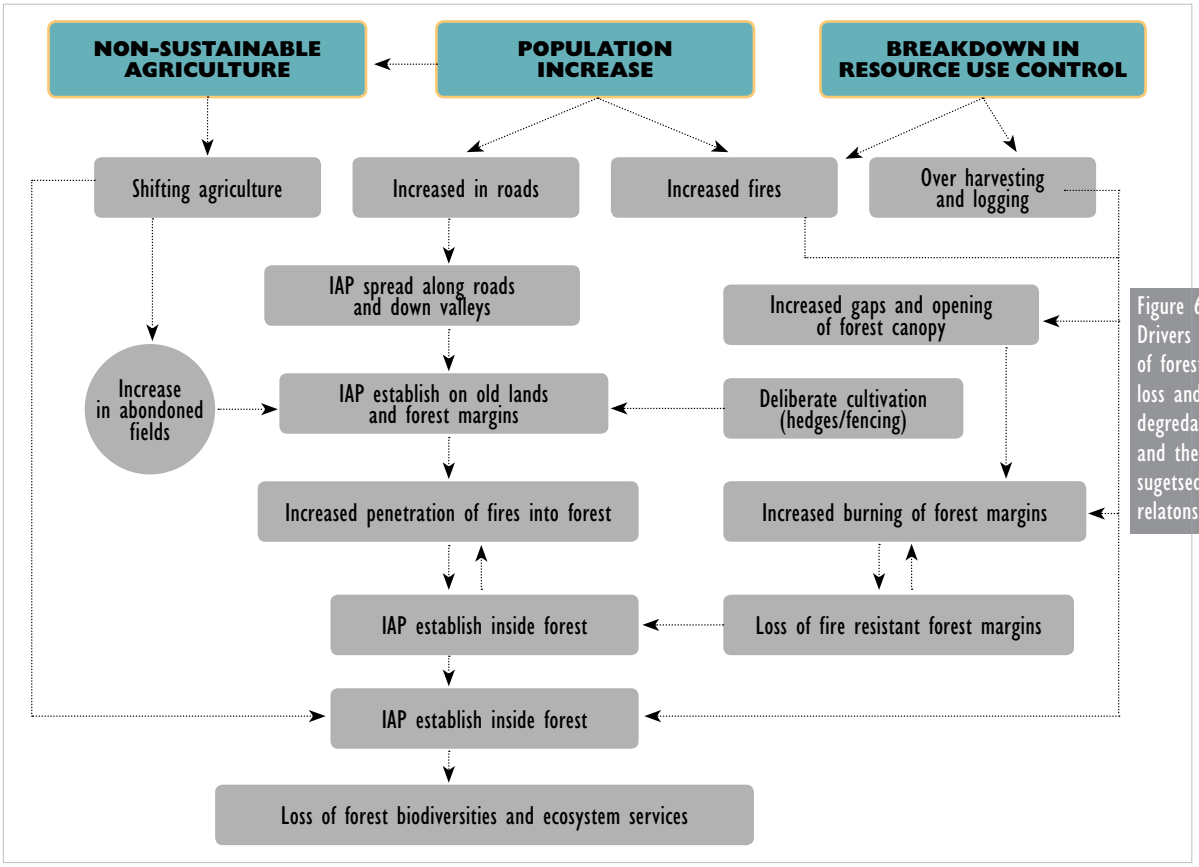


Figure 6.2: Drivers of forest loss and degredation and there sugetsed relatonships

Table 6.3: The relationship between the indirect and direct drivers of forest loss and degradation.

INDIRECT	DIRECT
• Poverty and high reliance on forest resources. • Poor poverty reduction planning. • Poor implementation of policy around participatory forest management and community-based natural resource management. • Poor law enforcement.	1. Non-sustainable use of forest resources (e.g. poaching or bark stripping for commercial markets in urban centres) 2. Weak incentives to conserve forests (tragedy of commons scenario).
• Poor government extension support for sustainable agricultural practises (current and past). • Population increase and shortage of arable land. • Poor law enforcement.	3. Non-sustainable agriculture (slash and burn/shifting agriculture invades margins and creates gaps inside forest).
• Poor fire management in rangelands.	4. Inappropriate fire regimes (either intentional or unplanned) – either be too frequent, too seldom or under the wrong conditions – damage the forest margins and sometimes even the interior.
• Poor law enforcement. • Breakdown in traditional authority structures (poor resource control measures at local level).	5. Illegal logging, hunting, commercial medical plant harvesting, bark stripping.
• Free-ranging livestock.	6. Livestock in forest suppresses forest recovery by eating seedlings and spreading AIP seeds.
• Poor extension service (environmental awareness) and the provision of invasive fencing plants.	7. Alien plants grown as hedges around homesteads act as infestation sources (spread along roads with birds and livestock into forests).

and the environment. Consequently, forest conservation in the communal parts of South Africa is currently in 'crisis'. It suffers what Shackleton (2009) refers to as an 'institutional control vacuum', with neither traditional nor government authorities providing adequate regulation, control, monitoring or advice on sustainable harvesting methods and land management.

DIRECT DRIVERS

Direct causes of forest loss and degradation include:

- Poor fire management, especially in the forest margins and surrounding grasslands.
- Invasion by alien invasive plants, especially of the margins and gaps in the forests.
- Illegal hunting and logging.
- Clearing of lands for cultivation.

7

FORESTS: DEFINING THE GAP – STATUS QUO VS NATIONAL READINESS

7.1 LAND USES AND REQUIRED ACTIVITIES FORESTS CONTEXTS

FOREST CONTEXT

Forests can be described in a variety of ways, but in terms of this work it is best to view them as being in one of five land-use contexts:

- Forest in protected areas.
- High value priority forests (larger forest patches > 1,000 ha) on communal land.
- Small forest patches on communal land (headman's forest).
- Indigenous forests on commercial timber estates (private or state).
- Forests on private farms.

The context will influence the timing, responsibility and types of activities that should be applied to the various land-use or mitigation scenarios.

FOREST ZONES AND LAND USES

There are a set of common land-use types that cover most forest contexts, and a set of activities that are required to achieve national readiness. These activities may apply to any number of the land-use types. Each land use and activity is further explored in Table 7.1.

Within forest contexts, there are several forest zones and land-use scenarios:

- **Forest interior**:
  The forest interior is reasonably robust and generally only vulnerable to illegal hunting and harvesting of plant products. Although very difficult to control, these should be managed primarily through Participatory Forest Management (PFM) and traditional authorities. The current condition of the forest interior can be classified along a gradient from intact to degraded.

- **Forest edges or margins:**
  Forest edges are vulnerable to invasion by alien plants, which should be removed with appropriate methods and regular follow up. Margins should be burnt periodically with cool burns to reduce the fuel load that naturally accumulates there and increases the risk of fire penetrating the forest canopy. The current condition of the forest margin can be classified along a gradient from intact to degraded.
- **Arable lands in a margin or within a forest**:
  In some forests, land is cleared in the margin or interior for arable purposes, for example to hide illegal crops such as cannabis. The nature of the farming is often akin to typical slash-and-burn shifting agricultural systems that can cause a lot of damage to forest ecosystems. Not only is the forest physically damaged by the removal of the natural vegetation, but the soil is depleted of organic matter and nutrients. Once the soil is exhausted, the crop is planted elsewhere, and the soil is left exposed to erosion. The area often becomes heavily invaded by AIP, which then have an increased chance of penetrating other areas of the forest.
- **Natural gaps, glades and opened areas within a forest that are regularly subject to livestock grazing and sheltering**:
  Forest gaps should be protected

from livestock, which graze and trample the emerging plants that are integral to the successional dynamics of forest re-establishment. Gaps are also prone to infestation by AIP, particularly woody pioneers and creepers, and these require monitoring and clearing.

- **Areas that are frequently accessed to extract forest products**:
  Some areas within a forest are accessed frequently by members of the local community extracting resources for use as timber, medicines and food. These areas are prone to degradation as plant and animal populations decline. The disturbance associated with human activities increases the likelihood of AIP infestation.
- **Surrounding matrix areas that have influence over the forest patch**:
  Areas around the forest patch can have a particularly strong influence on the forest patch. For example, grassland areas downslope of a forest patch can increase the risk of catastrophic fires running upslope into the margins and interior of the forest. Planting commercial timber or community woodlots immediately adjacent to a forest increases the likelihood of AIP infestation in the margins and interior. Management consideration of the forest should take such areas into account.

FOREST ACTIVITIES

A range of activities can be done in forests either to preserve their integrity or to help them recover from transformation or modification.

7.1.1 Forest zonation, planning, mapping and biodiversity inventory:

Zonation, planning, mapping and inventory can be conducted at multiple scales. At a provincial or regional scale, a systematic conservation planning approach is required to identify representative samples of each forest type for priority conservation areas.

At a local scale, ground surveys are required to:

- Map ecological zones or land uses.
- Identify and delineate high-value conservation areas for special forest PAs (under NFA), sustainable use areas, and sacred forests.
- Quantify biodiversity.
- Map areas of forest loss and degradation.
- Measure health or condition of different degraded zones.
- Identify priority degraded forests areas for restoration projects.

7.1.2 Community-based participatory forest management:

The National Forests Act, 1998 (Act 84 of 1998), and the Forestry Law Amendment Act, 2005 (Act 35 of 2005) emphasise the principles of Sustainable Forest Management (SFM), and Participatory Forest Management (PFM). This involves the formation of community forest management committees with a constitution and elected members. SFM has a set of principles, criteria and indicators that require on-going monitoring. It requires forest management zonation, allowing for core conservation areas, low utilisation buffer areas, and sustainable use areas. It also promotes the development of non-timber forest product enterprises (such as crafts, and bee-keeping) and ecotourism, as well as community-based forest monitoring and reporting. PFM plans are designed to establish traditional authorities' roles in controlling grazing in forests, obtain consensus, and provide the communal basis for sustainable harvesting rates, law enforcement, and use of forest products (such as medicinal plants, firewood, and structural timber).

All forest management activities, including control of access, harvesting, hunting, fire management and livestock management should be conducted using SFM and PFM principles, where appropriate. In cases where there is no community to be involved, management is done by the relevant authority only.

Forest edges are vulnerable to invasion by alien plants, which should be removed with appropriate methods and regular follow up. Margins should be burnt periodically with cool burns to reduce the fuel load that naturally accumulates there and increases the risk of fire penetrating the forest canopy. The current condition of the forest margin can be classified along a gradient from intact to degraded.

7.1.3 Forest restoration:

Restoration of degraded forests is only sustainable if the drivers of forest degradation are identified and addressed, particularly alien plant invasions, livestock grazing/trampling, and poaching. For community forests outside of the high-value priority forests, the focus of forest restoration should be on removing AIPs, key species enrichment planting, and fire and ecotone management.

7.1.4 Reforestation:

Only areas that sustained forests within the last 50 years should be considered for reforesting as it is unlikely that anything beyond this could be reasonably identified or re-forested. Anecdotal evidence combined with historical imagery is required to identify such areas, which should then be prioritised according to the potential for optimising social and ecosystem services in conjunction with carbon sequestration. Management objectives for reforestation should take cognisance of the type of forest and the reforestation zones. The aim of reforestation of sections of high-value priority forests should be restoring original forest biodiversity, while the aim of reforestation of smaller, community or headman's forests should be developing forests with high utility value, focusing on establishing useful species according to the principles of agro-forestry and food forests.

Table 7.1: Required activities in each forest land type.

KEY ACTIVITIES FOREST CONTEXT	1. FOREST ZONATION, PLANNING, MAPPING AND BIODIVERSITY INVENTORY	
Forest in protected areas	Each forest patch in the PA should be correctly surveyed and mapped so that the various land-use and forest zones are delineated, and health condition classes assigned to each zone. The forest should be included in the provincial or regional conservation plan to assess its conservation priority.	
High-value priority forests (larger forest patches >1,000 ha) on communal land e.g. Nstubane forest, Pondoland	The forest should be included in the provincial or regional conservation plan to assess its conservation priority. Within the area under communal jurisdiction, the following need to be identified and delineated: • Sacred forest areas. • Forests with unique biodiversity features (endemic species). • Current resource-use patterns. • Management zones (core protected areas, low utilisation areas, buffer zones, resource extraction areas). • Key ecological connectivity (stepping stone) patches. • Priority matrix areas.	
Small forest patches on communal land (headman's forest)	The forest should be included in the provincial or regional conservation plan to assess its conservation priority. Within the area under headman's jurisdiction, the following need to be identified and delineated: • Sacred forest areas. • Forests with unique biodiversity features (endemic species). • Current resource-use patterns. • Management zones (core protected areas, low utilisation areas, buffer zones, resource extraction areas). • Key ecological connectivity (stepping stone) patches. • Priority matrix areas.	
Indigenous forests on timber estates	The forest should be included in the provincial or regional conservation plan to assess its conservation priority. Each forest patch on the estate should be correctly surveyed and mapped and then detailed in the estate management plan with adequate resource allocation, particularly for the management of AIP and fire, both of which are key issues on timber estates. Matrix areas that have influence over the forest need to be clearly considered in the plan.	
Forests on private farms	The forest should be included in the provincial or regional conservation plan to assess its conservation priority. Regional conservation extension services should assist with the survey and mapping, which should then be detailed in the estate management plan with adequate resource allocation, particularly for the management of AIP and fire, both of which are key issues.	

	2. COMMUNITY-BASED PARTICIPATORY FOREST MANAGEMENT	3. FOREST RESTORATION	4. REFORESTATION
	Where a community has a historic access claim to forest within a PA, then appropriate PFM methods should be used to agree on the conditions of access, ensuring any use or extraction is sustainable. The forest should be specifically included in the PA management plan, with appropriate resource allocation for the management actions.	Degraded forests or zones within a forest should be managed towards a healthier condition, as the focus is biodiversity conservation. Actions should focus on: • Removal of AIP. • Reintroduction of forest trees and fauna. • Management of the margins to prevent fuel load accumulation.	Reforestation may only be applicable in exceptional cases where deforestation may have occurred prior to proclamation. The complexity of reforestation is such that it is not possible to give more detail here, other than to say that there must be adequate planning and consultation with technical experts to ensure success.
	Support existing, or establish new, Participatory Forest Management Committees (PFMCs) to oversee the following: • Work with conservation extension staff (state or NGO) to develop a management plan for the forest. • Develop small business enterprises that use non-timber forest products. • Develop ecotourism plans if appropriate. • Develop a community forest ranger system to ensure enforcement and forest monitoring and reporting.	Identify and manage on-going drivers of degradation using the forest ranger system. Degraded forests or zones should be prioritised for restoration using appropriate soil stabilisation and re-vegetation techniques.	Many high-value forests in communal areas of EC and KZN have lost sections to slash and burn farming that are no longer used. Re-forestation should be started through ongoing removal of AIP, protection of livestock, and directed succession by planting of pioneer forest species.
	Support an existing, or establish a new, Participatory Forest Management committee (PFMC) to see that all resource extraction, livestock access and fire management needs are identified and catered for with the communal management system.	Small patches within ecological corridors should be prioritised for restoration. The surrounding matrix should be management by the PFM committee. Where small patches are under heavy pressure consider establishment of woodlots as buffers and alternative wood sources.	Areas that were once forest are unlikely to be reforested in such contexts, so management should focus on soil stability and AIP control, aiming for the land to be managed towards either a stable natural vegetation type or a productive farming unit. Suitable areas can be identified for the establishment of community agro-forestry and food forest projects (possibly timber) using indigenous species.
	Where a community has a historic claim to forest within an estate then appropriate PFM methods should be used to agree on the conditions of access, ensuring any use or extraction is sustainable.	Companies, which are obliged to clear AIP under NEMA regulation and certification schemes (if relevant), should have a detailed AIP management plan with a budget. Small patches within ecological corridors should be prioritised for restoration.	Where plantations are decommissioned, these area should be managed to follow natural forest succession pathways, but with a very strong emphasis on long-term AIP control.
	Where a community has a historic claim to forest within a farm, then appropriate PFM methods should be used to agree on the conditions of access, ensuring any use or extraction is sustainable.	Where priority sites are identified for restoration, farmers should approach local extension staff or NGOs for assistance with the technical processes and planning.	Where sites are identified in regional conservation plans for reforestation, small-scale projects could be initiated by various NGOs (e.g. Green-pop).

7.2 FORESTS: NATIONAL AND PROVINCIAL SCALE MEASURES (TIER 1 AND 2)

Several key requirements need to be in place for forest conservation and restoration to be implemented at a national, regional or local scale (Table 7.2).

Table 7.2: National requirements forest restoration and management.

REQUIREMENT	STATUS QUO
A clear spatial plan for forests across the country, indicating historic and current boundaries, and conservation value and priority.	Although reasonable maps exist for the current distribution of forests, and there has been prioritisation of these, essential local information is needed to identify suitable project sites, especially regarding historic delineation and current condition.
Priority forests (or clusters of forests) have been identified and surveyed so that zonation maps, condition assessments and biodiversity inventories form the basis of a realistic management plan that is adequately resourced.	Most forests have not been surveyed at all and do not have management plans that are adequate or resourced.
Strong PFM and CBRNM support for forestry management.	Although PFM and CBRNM has been developed and endorsed by government in South Africa, it is poorly supported and generally under-resourced. A few effective projects exist.
Strong provincial and national forestry and conservation authorities that are mandated, resourced and able to ensure effective forest conservation and restoration.	The national and provincial forestry and conservation departments are generally under-staffed and under-funded and largely ineffective in the management of most natural forests (with some exceptions).
Implementation of the National Forest Act of 1998 and other relevant legislation.	Understanding and enforcement of the existing laws is ineffective. Very limited capacity to police the thousands of forest patches across the provinces. Little political will to enforce some of the laws in communal areas.
Regional and local support for forest-based enterprise development and sustainable forest use.	Weak support for community forestry from forestry or conservation departments. Limited funding and finance opportunities.
Clear land tenure, leadership authority, and land-user rights for all forests.	Most forests occur in communal areas, and there is often unclear traditional authority jurisdiction or lack of traditional leadership authority to enforce any management plan. Forests occur on many privately-owned areas that are currently subject to land claims, so future ownership and authority structures are unclear. Instances of unclear user-rights to forests on private land by neighbouring communities.
Monitoring, reporting and verification of carbon stocks and fluxes (MRV ability).	Poor capacity within state departments to do MRV. Technical capacity exists in tertiary and research institutions (e.g. SAEON), but capacity and funds are limiting.
Understanding of succession and recovery dynamics of forest recovery	Limited long-term research has been done to understand the communal lands and forest context.
Clear guidelines for AIP control in forests	Some dispute in ecological circles about the most effective and efficient ways to handle AIP in forests.
Strong support for community-based carbon mitigation projects.	Little extension support available from either forestry or conservation departments.

7.3 FORESTS: LOCAL SCALE ACTIVITIES AND MEASURES (TIER 3)

If effective and cost-efficient implementation models and institutional arrangements are to be designed, a clear understanding of the scope and nature of required activities and measures is necessary. Based on an analysis of the location and nature of drivers of deforestation and forest degradation, a set of activities and measures needs to be identified that will address the drivers in a comprehensive manner. Furthermore, ensuring the longevity of interventions (and forests) over the long term should be considered. Before attempting to identify a particular capacity, it is prudent first to list and describe the full set of functions that need to be undertaken. Thereafter implementation models can be developed in an efficient manner to take care of all required tasks.

Although a comprehensive assessment of drivers has not yet been commissioned, a general process can be recommended, based on the input of local experts and the project team's prior experience. For example, the principle determinants of deforestation and forest degradation in southern KwaZulu-Natal and the Eastern Cape are direct drivers such as the unsustainable harvesting of fuelwood, poles and medicinal plants, as well as infestation by alien invasive species. In this context, a broad suite of activities may be required to adequately halt deforestation and degradation. These may include:

- **Strategy development** – establishment of forest and fire management plans, forest zonation, the identification of potential buffer zones and creation of community forestry

Table 7.3: Tier 3, local scale requirements forest restoration and management.

REQUIREMENT	STATUS QUO	REQUIREMENTS FOR ‚READINESS' (ENABLERS)
Communities that surround forests.	Additional support is required to address poverty and enhance development.	Support and funding for community-based natural resource enterprises. (Carbon projects could provide funding and employment opportunities).
Community forestry (PFM), and community-based natural resource management (CBNRM).	Poorly implemented across country with limited follow up further to initial establishment.	Priority action required to roll out a programme of PFM. This is a significant obstacle to realising potential of carbon sequestration projects in communal areas.
Support for forest-based enterprise development and sustainable forest use.	Poorly implemented, due to weak support for community forestry. Limited funding and finance opportunities.	Need for strong institutional support for PFMC, and establishment of forest-users associations (FUA) within these structures.
Land tenure and unclear land user rights.	Most forests occur in communal areas, and about 10% of these areas are subject to land restitution claims.	Encourage the formation of community property associations with well-defined land and forest user rights. Government support for CBNRM.
Capacity and support for required monitoring, reporting and verification of carbon stocks and fluxes (MRV ability).	Poor.	Funding and institutional mandate needed to support this (A central agency such as a NFU with remote sensing capacity).
Understanding of forest extent, past loss and spatial degradation.	Poor-moderate. Essential information needed to identify suitable project sites.	As above.
Understanding of succession and recovery dynamics of forest recovery.	Limited long-term research has been done to understand the communal lands and forest context.	Research trials and long-term monitoring needed to improve understanding (SAEON, and academic institutions).
Implementation of the National Forest Act of 1998,	Currently parties are ineffective in carrying out their mandate to protect and manage forests.	Additional funding and intuitional support urgently needed. Forest protection and management should be a shared responsibility across conservation authorities.
Support for establishing community-based carbon mitigation projects.	Weak.	
Role of provincial and national conservation authorities in forest management.	Currently weak in most provinces.	Needs to be improved.

management (CFM) plans, if necessary.

- **Resource use control** – law and management plan enforcement, controlling grazing (cattle) and the collection of medicinal plants, firewood, poles and structural timber.
- **Forest management** (that may require extended implementation capacity) – control of alien invasive plants (AIP), implementation of fire management plans, implementation of erosion control measures.
- **Reforestation** – nursery, establishment and forest management over time. This may include the establishment of high-production buffer zones.

Once activities and measures to address drivers of deforestation and forest degradation have been identified, the implementation of required activities on the ground needs to be addressed. Appropriate forest management may require a broad range of tasks to be undertaken, including conducting forest surveys, halting illegal logging, controlling the rate and type of harvest, addressing erosion, removing alien invasive species, and implementing early season burns. Although DAFF and DEA have existing regional officers who could possibly undertake a number of activities, substantial additional implementation capacity may be required.

A review of past implementation efforts would greatly improve the probability of success of future interventions. Lessons should be drawn from existing DAFF and DEA implementation as well as private and NGO sector initiatives. Once the review of drivers and barriers within a particular area is complete, it is suggested that such a review is undertaken on a region-by-region basis to ensure that adopted implementation models are pertinent.

SECTION FIVE

REALISING OPPORTUNITIES FOR BIOGAS DIGESTERS

8

INTRODUCTORY BRIEF – BIOGAS DIGESTERS

8.1 SOUTH AFRICAN CONTEXT

Biogas digesters use of anaerobic bacteria producing gas under oxygen-free conditions from various organic substances such as food waste, animal manures or wastewater sludge. The gas produced is typically composed of 65% methane (CH4), 35% carbon dioxide (CO_2) and traces of contaminant gasses. The biogas is most commonly used to run a generator and produce renewable electricity; however, the biogas can also be used for heating purposes or as a transport fuel after the methane content is increased and the gas is pressurised. Although biogas, and the renewable energy derived from it, is the most valuable product, there is another product called the digestate. This is a largely inert wet product with valuable plant nutrients and organic humus, which can be used as soil conditioner (Redman, 2010).

The process commonly referred to as Anaerobic Digestion (AD), comes in various forms and with various capacities, with on-farm facilities using manure as the main feedstock perhaps being the most common one globally. With a total estimated GHG mitigation potential of 3.6 million tCO_2e, biogas from farm manure was identified in the South African Terrestrial Carbon Sink Assessment (DEA, 2015) as the area with the largest AFOLU mitigation potential, and consequently, is the focus of this element of the study.

8.1.1 Concept and status

The basic types of larger-scale on-farm digesters are the covered lagoon digester, the Continuously Stirred Tank Reactor (CSTR) and the plug flow digester (MSU, 2003; SABIA, 2015). There are also smaller rural digesters like the conventional brick and mortar fixed dome digester and more recent designs like the in-situ cast, plastic moulded and bio-bag digesters.

LARGER SCALE ON-FARM DIGESTERS.

The three basic types of larger scale on-farm digesters are described below:

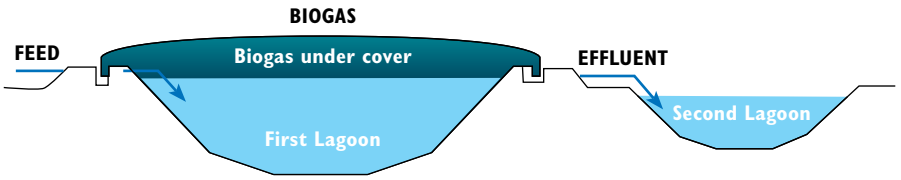


Figure 8.1: Covered lagoon digester – a 120 kWe lagoon digester facility is located at a farm north of Pretoria.

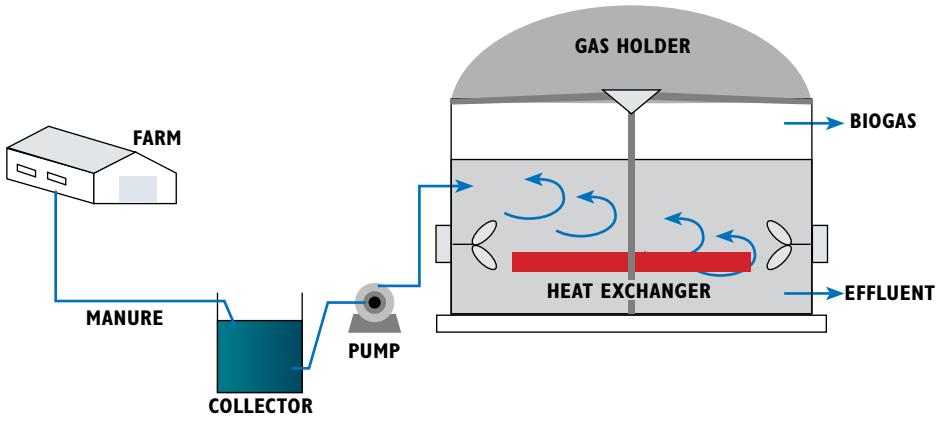


Figure 8.2: Continuously Stirred Tank Reactor – Bio2Watt's 4.4 MWe plant in Bronkhorstspruit, situated on the premises of Beefcore, one of South Africa's largest feedlots, is a good local example of a CSTR.

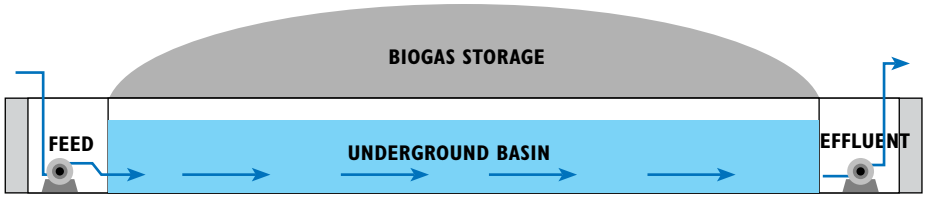


Figure 8.3: Illustration of a plug flow digester.

COVERED LAGOON DIGESTER

Diluted liquid manure, generally with less than 2% solids, is first fed into a deep anaerobic lagoon with an airtight cover trapping the gas produced (Figure 8.1). Biogas is produced and recovered, depending on temperature, as the lagoon is not heated. Although this is not optimal, the covered lagoon is attractive because of its low capital requirements. The effluent is not suitable for discharge to receiving waters and is therefore treated further in aerobic or facultative lagoons.

CONTINUOUSLY STIRRED TANK REACTOR (CSTR)

The CSTR is an engineered tank that provides for continuous heating and mixing of the substrate (Figure 8.2). Generally, these tanks are built above ground. CSTRs treat slurry manure with a solids concentration in the range of 3–10% and are compatible with scraped and flushed manure. The CSTR is more expensive to install, operate and maintain than a plug flow digester and is generally only used for commercial applications.

PLUG FLOW DIGESTER:

A plug flow digester handles greater amounts of solids (typically 8–13%) than either a covered lagoon or a complete mix digester (Figure 8.3). The manure/contents needs to be thick enough to keep particles from settling to the bottom of the tank. Swine manure for example cannot be treated because of its lack of fibre. Plug flow digesters are typically five times longer than they are wide and have the basin underground. Depending on the design, they can be stirred and heated if required.

BiogasSA installed its first pilot floating dome plug flow digester at an HIV/Aids clinic in Johannesburg. The Cane Growers Association is currently installing a low-cost 100 m3 floating dome plug flow digester for cane growers in KwaZulu-Natal. The designs of these are different from the larger-scale plug flow digester as the dome holding the gas is floating (not fixed) and, most importantly, is of a more basic and cheaper design. Innovative approaches like this can make digesters more affordable and more widely accepted. The Cane Growers Association demonstrator is aimed at creating a basic low-cost digester that is also suitable for small scale growers. This should result in a larger uptake and increase the socio-economic impact.

SMALL-SCALE RURAL DIGESTERS

Small-scale digesters are generally neither mixed nor heated, in order to keep the system as low-cost and low-maintenance as possible (Figure 8.4). With the entry-point higher than the extraction-point there is a gravity-governed flow and no pumps are required. Small-scale digesters are generally buried, to ensure a constant season-independent temperature, and to protect structural integrity in the longer term. The basic concept remains similar to the larger scale digesters.

The brick and mortar fixed dome digester is a classic low-cost and labour-intensive design that has been widely deployed globally for several decades, in India and China in particular. Although it is cheap, an important drawback is the highly skilled workmanship required to ensure the dome is air/gas-tight in the longer term (Bohl, 2011; FAO, 1992). Poor workmanship can severely limit the technical lifespan, with the result that installations fall into disuse after only a few years.

Innovative new designs using different materials are currently becoming popular. These include in situ cast, plastic moulded and bio-bag digesters (Figure 8.4). Many of the newer designs have flexible domes submerged in water and use the water table to keep a constant gas pressure. These newer designs are being commercialised in South Africa and several locally designed and produced systems are now available, for example from Agama in Cape Town, Energyweb in Pretoria and BiogasSA in Johannesburg.

OVERALL UPTAKE

In South Africa, the biogas industry is still at the 'emerging' stage. The South African Biogas Industry Association estimates that there are only about 700 biogas digesters in the country so far. About 50% of these are small-scale domestic/rural digesters, typically in agricultural settings. About 10% are larger scale commercial installations such as the Bio2Watt 4.4 MWe plant in Bronkhorstspruit. Approximately 40% of installations are wastewater treatment works.

A major challenge for the uptake of biogas technology is finding affordable concepts that balance capital costs with good biogas yield and revenue generation. Payback times are most often in excess of 10 years. BiogasSA indicates that only for farm-size digesters in the order of 0.5 MWe is the payback period reduced to around 5–6 years. Even these shorter payback times are often beyond the limits of what is acceptable for investors (commercial projects) and project owners (in-house projects).

Brick and Mortar

In Situ Cast

Plastic Mould

Figure 8.4: Illustration of small-scale biogas digesters

In order to realise a larger uptake, investment costs need to be further reduced and revenues need to be increased. Innovative standardised concepts such as the bio-bag can reduce investment costs while government intervention pricing in the co-benefits such as GHG emission reduction, job creation and access to biogas electricity as an energy source and compressed biogas as a transport fuel, would be helpful.

8.1.2 Current initiatives and governance

Although the biogas industry is still emerging, it is relatively well organised, with an active industry association and a national platform:

- **South Africa Biogas Industry Association** (SABIA)
  - Established in 2014, it currently has about 40 members.
  - The steering committee has industry representatives.
  - It is focused on promoting the needs of industry stakeholders and facilitating the development of a prosperous biogas industry in southern Africa.
  - It has an Info-hub, which co-organises a (bi-)annual conference and working groups.
- **National Biogas Platform**
  - Established in 2013, this a collaboration between the public and private sector.
  - It is led by the Department of Energy, in partnership with SABIA and GIZ.
  - GIZ has been appointed to facilitate and coordinate activities.
  - Members include government departments, provincial and local government, industries, Eskom, research institutes, and financing institutions.
  - It is focused on sharing lessons learned, creating a conducive regulatory framework, and unlocking/creating financing options.
  - It has established working groups covering focus areas and co-organises a bi-annual conference.

In order to stimulate the uptake of biogas technology, both organisations are working with the relevant government departments to develop clearer licensing processes adapted to the specifics of biogas projects. They are also working on the development of appropriate incentives to enhance the financial attractiveness of projects and unlock financing opportunities.

Biogas projects are generally (erroneously) perceived to be more complex to rollout than, for example solar and wind energy projects. As a result, the uptake of biogas technology in the country, both on a small and on a large scale, is minimal, and overshadowed by other forms of renewable energy. Biogas is hampered by the size of activities, which is limited by biomass volumes available at site or close by, and a relatively high price per unit of energy required to make projects viable. Several governmental initiatives do include biogas components but they often lack an emphasis on biogas in particular, resulting in a slow and low uptake of biogas technology within these initiatives.

The Renewable Energy Independent Power Producer Programme (REIPPP), introduced in 2011, has been successful in promoting renewable electricity overall, but it has not delivered in terms of biogas or biomass to electricity. The separate IPP programme for small-scale projects (< 5 MWe), running alongside the REIPPP, does not currently include any biogas projects.

Innovative standardised concepts such as the bio-bag can reduce investment costs while government intervention pricing in the co-benefits such as GHG emission reduction, job creation and access to biogas electricity as an energy source and compressed biogas as a transport fuel, would be helpful.

One of the commitments under the Green Accord was the formation of the South African Renewable Energy Council (SAREC) to "establish an organisation that will facilitate the renewable energy sector working in partnership with other social partners in the development of the sector" (Green Accord, 2011). SAREC focuses on solar electric, solar thermal, wind and energy efficiency. The four participating industry associations (SAWEA, SAPVIA, SASTELA and SESSA) represent these specific areas. At the time SAREC was formed, the biogas industry did not yet have an association and therefore SABIA is currently not participating in SAREC.

The Eastern Cape Department of Economic Development, Environmental Affairs and Tourism is one of the few organisations with a specific programme targeting the rural application of bio-energy – the provincial Bio-Energy Implementation Support Plan. It is run by the renewable energy unit of the Eastern Cape Rural Development Agency. The focus of this programme includes biogas from municipal waste, rural household biogas digesters, agricultural biogas for vehicles, as well as bio-energy villages managed by service cooperatives.

According to the General Household Survey (2015), there is a total of 5.0 million households in rural areas. The "Biogas Industry in South Africa" study (GIZ, 2016), which was based on multiple governmental sources, estimates that 3.1 million of these rural households hold livestock, of which 2.5 million (81%) hold from 1–10 cows.

The off-grid electrification programme of the New Household Electrification Strategy, implemented as a collaboration between the DoE and the Department of Cooperative Governance and Traditional Affairs (COGTA), does include biogas but is currently focused on Solar Home Systems (SHS). The full spectrum including biogas and biomass still needs to be unlocked.

The Department of Energy (DoE)'s Water for Energy Programme targets the development and implementation of labour-intensive energy related initiatives including 'biofuels development and implementation in rural applications'. Biogas initiatives in the Eastern Cape and Limpopo have so far been implemented as part of this programme.

The Department of Environmental Affairs (DEA) runs a 'Green Programmes and Fund' funded by and in collaboration with UNIDO and GEF. The objective of this programme is to promote market-based adoption of integrated biogas technology in small, medium and micro-scale enterprises (SMMEs). The programme has four components: capacity building/ technology support; market and regulatory framework development; technology demonstration and scaling up. The programme is in the process of selecting 5–10 demonstration projects for funding.

8.1.3 The value of biogas

In addition to its contribution to the mitigation of GHGs, biogas technology can deliver substantial socio-economic benefits to farming and rural communities. On the one hand this may be seen as a co-benefit, it could also be seen as a prerequisite. People need favourable conditions for improving their livelihood and business environment in order to support any biogas uptake initiative.

The nature of biogas technology – requiring feedstock supply and active operation of the facility – does make it more complex to implement than, for example, solar panels on a roof. However, this has the positive benefit of greater local permanent job creation. While the job creation potential is difficult to quantify, it is fair to say that, per MW electricity, the job creation potential for biogas is higher than for solar and wind.

RURAL AGRICULTURAL HOUSEHOLDS

According to the General Household Survey (2015), there is a total of 5.0 million households in rural areas. The "Biogas Industry in South Africa" study (GIZ, 2016), which was based on multiple governmental sources, estimates that 3.1 million of these rural households hold livestock, of which 2.5 million (81%) hold from 1–10 cows. For a rural small-scale digester to be viable, a minimum of 2–4 cattle are required (GIZ, 2016; Lawbuary, 2000). However, food waste and other organic waste streams could be added to complement a low number of cows. It can therefore be assumed that 2.5 million rural agricultural households would qualify for anaerobic biogas digesters. This number corresponds with the 3 million subsistence farmers recorded by DAFF (2012).

The estimated 2.5 million rural agricultural households holding cattle could benefit from biogas in various ways depending on whether the household is connected to the grid or not:

- Biogas to rural agricultural households without access to the grid:
  - About 337,500 households are not grid connected (StatsSA, 2016).
  - Current cooking fuels are: wood, paraffin and coal.
  - Ease of cooking and no fuel

collection has potential for time and cost savings.
  - Biogas is a clean burning alternative, improving indoor air quality.
  - Digestate can be used as fertilizer with a high availability of nutrients and high crop yields.
- Biogas to rural agricultural households with access to the grid:
  - About 1,652,500 households use electricity for cooking (StatsSA, 2016).
  - About 510,000 households with access do not use electricity for cooking.
  - Biogas can be used as an alternative for electricity.
  - Same benefits as for non-grid-connected households.
  - Digestate can used as fertilizer with a high availability of nutrients and high crop yields.

The actual uptake of bio-digesters by rural agricultural households will depend on their advantages relative to the existing energy used for cooking. The most important factor in this regard will be the cost, although ease of use, reduced efforts to obtain fuel, and cleanliness of cooking, will also play a role. Although there are other benefits to using biogas, cost will remain the main driver for poor households when comparing it to wood, paraffin and coal. The cost of cooking on biogas should be significantly lower than cooking on electricity, as this is the most significant competitive benefit that could motivate a switch. It can be assumed that when biogas is equal in cost or slightly cheaper compared to wood, paraffin and coal, there will be greater uptake.

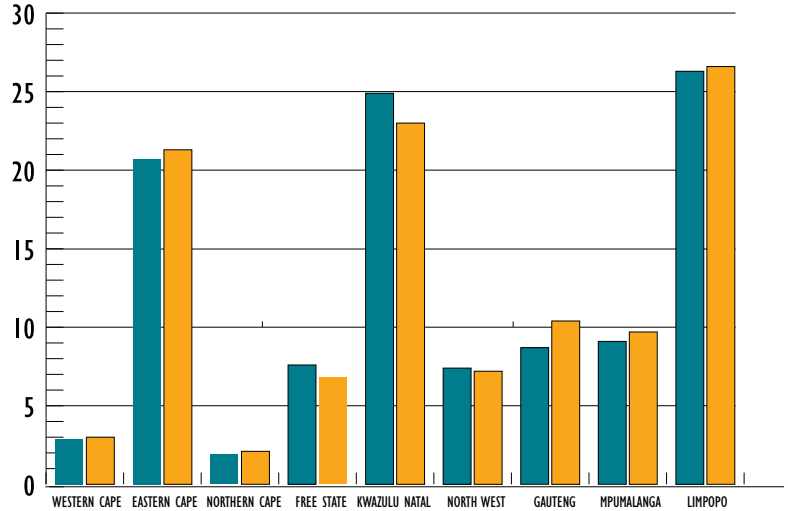
FARM-SCALE DIGESTERS

The total number of commercial cattle farmers in South Africa is estimated at 50,000 holding 11 million cattle, with emerging farmers and communal farmers estimated at 240,000 and 3 million respectively, holding 5.6 million cattle. Among the 50,000 commercial farmers in South Africa, there are approximately 70 feedlots, with the largest 13 feedlots accounting for 77% of total feedlot capacity. Karan Beef in Heidelberg is the largest feedlot with 120,000 standing cattle capacity (27%), followed by Bull Brand with 40,000 standing cattle capacity (9%) (DAFF, 2012).

Feedlots are ideally suited for the application of biogas digesters as large volumes of fresh manure can be collected daily at a single location. Nevertheless, smaller-sized farms can also apply biogas digesters as long as the type and configuration of the digester is adjusted accordingly, to simplify and reduce the upfront investment.

In addition to cattle farmers, South Africa has 3,665 dairy farmers, holding a total of 671,517 cows with an average of 399 cows per farm. The provinces with the largest number of milk producers are Western Cape (502), Eastern Cape (251), KwaZulu-Natal (253) and Free State (280). The provinces with the largest cows in milk per producer are Eastern Cape (863) and KwaZulu-Natal. Figure 8.5 below illustrates the intensity of dairy farming on a district level (Milk SA, 2016).

The 240,000 emerging farmers and 3 million communal/subsistence farmers, holding 5.6 million cattle, are assumed to be included in the rural agricultural households. If each of the reported 2.5 million households holding cattle holds 2.2 head on average, the 5.6 million holding capacity is reached. It therefore appears that the numbers of cattle are spread thinly across the many household that hold some cattle for subsistence farming, and



Source: Community Survey 2016, Agricultural Households (StatsSA, 2016) http://cs2016.statssa.gov.za/wp-content/uploads/2016/07/NT-30-06-2016-RELEASE-for-CS-2016-_Statistical-releas_1-July-2016.pdf

Figure 8.5: The number of agricultural households per province (expressed as a percentage)

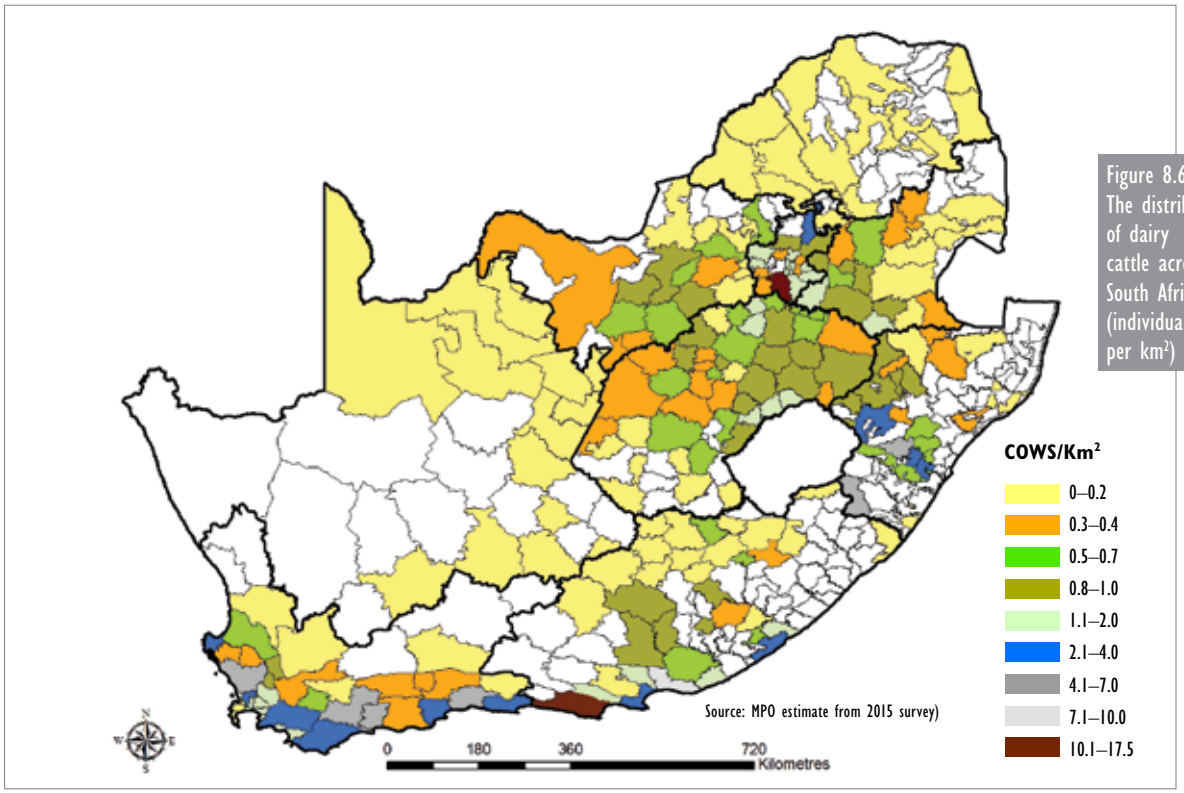


Figure 8.6: The distribution of dairy cattle across South Africa (individuals per km²)

emerging and subsistence farmers should be included in the total of rural agricultural household to avoid double counting.

About 50,000 commercial cattle farmers, 3,665 dairy farmers and some of the 240,000 emerging and communal cattle farmers with larger holdings could benefit from biogas as follows:

- Green electricity and heat generation on site.
- Improved manure composition and less odour.
- Digestate fertilizer with higher availability of nutrients and higher crop yields.
- No acidification of the soil as digestate has a higher pH.

For the larger feedlots, it would also be an option to convert biogas in Compressed Biogas (CBG) for use as a transport fuel or a non-compressed natural gas substitute. This is only possible when economies of scale allow for efficient additional upgrading to a near-natural-gas quality, removing carbon dioxide and impurities and, in case of CBG, compression to about 250 bar. The study 'Facilitation of Large Scale Uptake of Alternative Transport Fuels - The Case for Biogas' (DEA, 2016), shows a threshold of around 750 Nm_3 of biogas (65% biogas content) per hour is required as a minimum to provide these economies of scale. This threshold is equivalent to about 32,500 standing cattle in a feedlot, which means that the four largest feedlots in the country could qualify. For dairy farms with cows producing a larger amount of dung per day, the equivalent threshold is about 14,000 cows. No dairy farms of this size exist in South Africa.

Producing CBG for use as a transport fuel provides the highest monetary value per unit of energy and therefore is the most attractive option, economically, if the required economies of scale can be achieved. The second best option is replacing natural gas as a general fuel, while the least economically attractive option is producing electricity. These comparisons are illustrated in Figure 8.8.

Driving on natural gas is an emerging market and so too is the use of CBG (which can replace natural gas) as a fuel. The larger feedlots, which could, because of their size, be economically viable CBG producers, may be reluctant to choose this option as it can be difficult to secure sufficient offtake. The location of the larger feedlots close to urban areas would however provide the potential to secure offtake.

Farmers' heat demands are generally low and so they are not particularly

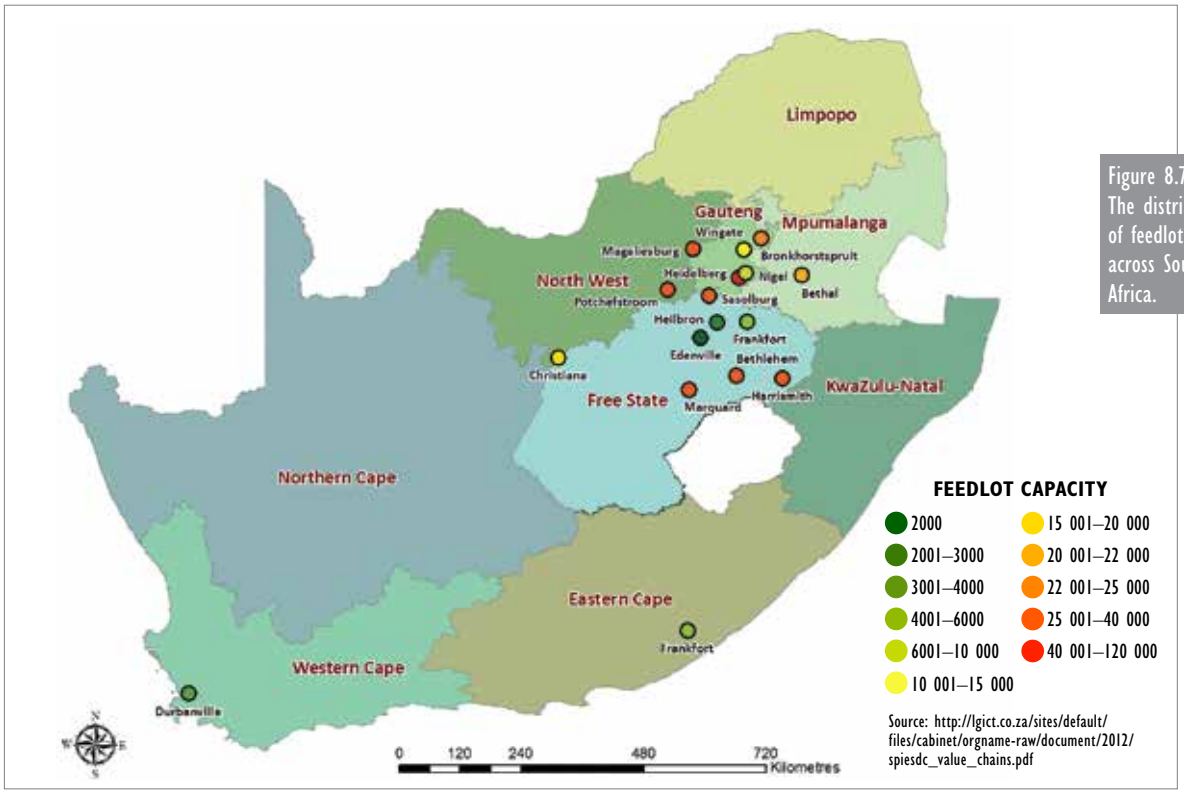


Figure 8.7: The distribution of feedlots across South Africa.

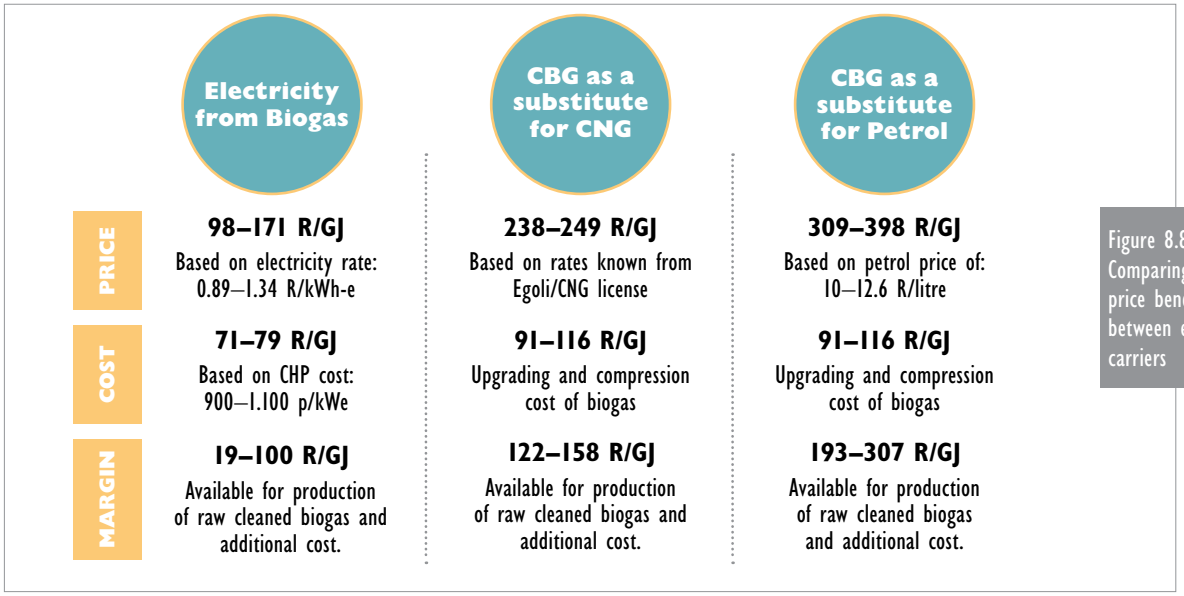


Figure 8.8: Comparing net price benefit between energy carriers

interested in burning biogas directly to produce heat. If heat is required, it can be produced cheaply using alternative resources like wood and coal. Moreover, some heat can be recovered from the generator. In contrast, electricity is costly and producing one's own can provide a good return for a farmer. Problems arise, however, when access to the grid is required for wheeling electricity to another site, or private customer, or for selling electricity to the municipality or Eskom. Current regulations prevent easy access and municipalities and Eskom are not willing to pay a higher price than their current cost price. With this monopoly in place, and effective regulations for access lacking, producing captive biogas for conversion to electricity (for own use) is the type of biogas project most likely to appeal to farmers.

8.2 CONCEPT AND CLIMATE VALUE

8.2.1 The Concept

When looking at biogas digestion from a mitigation perspective, it is important to determine how the biogas produced will be put to use, to allow for comparison with conventional uses that are generally based on fossil fuels. Figure 8.9 shows the concept of biogas digestion and the different modalities of using the biogas, that is, as electricity, transport fuel, or heat. In addition, the digestate produced can be used as high-quality fertiliser.

As discussed under Section 1.1.3, 'The value of biogas', the dominant application of biogas for farmers is conversion to electricity, while for rural agricultural households the use of biogas for cooking and heating is most common. Using these facts as a basis, carbon mitigation potential is assessed against a so-called baseline – the activity in the absence of the use of biogas.

RURAL AGRICULTURAL HOUSEHOLDS – BIOGAS FOR COOKING AND HEATING

Even when electrified, poor rural households can often only afford to use electricity for lighting, running entertainment appliances, and charging phones. Cooking and space heating are more energy intensive and therefore it is more economical to use wood, LPG, paraffin or coal. Some of these are the most polluting indoor methods, which continue to affect indoor air quality (IARC, 2010; Stats SA, 2009 and 2015).

According to the 2016 Community Survey of agricultural households by Statistics South Africa (StatsSA, 2016, rural agricultural households use the following alternative fuels for cooking and heating. These figures are being used to establish the baseline:

- Wood 72%
- LPG 13%
- Paraffin 11%
- Coal 2%
- Other (i.e. animal dung) 2%

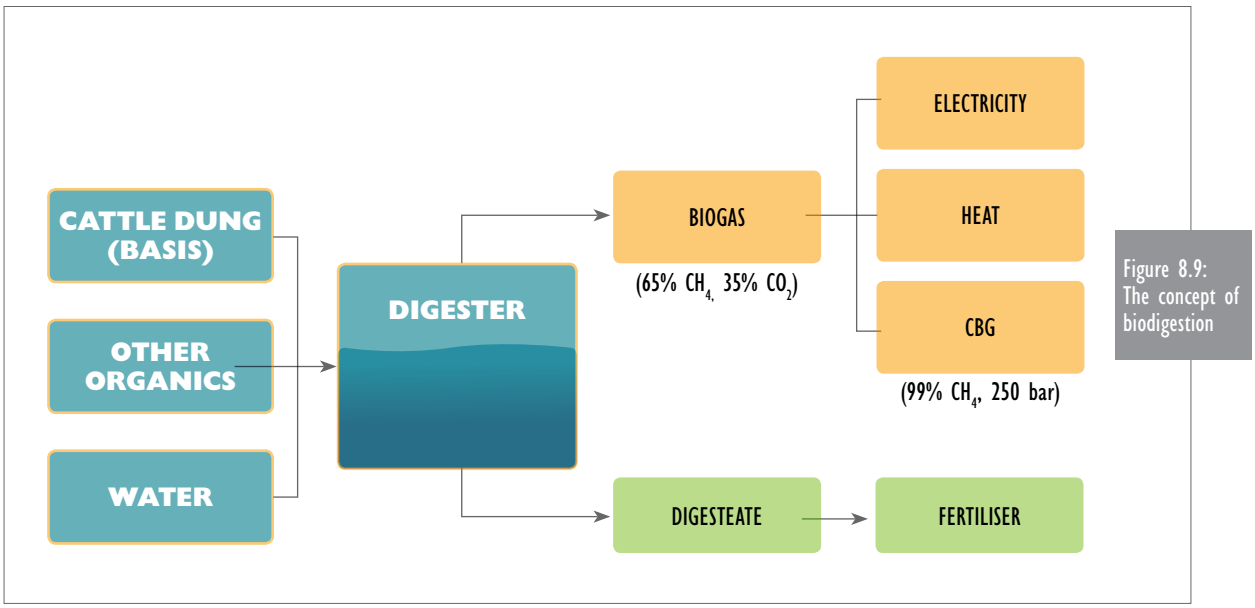


Figure 8.9: The concept of biodigestion

CATTLE AND DAIRY FARMS

Regarding farm-scale digesters, it is necessary to distinguish between larger-scale cattle and dairy farming operations and smaller ones. Currently, biogas is most likely to be used for electricity production, but the 14 largest feedlots and dairy farms in the Eastern Cape and KwaZulu-Natal, which, on average, pass the viability threshold, may be candidates for biogas for transport. The smaller feedlots, non-feedlot cattle farmers holding cattle in kraals at night, and smaller dairy farmers would not reach the threshold of biogas for transport but may be interested in biogas for the production of electricity, most likely for own use, and to avoid grid access difficulties.

The baseline for biogas to electricity is the use of grid electricity, and likewise, the baseline for biogas for transport is the use of conventional diesel and petrol in South Africa, the fuels used in the absence of biogas. Mitigation potential can be determined by quantifying biogas production potential and converting it to electricity and CBG (for transport), and determining the GHG emissions when using equal amounts of conventional grid electricity and transport fuels.

8.2.2 Potential and carbon impact

For the two main groups with biogas mitigation potential – dairy farms and rural agricultural households with cattle – the total mitigation potential is estimated and subsequently compared, since the realised biogas potential is currently very limited.

RURAL AGRICULTURAL HOUSEHOLDS – BIOGAS FOR COOKING AND HEATING

The potential for the use of biogas for cooking and heating is quantified assessing the number of households currently not using gas or electricity for cooking, and their heat consumption. By installing biogas digesters, conventional fuels for cooking could be replaced by biogas. A successful introduction of biogas digesters could also result in a surplus of biogas, above the current needs, being produced. However, if biogas is not used to replace conventional fuels, it may reduce the amount of GHG in the atmosphere and therefore not form a climate change mitigation activity.

The average consumption of wood for fuel in South Africa is estimated at 4.5 tons per household per annum. This estimate was based on a study published by the Programme for Basic Energy and Conservation, a regional programme implemented by the German Agency for Technical Cooperation (Damm and Triebel, 2008). This study takes into account several micro-studies at local level and determines an average via analysis. The equivalent energy value of annual wood usage is estimated to be 92 GJ/year based on the total annual energy for cooking and heating, including paraffin and coal usage.

The average 92GJ/a or 253 MJ/d energy demand of a rural household cannot easily be satisfied by biogas from a small-scale digester. A farmer would need 59 cows to get enough biogas to meet this demand from a small-scale digester running mainly on dung collected from cattle kraaled only at night. Although the variance in consumption of wood per household is high, from 0.6–7.7 tons (Gandar, 1981, 1983; Liengme, 1983; Banks, et al 1996), in most cases 1–10 cows would be insufficient to fulfil total energy demand.

The average consumption of wood for fuel in South Africa is estimated at 4.5 tons per household per annum. This estimate was based on a study published by the Programme for Basic Energy and Conservation, a regional programme implemented by the German Agency for Technical Cooperation

(Damm and Triebel, 2008)

With biogas being insufficient to meet total demand, biogas potential limits the total offset potential. For the effective implementation of biogas in rural agricultural households, it may be necessary to combine a variety of organic waste streams in order to make biogas an attractive and viable solution. If cattle dung is to be used, it would require rural households to kraal cattle overnight, which is currently not always done. For calculation purposes, we assumed a range of 40%–80% being kraaled overnight. The circumstances around practical implementation and viability are dealt with in more detail in Section 2 of this report, 'Defining the gap'.

The calculation of baseline emissions for rural agricultural household cooking and heating not using electricity is based on the known fuel-mix of wood, LPG, paraffin and coal (StatsSA, 2016). It is assumed that these baseline emissions can be offset by the use of biogas to the extent that biogas can replace conventional fuels. The dominant factors for GHG mitigation are the total energy value of biogas and the GHG intensity (tCO_2/GJ) of the baseline for the specific fuel-mix. There may be some leakage of methane from biogas systems, but generally the risk of leakage is limited if systems are installed and operated correctly. For rural agricultural households cooking on electricity the GHG intensity (tCO_2/GJ) of the baseline is determined by the grid and is derived from the known grid emission factor of 1.03 tCO_2/MWh, as indicated in Eskom's annual report of 2011.

As illustrated in Figure 8.1, the GHG mitigation potential for biogas in rural agricultural households is estimated to be 444,845 to 667,267 tonnes CO_2 per annum. Under the carbon tax offset mechanism (NT, 2015) this would represent a value of 53 to 80 million Rand annually.

Table 8.1: Rural Agricultural Households – Mitigation potential biogas for cooking and heating

FUEL	FUEL (–)	EMISSION FACTOR (tCO_2/T FUEL)	HEATING VALUE (GJ/T)	CARBON INTENSITY (tCO_2/GJ)	CONTRIBUTION FUEL MIX (tCO_2/GJ)
Wood	72%	1.78	20.5	0.087	0.064
Lpg	13%	1.69	46.1	0.037	0.005
Paraffin	11%	2.96	43.9	0.067	0.007
Coal	2%	1.85	23.7	0.078	0.002
Other	2%	Not Included	Not Included	Not Included	Not Included
				Weighted Average Fuel Mix Carbon Intensity	**0.078**

Total energy potential based on 5.54 million cattle – 100% kraaled	8.6	million GJ/a
Additional 20% for adding other waste	10.3	million GJ/a
Rural Households Not Using Electricity For Cooking	847.500	
Percentage of total rural households	17%	
Average GHG footprint of a household per GJ	0.078	tCO_2/GJ
Sub-Total	**136.133**	
Rural Households Using Electricity For Cooking	1.652.500	
Percentage of total rural households	33%	
Average GHG footprint of a household per GJ	0.286	tCO_2/GJ
Sub-Total	**975.979**	
Total emission reduction potential (100% kraaled)	1.112.112	tCO_2/a
Total emission reduction potential (40–80% kraaled)	444.845–667.267	tCO_2/a
Annual monetary value at 120 R/ton (NT, 2015)	53–80	tCO_2/a

Source: Emission factors: Schedule 1 of the Draft Carbon Tax Bill (NT, 2015). Heating values: DEFRA, 2012 and WSP, 2010. Grid emission factor: Eskom annual report, 2011. Household cooking preferences: StatsSA, 2016.

A lack of data makes it impossible to determine what percentage of fuel wood might be collected sustainably, but it is reasonable to assume that wood collected for cooking and heating is generally harvested unsustainably. If this is not the case, the emission reduction potential reduces the share of wood in the total household energy needs by 72%.

One of the major challenge for realising the mitigation potential of rural agricultural households is convincing households currently able to afford electricity to convert partially to biogas.

CATTLE AND DAIRY FARMS

As mentioned above, the biogas mitigation potential for cattle and dairy farmers is determined on the basis of electricity generation offsetting grid electricity. Data regarding head of cattle and different ownership categories was sourced from the Department for Agriculture, Forestry and Fisheries (DAFF, 2012/2015), and data regarding dairy farming from Milk South Africa's Lacto Data (MilkSA, 2016).

For calculations purposes, assumptions have been made regarding the percentage of cattle or cows being 'kraaled'. At feedlots, cattle stay predominantly where they are fed, and have only very limited freedom to walk around. Conservatively, it can be assumed that 80%–90% of dung can be collected. Commercial cattle in the field are often not kraaled at night and a kraaled percentage of 20%–40% has been assumed. Dairy farms generally gather cows twice a day at the sheds to milk and feed them. Most of the manure is produced during this time. Conservatively, it can be assumed that 60%–80% of manure produced can be collected at the sheds for biogas production purposes.

Electricity is produced by means of a generator that typically has an electrical efficiency in the range of 30%–40%. For calculation purposes, an electrical efficiency of 35% has been used.

The overall GHG mitigation potential of commercial cattle and dairy farming has been estimated at 1.0 to 1.4 million tonnes CO_2 per annum, representing a total monetary value under the South African carbon tax offset mechanisms of 117 to 168 million Rand.

In this section, the carbon impact of farmers using biogas has been analysed, and the production of biogas for transport has been assessed and compared with the main scenario, the production of electricity from biogas. The results in the table below illustrate two main differences. Firstly, the mitigation potential for the four largest qualifying feedlots in the country is reduced by 44%, or in the high scenario, from 12.1 to 6.8 $MtCO_2/a$. Secondly, the revenue potential is increased by 255%, or in the high scenario, from 137 million Rand to 346 million Rand.

The lower emission reduction is the result of displacing fuel with a lower GHG intensity per GJ: petrol (67 kg CO_2e/GJ) instead of the coal (88 kg CO_2e/GJ) used for grid electricity. The very attractive revenue potential is based on the higher Rand value per GJ of petrol over electricity: 171R/GJ in the case of an electricity price of 1.54 R/kWh and 398 R/GJ in the case of a petrol priced at 12.6 R/l. Despite the lower mitigation potential, the double revenue potential makes biogas for transport an attractive option.

Table 8.2: Commercial Farming – Mitigation potential biogas for electricity generation

COMMERCIAL FARMERS LOW SCENARIO	CATTLE (HEAD)	KRAALED (–)	DUNG (t/a)	BIOGAS (Nm^3/a)	ELECTRICITY (MWh)	CAPACITY (MW)	GHG MITIGATION (tCO_2/a)	MITIGATION VALUE (R/a)
FEEDLOTS	828,493	80%	3,628,800	145,152,000	300,130	38	309,134	37,096,028
COMMERCIAL IN-FIELD	7,475,507	20%	2,728,560	109,142,400	225,673	28	232,443	27,893,171
DAIRY FARMS	671.517	60%	5,147,178	205,887,112	425,711	53	438,483	52,617,904
Total	**8,975,517**	**N/A**	**11,504,538**	**460,181,512**	**951,514**	**119**	**980,059**	**117,607,102**

COMMERCIAL FARMERS HIGH SCENARIO	CATTLE (HEAD)	KRAALED (–)	DUNG (t/a)	BIOGAS (Nm^3/a)	ELECTRICITY (MWh)	CAPACITY (MW)	GHG MITIGATION (tCO_2/a)	MITIGATION VALUE (R/a)
FEEDLOTS	828,493	90%	4,082,400	163,296,000	337,646	42	347,775	41,733,031
COMMERCIAL IN-FIELD	7,475,507	40%	16,371,360	218,284,800	451,346	56	232,443	55,786,341
DAIRY FARMS	671.517	80%	2,941,244	274,516,150	567,615	71	438,483	70,157,205
Total	**8,975,517**	**N/A**	**23,395,004**	**656,096,950**	**1,356,607**	**170**	**980,059**	**167,676,578**

Table 8.3: Four largest feedlots – Largest feedlot electricity generation

RENEWABLE ELECTRICITY	CATTLE (HEAD)	KRAALED (–)	DUNG (t/a)	BIOGAS (Nm^3/a)	ELECTRICITY (MWh)	CAPACITY (MW)	GHG MITIGATION (tCO_2/a)	MITIGATION VALUE (R/a)
LARGEST 4 FEEDLOTS	240,000	80%	1,051,200	42,048,000	86,942	11	89,551	10,746,072
LARGEST 4 FEEDLOTS	240,000	90%	1,182,600	47,304,000	97,810	12	100,744	12,089,330

COMPRESSED BIOGAS FOR TRANSPORT	CATTLE (HEAD)	KRAALED (–)	DUNG (t/a)	BIOGAS (Nm^3/a)	ELECTRICITY (MWh)	PETROL REPLACED (Litres/a)	GHG MITIGATION (tCO_2/a)	MITIGATION VALUE (R/a)
LARGEST 4 FEEDLOTS	240,000	80%	1,051,200	42,048,000	894,264	26,148,068	50,376	6,045,177
LARGEST 4 FEEDLOTS	240,000	90%	1,182,600	47,304,000	1,006,047	29,416,577	56,674	6,800,824

	PRICING		VALUE (LOW SENERIO)			VALUE (HIGH SENERIO)		
			PRODUCT	CARBON	TOTAL	PRODUCT	CARBON	TOTAL
ELECTRICITY	1,5	R/kWh	146,715,175	12,089,330	158,804,506	130,413,489	6,800,824	137,214,313
BIOGAS FOR TRANSPORT	13	R/l petrol	382,415,495	10,746,072	393,161,566	339,924,884	6,045,177	345,970,061

8.3 PRIOR AND EXISTING PROJECTS

Project developers currently see captive projects producing electricity for own consumption as the main option. Farms with a substantial amount of manure and other organic waste available can produce sufficient electricity to cover the biogas to electricity potential. However, each case is different, and to unlock the full potential, grid access and feed-in rate issues also need to be addressed.

For larger cattle farms, dairy farms without milk processing, and the larger feedlots, captive power can be limited by on-farm demand. Wheeling electricity via the grid to a customer, or selling electricity to Eskom or a municipality, although not impossible, is a complex and lengthy process as the regulations that standardise a project-viable feed-in rate and allow for easy access are lacking. In practice, there are more captive biogas projects than grid-connected biogas projects, which is a sign that material barriers for the development of grid-connected projects exist.

There is currently no up-to-date national database available. A project list has been compiled using multiple sources:

- SABIA's list of projects (SABIA, 2014).
- A recent GIZ study of projects in the Eastern Cape (GIZ, 2016).
- Stakeholder engagement and desk research.

Only biogas projects that concern farms or agricultural households have been selected. The intention was initially to focus only on realised initiatives, but some projects in the planning phase have also been included. The status of the projects is indicated in a separate column in Table 8.4, and it is evident that projects which were successfully commissioned did not always became operational, or, after becoming operational, some projects ran into problems.

The table illustrates that farm-related projects are all aimed at electricity production or a combination of electricity and heat production, while rural household projects are aimed at producing heat, mainly for cooking purposes. Only one feedlot with biogas projects has been identified, while the 14 largest feedlots in South

Table 8.4: Prior and existing biogas projects in South Africa

Project Name	Location	Status	Feedstock	Output
Bio2Watts Bronkhorstspruit	Bronkhorstspruit, Gauteng	O	120 kt/a manure from the Beefcore feedlot and other waste.	Electricity: 4.6 kWe Fertilizer: 20 kt/a
Buffalo Bull Farm, Mooiplaas	Mooiplaas, Eastern Cape	I	15m³ baffle reactor, 400m³ membrane digester and 10m³ floating dome digester (2007)	Heat
Cape Dairy Project (Bio2Watts)	Malmesbury, Western Cape	P	7,000 dairy cows permanently residing on the farm	Electricity: 4.8MWe
Echwebeni Village, Mount Frere district	Echwebeni, Eastern Cape	O	5 digesters for local community (2014)	Heat
Fort Cox Agricultural College, Fort Cox, Alice	Middledrift, Eastern Cape	O	2 Puxin digesters, pumps, stoves, heaters (2011 and 2013)	Heat
Fort Cox College of Agriculture and Forestry	Middledrift, Eastern Cape	O	Various substrates tested in two 10m³ bio-digesters.	Research
Hlane Village, Mount Frere district	Hlane, Eastern Cape	Op	5 digesters for local community. 1 not in operation (2015)	Heat
Indwe Project (WRC), Indwe	Indwe, Eastern, Cape	O	4 BiogasPro's and a Sintex (2011). 1 still in operation	Heat
Keiskammahoek	Keiskammahoek, Eastern Cape	O	2 BiogasPro digesters, fencing, gardens (2015)	Heat
Melani Village – Demo by Fort Cox College	Eastern Cape	O	Mixed feedstock rural village of 500 households. 10m³ digester and biobags.	Demo in rural village delivering heat.
No2 Piggery, Queenstown	Queenstown, Eastern Cape	O	42 t/d of pig manure fed to 600m³ digester.	Electricity: 190kWe Heat (CHP)
Ocean View Farm, Cintsha	Cintshe, Eastern Cape	I	15m³ balloon digester (2006)	Heat
Uilenkraal Dairy Farm – Cape Advanced Engineering	Darling, Cape West Coast, in the Western Cape	O	Bovine manure > 5t/d`	Electricity: 500kW+
University of Fort Hare Piggery Digester	Alice, Eastern Cape	I	5000m³ Lagoon digester (2013)	Heat
University of Fort Hare Experimental digesters	Alice, Eastern Cape	O	10m³ balloon digester and a 1.5m³	Research
Zandam Cheese & Piggery – iBert	Durbanville, Western Cape	O	30 t/day waste pggery and other waste fed to 400m³ digester.	Electricity: 75kWe Heat (CHP)

STATUS COLUMN LEGEND: **I**= Installed **O**= Operational **Op**= Partially Operational **P**= Planned

Africa, with capacities ranging from 2,000 to 120,000 head of cattle, represent a substantial opportunity. Enquiries at feedlots, including the largest feedlot in the country, Karan Beef in Heidelberg (120,000 head), revealed that although biogas technologies have often been considered, they have not been considered viable, for various reasons.

9

DEFINING THE GAP – STATUS QUO VS. NATIONAL-SCALE READINESS

9.1 TECHNICAL SCOPE

Note: In the case of anaerobic bio-digesters this will include their number and distribution, capacity and whether or not they are associated with beef feedlots.

9.1.1 Potential

CURRENT TECHNICAL SCOPE AND IMPACT

Biogas activities in the country are currently very limited, both at the rural agricultural household scale and at the farm scale. SABIA estimates that there are about 700 bio-digesters, with the majority being small-scale domestic/rural digesters, typically in an agricultural setting. The remainder are larger biogas facilities in wastewater treatment projects, and a small number of large commercial-scale digesters (including one farm related-initiative).

There are relatively large numbers of domestic/rural digesters, although the individual sizes are very small, and in terms of energy and mitigation potential, the impact is limited. The one farm related project, at the Beefcore feedlot in Bronkhorstspruit (the 4th largest feedlot in South Africa with 25,000 head of cattle standing capacity), has large-scale commercial biogas facilities in the form of a Bio2Watt 4.4 MWe plant.

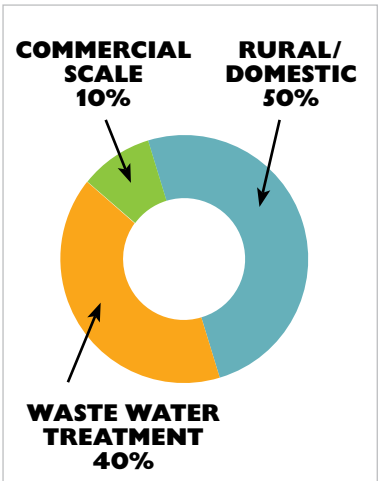


Figure 9.1: Allocation of numbers of bio-digesters in South Africa

The current numbers of biogas projects and the relatively few realised farm-related initiatives mentioned in Section 1.3 show that the overall potential of the fledgling biogas industry in South Africa is still to be unlocked.

OPTIMAL SCOPE AND POTENTIAL

Taking into account the faeces from cattle, dairy cows, chickens, pigs, sheep and goats, the theoretical potential in South Africa is 5.4 Mt CO_2, assuming that all biogas for offsetting electricity from the grid has a 35% biogas to electricity efficiency (see table above). To estimate practical potential, one needs to consider the extent to which each type of animal is held in large numbers, at specific point sources, where fresh faeces can be collected effectively.

Table 9.1: Theoretical biogas potential from animal faeces

LIVESTOCK	NO OF ANIMALS	MITIGATION POTENTIAL [TCO_2]
Cattle	13,840,000	2,406,176
Sheep	24,332,571	944,513
Chicken	142,687,572	886,189
Dairy	671,517	729,853
Goats	6,039,490	234,434
Pigs	1,566,655	182,438
Total	**189,137,805**	**5,383,603**

Note: Underlying faeces per day and biogas yields as per Austin & Blignaut, 2007.

Beef cattle and dairy cows are mainly held by commercial farmers in feedlots and sheds to optimise production. In this situation, fresh and clean manure collection is possible. Feedlots can be assumed to have an effective collection rate of 80%–90% as cattle are standing at the feedlot almost all day. On dairy farms, cows are generally walked in to the sheds twice a day to be milked and fed. Much of the manure is produced during that time and a collection rate of 60%–80% can be assumed.

Households in rural areas commonly hold a few cows for subsistence purposes. These cows generally roam free, but some are kraaled at night for safety and security. Biogas potential depends on the percentage kraaled.

Households in rural areas commonly hold a few cows for subsistence purposes. These cows generally roam free, but some are kraaled at night for safety and security. The biogas potential depends on the percentage kraaled, but we have estimated this to be in the range of 20%–40%.

Chickens are commonly held in poultry houses accommodating large numbers of chickens in a very limited space to optimise economic efficiency. Although the percentage of free-range chickens is growing slowly, most remain non-free-range. Although chicken manure is less easy to collect, it could be collected as part of the litter. In rural situations, there is a limited number of chickens and they are seldom concentrated in a small space, so the collection of chicken litter would be difficult. For mitigation potential estimations, only chicken farms have been included.

With pigs held in controlled, concentrated animal feeding facilities, manure can easily be collected. When pigs roam (partially) freely outside, the manure mixes with soil as the pigs root for food, and is therefore more difficult to collect.

Fresh cow dung is generally required as a basis for effective inoculation in biogas digesters. Sheep and goats usually roam freely, and only a very limited number, mostly in rural households, are kraaled. Therefore, for calculation purposes, with the addition of other waste including sheep and goat dung, we assumed a 20% additional production of biogas for rural agricultural households.

In assessing biogas potential, we distinguish between rural agricultural households and farms. Each category is considered separately.

RURAL AGRICULTURAL HOUSEHOLDS – BIOGAS FOR COOKING AND HEATING

Rural households have a larger total energy demand related to cooking and heating than biogas can provide. Nevertheless, bio-digesting the dung of 2–4 cows can provide enough energy for cooking needs, thereby reducing the amount of fuel to be collected or bought, but cows need to be kraaled, at least at night, for optimal dung collection. We estimate the incidence of kraaling to be in the range of 20%–40%.

Based on a fuel mix of wood, LPG, paraffin and coal as determined by Statistics South Africa (StatsSA, 2016), the GHG footprint of cooking per unit of energy, for agricultural rural households not cooking on electricity, has been assessed. For households cooking on electricity, the GHG intensity was derived from the electricity grid emission factor (Eskom, 2011).

On the basis of the aforementioned 'baselines' and the total amount of energy from biogas that can be produced from the 5.5 million cattle in the category 'emerging and subsistence farming' (DAFF, 2015), plus 20% other animals faeces, the theoretical carbon mitigation potential and Rand value under the carbon tax offset mechanism (120 R/tCO_2) has been assessed at 1.1 million and 133 million Rand respectively, as illustrated in the Figure 9.2. When cattle are only kraaled in 40%–80% of cases, the potential is reduced proportionally.

CATTLE AND DAIRY FARMS

The most common type of project is electricity production for own consumption and farms are likely to do as well if there is no substantial heat demand at site. By producing electricity for own consumption, complexities with grid access and feed-in rates are avoided. However, demand on site is not always sufficient. Examples of this can be the larger feedlots and dairy farms which do not process any milk on site. Whether producing electricity for own consumption or delivery to the grid has an impact on profitability and project viability, the mitigation potential will however

be unaffected, as it still concerns the replacement of grid electricity.

Producing heat from biogas is not likely to be a viable business case as alternatives like wood and coal can be available at a much lower cost. Offsetting grid electricity in that sense makes most economic sense. Moreover, with electricity prices likely to further rise in the future and continued risk regarding security of supply in the country it remains an attractive case.

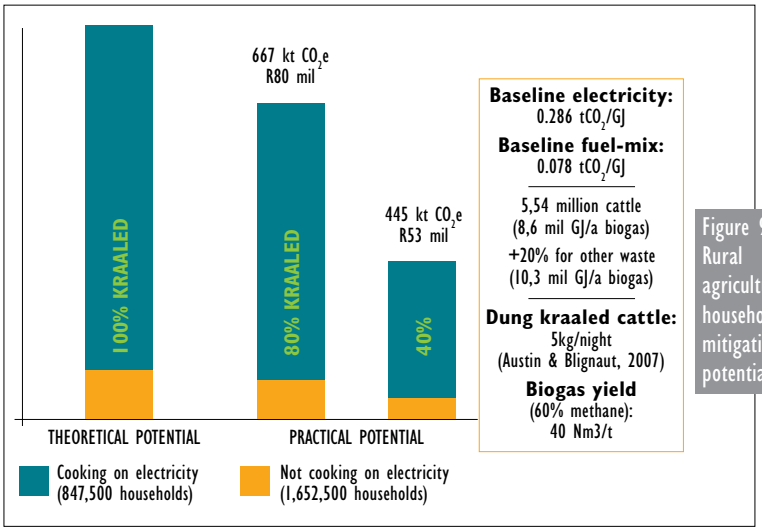
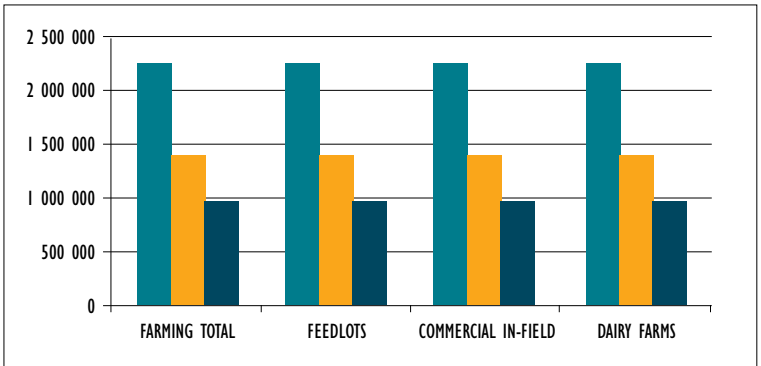


Figure 9.2: Rural agricultural households mitigation potential

Using the effective collection rate estimates (see above) based on animal husbandry practices like kraaling animals for the night, holding of animals in stables and feedlots, the numbers of animals, dung per animal per day and a biogas yield, the practical biogas potential has been calculated and compared with the theoretical potential using a 100% collection rate. The overall results are presented in Figure 9.3.

Subsistence farming has been included in the potential for rural agricultural households.



EFFECTIVE COLLECTION RATES

TYPE	THEORETICAL	HIGH	LOW
Feedlots	100%	80%	90%
Commercial In-field	100%	20%	40%
Dairy Farms	100%	60%	80%

Figure 9.3: Beef and dairy farming mitigation potential

Table 9.2: Practical potential chicken farms and piggeries

CHICKEN FARMS SIZE	GENERATOR [KW]	FARMS		BIRDS	COLLECTION	MITIGATION [TCO_2/A]
Percentage of farms >= 700,000	> 500 kW	17	2%	13,920,499	90%	77,912
Farms size 80,000 – 700,000	50 – 500 kW	243	28%	115,412,196	90%	645,952
Farms size 20,000 – 80,000	10 – 100 kW	501	58%	12,467,035	90%	69,777
						793,641

	NO OF PIGGERIES	SOWS		PIGS	COLLECTION [-]	MITIGATION [TCO_2/A]
Commercial farms	243	110,400	87%	1,368,344	90%	143,597
Small farmers	1,500 – 3,000	16,000	13%	198,311	90%	20,811
		126,400	100%	1,566,655		164,408
					Correction for small farmers under 10kW threshold	-20,811
					Total practical potential	**143,597**

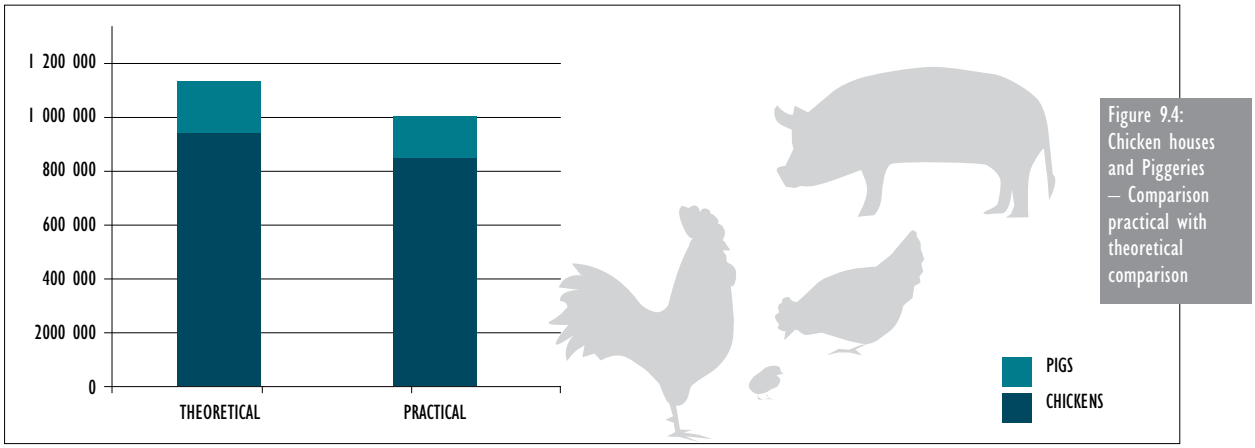


Figure 9.4: Chicken houses and Piggeries – Comparison practical with theoretical comparison

PIGGERIES AND CHICKEN HOUSES

Piggeries and chicken houses farming animals in an intensified way create point sources of faeces which can relatively easily be fed to a bio-digester. As the amount of faeces produced per animal per day is low, a large amount is required to achieve the scale that makes biogas production viable. Although, as indicated earlier in this report, the purely financial attractiveness is limited for applications below 500 kW. In this range, it is probably necessary to provide financial incentives. A practical threshold of 10 kW has been set as the smallest biogas gensets available are around that size.

Intensive farming requires ventilation, especially in summer. In addition, piggeries and chicken houses have to be heated on cold days in winter. The electricity generated could be used to operate fans for ventilation and cooling purposes.

Based on the number of animals, faeces per animal per day, and biogas yield, the practical biogas potential has been calculated and compared with the theoretical potential using a 100% collection rate. The overall results are presented in the figures above.

GAP ANALYSIS

The graph below illustrates theoretical and practical mitigation potential. No reference is made against the current baseline as the whole biogas industry is a fledgling and there are only a handful of farming projects with a low penetration of biogas technology in rural households. It can be assumed that less than 10% of the practical potential has yet been realised.

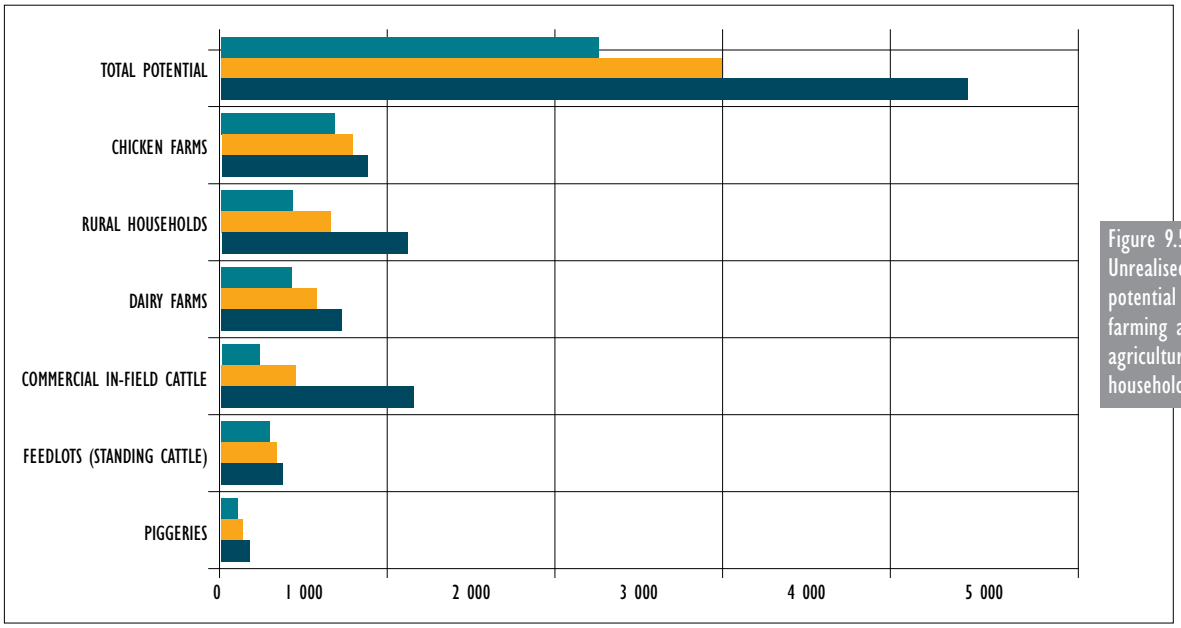


Figure 9.5: Unrealised potential in farming and agricultural rural households

The total theoretical potential is 4.5 million tCO_2/a, of which 3.0 million tCO_2/a can practically be realised in an optimistic high scenario, and 2.6 million tCO_2/a can practically be realised in a low scenario. Although the practically achievable mitigation potential of the low and high scenarios for the different categories is of the same order of magnitude, it should be noted that the potential of rural households and commercial in-field cattle will be harder to realise because they constitute a wide spread of small point sources across the country. Nevertheless, in these categories, biogas technology can improve the lives of rural farming communities significantly and therefore is attractive from a socio-economic standpoint.

9.2 DRIVERS AND BARRIERS

Note: The exploration of drivers and barriers is equally applicable to both the realization of biogas digester opportunities as well as biomass-to-energy initiatives. It is only considered once here to avoid unnecessary replication.

CURRENT DRIVERS AND BARRIERS

The project team engaged with farmers and project developers to identify and assess opportunities and barriers. This included attending the national biogas conference in November 2015 in the context of a biogas for transport study. From these engagements and previous studies concerning biogas in South Africa, the following main drivers and barriers have been identified and categorised according to three subcategories:

- Policy and regulations.
- Economics.
- Technical and operational

The identified barriers and drivers are discussed per subcategory, below.

POLICY AND REGULATIONS

As described in Section 7 of this report, there is a myriad of acts and regulations one needs to comply with when developing a project. The approval process can be complex and costly, involving several specialist studies. Although the specific regulations are intended to ensure the development of environmentally sustainable projects, they can be quite cumbersome and the approval processes can take 3–5 years to conclude. However, not all project developers have the same experience and in some cases licences have been obtained smoothly. Part of the problem, in the context of these regulations, is dealing with the new concepts associated with a new type of technology, which requires expertise on the part of both project developers and government.

There are two main regulatory issues inhibiting the unlocking of the potential of biogas to electricity: clear regulations facilitating grid access and a feed-in rate. Although government is running a successful REIPPP programme for utility-scale renewables, this programme is not suited for smaller-scale biogas to electricity projects. Moreover, the small scale IPP programme

(1-5 MWe) running alongside the REIPPP programme is not getting much traction and it does not include any biogas projects so far.

For project developers who are not preferred bidders in a government IPP programme, obtaining a licence is a non-standard process. The Bio2Watt project in Bronkhorstspruit managed to get a licence from NERSA through agreements with the City of Tshwane and Eskom for the wheeling of the power between the project developer and the power purchaser, BMW. However, this was only achieved after a long and complex process developing and concluding new wheeling arrangements.

Currently, under the Electricity Regulation Act of 2006, one is allowed to construct and operate any generation plant for own use, or a captive project. The electricity regulation second amendment bill, when promulgated, will place a limit of 1 MWe on this exemption. It is currently not clear if net-metering (using grid electricity, but also delivering to the grid, and only being charged for the net usage) would fall under 'own usage'. This could, however, assist in optimising captive projects economically.

In terms of policy, biogas and other renewables are promoted according the 2003 White Paper on Renewable Energy and the subsequent Green Accord of 2011, which commit government to developing future renewable energy resources strategically in a systematic way. In line with these policies, renewable energy is firmly embedded in several national, provincial and municipal strategies, programmes and projects. Several governmental initiatives do include biogas, but they often lack an emphasis on biogas, in particular, resulting in a slow and low uptake of biogas as part of these initiatives. Examples of this, such as the NHES, IPP programmes and SAREC, were provided in Section 1.1.2 of this report, 'Social context and governance'.

The Working for Energy (WfE) programme managed by the DoE in collaboration with SANEDI includes 'biogas to energy from agricultural waste' and also has other renewable energy priority areas focused on smaller-scale applications and job creation. The WfE programme incentivises several biogas projects, but the current projects have not been very successful, possibly resulting from of a lack of sufficient expertise to bring small scale projects to fruition. The Greening Programmes and Fund, led by the DEA in partnership with UNIDO and GEF, also promotes biogas and funds demonstration projects but this has not funded any projects as yet.

ECONOMICS

One major limitation for the uptake of biogas technology in South Africa is its profitability. Payback times, more often than not, exceed 10 years. BiogasSA indicates that only in the case of farm-size digesters in the order of 0.5 MWe or above is the payback period reduced to 5–6 years.

Circumstances in South Africa are different from, for example, Europe, and spicifically Germany, where a biogas market has developed rapidly over the last decade, driven by a high electricity price, subsidies, easy access to the electricity/gas grid, as well as waste disposal restrictions and gate-fees.

A major challenge for the biogas industry is developing affordable concepts while maximising outputs for revenue generation to stimulate the uptake of biogas technology. Government could play a role in providing fair compensation for the renewable energy and co-benefits the biogas industry could deliver.

The small size and relative complexity of biogas projects makes them less attractive for financiers and funders. With a lack of biogas-dedicated funds, attention shifts to larger projects in other renewable energy sectors, such as solar and wind. To some extent, government is also more focused on solar and wind, with the IPP programmes dominated by these. The section 12B three-year accelerated allowance for renewable energy machinery investments includes a special provision for small scale solar PV (<1 MW) in the case of self-consumption, allowing a 100% investment allowance in year one. This provision does not apply to other forms of renewable energy, even though biogas, which is limited in scale by its nature, could benefit greatly from such a provision.

One significant economic driver for the uptake of biogas technology is 'energy independence', which would protect 'for-own-use' producers from power interruptions. Although supply and demand became more balanced since 2015, there is still a risk of load shedding. In rural areas, failure in transmission infrastructure is a common cause of power interruptions for farmers. Energy independence would also protect producers from Eskom price increases. Over the period 2007 to 2015, electricity tariffs tripled, and the price increase for 2016/17 was 9%. There is a considerable risk that further price hikes are in store.

Biogas that is converted into Compressed Biogas (CBG) and sold as a transport fuel is not liable for the levies and taxes applicable to fuel goods as it is not recognised as a fuel good. Consequently, a gross tax advantage of about 33.6% is achieved over conventional fuels. In contrast to fuel goods, however, CBG is liable to 14% VAT. The total net benefit is therefore about 20%. How long this 'informal tax incentive' deriving from a loophole in tax regulations is likely to continue, is uncertain.

TECHNICAL AND OPERATIONAL

Certain characteristics of biogas technology make the development of successful projects more complex than, for example, solar PV projects, whereby the end user, after installation, can continue using electricity as usual. For the end-user of electricity produced from a biogas digester installation, there is a much higher degree of involvement with the operation: biomass needs to be sourced frequently, and new systems need to be operated and maintained. From stakeholder engagement with the application of biogas digesters on farms and in rural households, it has emerged that a lack of understanding of what is required to feed and operate the bio-digester correctly can lead to bio-digesters becoming dysfunctional. While this should be prevented through proper instruction upon installation and ongoing support afterwards, the result is that biogas sometimes gets a bad reputation.

SABIA indicates that the fledgling biogas industry could benefit from further professionalisation through the introduction of quality standards and by comprehensive training of installers. Further professionalisation would ensure that installations are done correctly and with the right support to end-users for biogas digesters to be managed optimally.

The industry would also benefit from the development of new concepts that perform better under local market circumstances, and the effective adaptation of imported concepts. Industrial R&D could support such developments.

OPTIMAL SITUATION WITH KEY DRIVERS IN PLACE

Following the categorisation of barriers and drivers above, the optimal situation in which barriers are eliminated and drivers are strengthened is described below. In the process, the gap between the current state of play and the desired optimal situation becomes visible.

Table 9.3: A summary of barriers and drivers to implementation

POLICY AND REGULATIONS

	Barrier Or Driver	Optimal Situation
Barrier	Complex compliance to acts and regulations	Guidelines for streamlining the licensing of biogas installations both for project developers and government officials. Regulations adjusted on biogas critical points to facilitate streamlining of licensing.
Barrier	Non-standardized grid access and feed-in tariff for electricity producers not qualifying for government's IPP programmes.	Access to the grid for small-scale producers can be arranged with NERSA for wheeling electricity over the grid. A feed-in rate is established for small-scale producers not able to participate in IPP programmes.
Driver	Electricity Regulation Act of 2006, generation license exemption for own use. Future limitation: < 1MWe	The exemption is maintained and a future limitation removed or increased to 5MWe such that practically any biogas to electricity projects for own use is exempt. Net metering allowed as along as small scale project abide overall consume thereby abiding to the 'for own use' principle.
Driver	Renewable energy policies including biogas as part of a larger portfolio	Strengthened biogas components in off-grid electrification programme of the New Household Electrification Strategy (NHES) and consider inclusion of SABIA in SAREC. A simplified small-scale RE IPP programme acknowledging scale or replacement by providing an alternative access and feed-in tariff for small scale RE IPPs (see barrier above).
Driver	Working for Energy (WfE) programme and Greening Programmes and Fund.	The WfE programme and Greening Programmes and Fund support respectively successful rural and larger scale demos with assistance of experts with in-depth knowledge of biogas and viable concepts.

ECONOMY

	Barrier Or Driver	Optimal Situation
Barrier	Profitability of current biogas to energy concepts.	New standardized biogas concepts are developed which are profitable in a South African context, enabling project developers to attract financing.
Barrier	Small-scale nature inhibiting interest from financiers.	Programmatic approaches aggregate volume and/or concepts are standardized and de-risked increasing attractiveness to financiers. Biogas dedicated funds are in place to finance projects and programmes without competition of e.g. solar and wind.
Driver	12B three-year accelerated allowance	The special provision for solar allowing full appreciation in the first year is extended to small-scale biogas projects.
Driver	Energy independence	Drive for energy independence by making use of renewable resources is maintained through: - Matured and more cost effective biogas industry - Culture of sustainable self-reliance - Continued financial incentives

TECHNOLOGY AND OPERATIONS

	Barrier Or Driver	Optimal Situation
Barrier	Complexity of implementation	End-users are able to optimally run their bio-digesters through support in terms of guidelines, training and examples of good practice.
Barrier	Skills and experience base	A matured industry with: - Quality and industry standards - R&D centres - Recognized courses - Local production capacity As per National Biogas Platform 2017 priorities, local test centres established to assess practical yields of case specific substrates.
Barrier	Lack of trust in performance	Successful documented demonstration projects providing confidence in the market: - Rural small scale applications - Farm scale applications
Driver	New standardized simplified small scale concepts	Local industry picks up on international new small scale standardized concepts and adds local value by further development reduce complexity and decreasing cost.

OVERALL GAP ANALYSIS

A summary overview of the gaps identified in the three categories Policy and Regulations; Economics and Technology and Operations is provided in Figure 9.6. Scales for specific sub-categories and positions on the scales indicate the significance of gap.

Regarding regulations and policies, there is a suite of policies promoting the uptake of renewable energy in general. As illustrated, the generic approach to renewable energy does not always work for biogas, specifically, and some changes are recommended. An important gap is the lack of a practical and accessible incentive for grid connected biogas to electricity projects in the absence of an open electricity market. In addition, streamlining environmental regulations for biogas would be very helpful in easing required licensing processes.

On the economic side, current biogas concepts should be enhanced to increase profitability. Although this will be realised with industry maturation, biogas-specific incentives are required in the first phase to get the industry going and facilitate competition with other renewable energy alternatives. In addition, the industry would benefit from R&D targeted at adapting concepts to the local market.

From a technical and operational standpoint, risks could be reduced through industry guidelines for development and implementation, documented successful demonstration projects, and professional training to get the industry to the level of a trusted, proven, renewable energy application for various implementation areas such as agricultural households, cattle and dairy farmers, as well as chicken farmers and piggeries.

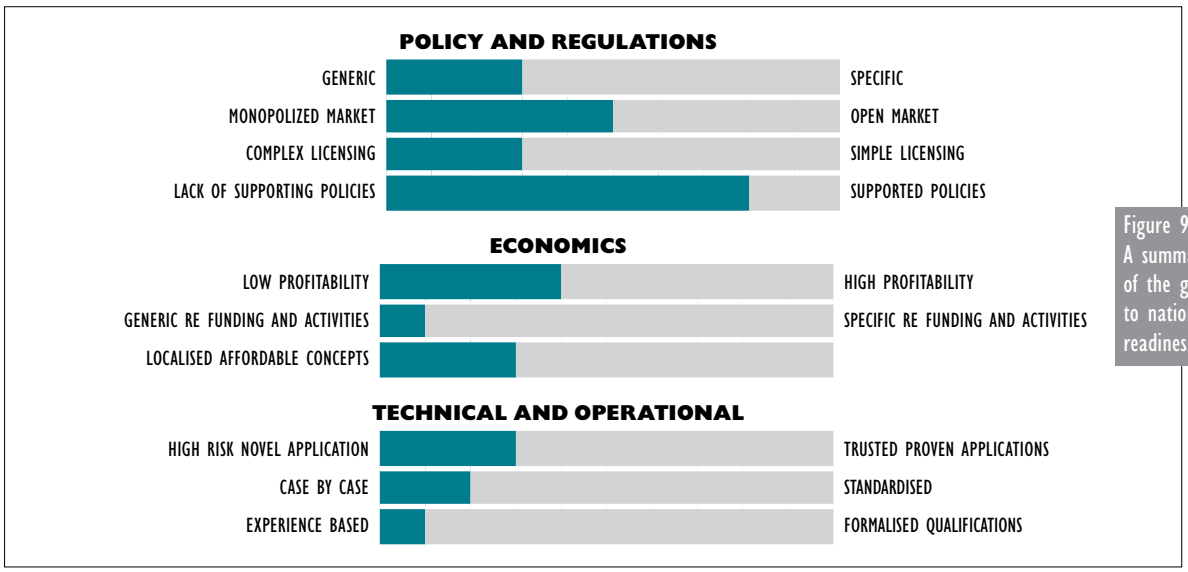


Figure 9.6: A summary of the gap to national readiness

9.3 FORMS OF IMPLEMENTATION

9.3.1 Implementation models

Two implementation models relating to the scale and distributed or centralised nature of activities, and the implementation target groups, are relevant to the biogas element. The first implementation model concerns the application of small scale bio-digesters rolled out in rural agricultural households. The second implementation model concerns larger-scale bio-digesters rolled out on feedlots, dairy farms and for farmers with cattle kraaled overnight. The two implementation models have different requirements relating to the implementation target groups and final means of use, as illustrated in the figure below.

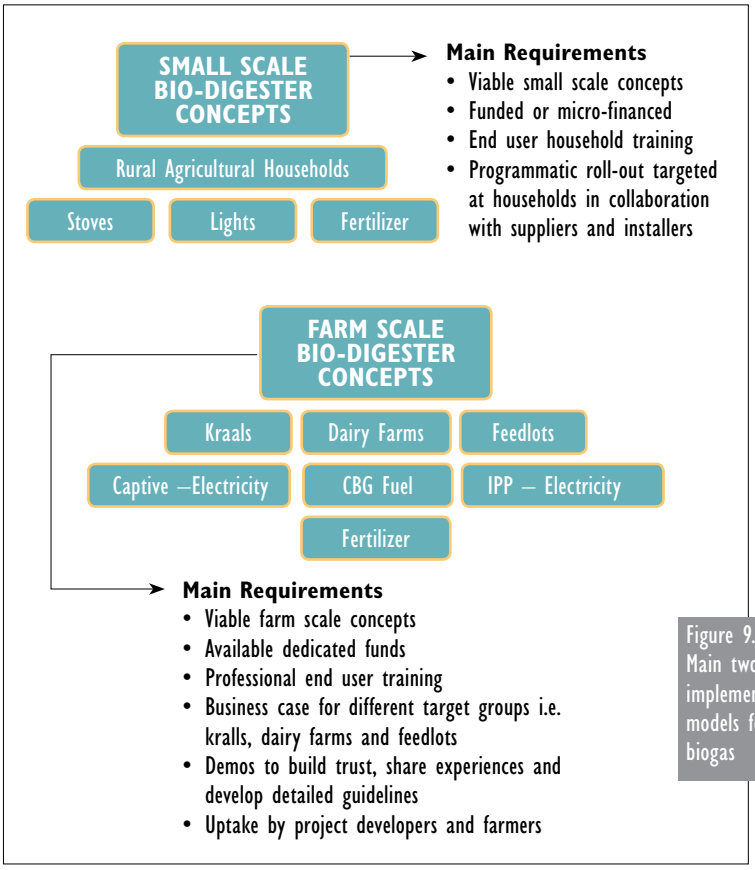


Figure 9.7: Main two implementation models for biogas

SMALL-SCALE BIO-DIGESTERS

Small-scale bio-digesters for rural agricultural households will need to be funded or (partially) micro-financed as rural households are not generally able to afford a bio-digester. Government and donor funding will potentially need to step in to overcome the investment hurdle with subsidies or a combination of subsidies and small micro-financed loans. The second option could assist in ensuring that end-users are committed to make the bio-digester installation a success.

Viable concepts for rural households need to be defined or developed by government together with biogas industry stakeholders, taking into account simplicity of implementation and use, water requirements and cost. Moreover, as it has become apparent from previous programmes in rural contexts, the concept will need to include thorough training upon implementation, and ongoing after-implementation support, to ensure that bio-digesters stay in use and households get the full benefit from the bio-digester in terms of gas yield and fertiliser usage.

Government could take the primary initiative, and a direct active involvement in rolling out the programme in certain areas, or delegated this role to potential donors with expertise in the provision of rural bio-digesters. As the expertise required by rural bio-digester programmes is different from farm-scale programmes, it is important to ensure that the correct rural-biogas-specific expertise is on board, together with the robust project management skills that will enable programs to deal with the complex nature of distributed rollouts of small scale digesters.

FARM-SCALE BIO-DIGESTERS

Farm-scale bio-digesters require initiative and investment from both project developers and farmers. Government will not need to subsidise such bio-digesters as long as viable farm-scale concepts are identified, developed and demonstrated, to build trust among farmers as well as financiers. It would be beneficial to realise demonstration projects for each of the target groups, that is, kraals, commercial farmers, dairy farmers and feedlots, to show financiers and other stakeholders how biogas technology can be successful both in technical and financial terms.

In the preparation stages of demonstration projects, it is essential to develop business cases that work with the current market constraints for biogas to electricity projects. If possible, larger projects delivering electricity to the grid (IPP projects) and a project aimed at producing CBG for transport should also be covered. The latter can only be realised by one of the largest feedlots in the country, and the value of its replication potential versus the effort required to develop a biogas for transport demo, should be carefully considered.

Important needs to address are the building of trust through successful demonstrations, the provision of biogas-dedicated funding and financing facilities to kick start the industry, the simplification and streamlining of licensing procedures, and the introduction of professional training and quality standards. Apart from the demo projects, government's role will be to create an enabling environment and enabling mechanisms for the uptake of biogas technology at farm scale, rather than being involved in actual projects.

Existing organisational infrastructure, such as the National Biogas Platform and the South African Biogas Industry Association, could assist in the creation of conditions conducive to the successful widespread take-up of biogas technology in South Africa. Many of the aspects mentioned above are already covered by existing working groups within the Platform and in SABIA. An investigation into how these working groups could become more efficient and more effective in delivering tangible results in the short term should be undertaken. One consideration might be to reserve budgets for the working groups to commission supporting studies or include specific elements as deliverables in the subsidised demonstration projects. It might also be desirable to introduce incentives to reward significant commitments of time and effort, for the greater good of the industry.

OPENING UP THE ELECTRICITY MARKET

Market reform of the electricity sector goes beyond the scope of the uptake of biogas and the promotion of biomass-to-energy activities and is part of a national debate. Part of this debate is the proposed establishment of an Independent

System and Market Operator (ISMO) as a state-owned entity that will provide "an independent system operation to ensure safe, secure an efficient operation of the integrated power system, trading of electricity at wholesale level; and to provide for matters connected therewith." This so-called ISMO bill has not yet passed cabinet and government is still in the process of redrafting it.

The opening up of the electricity market could assist in the development of the fledgling biogas and biomass to electricity markets. Pending overall national developments regarding electricity market reform, work on other solutions within the current constraints of market regulations around grid access and feed-in rates in collaboration with municipalities, Eskom and NERSA could be worthwhile. The aim would be to secure a special position for smaller-scale renewables other than via the IPP programmes, which have proven to be ill-suited for these.

9.3.2 Managing Feedstock and Biogas Usage

MANURE AND WATER

To operate a bio-digester successfully it has to be fed continuously with a sustainable supply of consistent biological feedstock to keep the anaerobic bacteria optimally active. Rural agricultural households and farmers generally have their own sources of manure that are sufficient to keep the digester going. In some cases, they may have to rely on supplies from external sources, but these are limited by transport costs and supply risks. Transport costs from beyond a 10 km radius begin to affect the viability of the business model (DEA, 2016). The approach taken in this study is therefore to focus on household and farm point sources for estimating and planning purposes. When actual projects are developed, additional sourcing of bio-feedstock from external sources close by could be considered, to optimise implementation on a case-by-case basis.

In addition to manure, bio-digesters require water at a ratio to manure of approximately one to one on a volume basis. When bio-digesters are installed, the supply of water should also be planned. While proximity to water may not pose a problem as there is usually a supply where cows access drinking water in feedlots or night kraals, water scarcity could pose a problem. Rainwater harvesting is one of the main possible sources, however, there should be enough water during the dry season as well.

BIOGAS STORAGE AND CONSUMPTION

As it is costly to store biogas produced under pressure, biogas is generally stored at low pressure for a few days to allow for maintenance and flexibility of biogas usage. A cost-effective solution is an integrated floating or flexible digester cover holding the gas. Biogas can also be stored temporarily in separate tanks and biogas bags but this comes at a higher cost. Biogas stored in large volumes needs to be pressurised to keep storage compact. Pressurising involves extensive cleaning and upgrading the gas to about 97% methane by removing carbon dioxide. When compressing biogas to 140 bars, up to 17% of the energy content can be lost (USDA, 2005).

As storage comes at a cost, it is preferable to keep storage requirements limited and rely on low-pressure (integral) systems. High-pressure storage is only feasible with substantial economies of scale in commercial operations that produce bio-methane instead of electricity and heat.

The average consumption of wood for fuel in South Africa is estimated at 4.5 tons per household per annum. This estimate was based on a study published by the Programme for Basic Energy and Conservation, a regional

(Damm and Triebel, 2008)

EFFECTS ON FINANCIAL FEASIBILITY

Biogas digesters can only be financially feasible when the supply of feedstock and off take of biogas is continuous and secured for the longer term. If a bio-digester becomes inactive, it can be hard to restart the digestion process, and during the time the digester is not running optimally, the financial performance deteriorates. Proper management of the digester requires prudent and trained operators and this is easier to ensure when the owner is in control of feedstock supply and usage of biogas, such as in households and captive farm projects.

In commercial projects where electricity or bio-methane is sold and external biomass sources are used to optimise and scale-up biogas production volumes, it is imperative that long-term agreements covering the supply of external feedstock and off take of electricity or bio-methane are in place to ensure the financial feasibility of the project.

9.3.3 Cost of biogas

A major challenge for the uptake of biogas technology is finding affordable concepts that balance capital costs with good biogas yield and revenue generation. Payback times are more often than not in excess of 10 years and economies of scale play an important role. BiogasSA indicates that, in the case of farm-size digesters in the order of 0.5 MWe, the payback period can be reduced to around 5–6 years. These payback times are often not attractive enough for investors and project owners. Nevertheless, co-benefits like energy independence and manure management can be important drivers in getting projects realised.

Table 9.4: Costs and benefits of a small-scale bio-digester at a rural agricultural household

FINANCIAL COST	ECONOMIC COST
Digester, transportation and installation	Social cost of bio-digester transport
Biogas burner	Time spent feeding digester
Repair and maintenance	
Training and technical assistance	

Financial Benefits	Economic Benefits
Avoided cost in relation to: • Fuel • Fertilizer • Medical expenditure	**Time saving from** • Cooking • Firewood collection • Utensil cleaning
Financial value of saved lives due to an improved indoor air quality using a clean burning fuel.	**Improved health:** • Productivity gains • Saved lives
	Environmental benefits: • Preservation indigenous trees • Erosion reduction • Greenhouse gas emission reduction

Source: M.T. Smith et al. / Waste Management 34 (2014) 352–362

RURAL AGRICULTURAL HOUSEHOLDS

In rural agricultural households, small-scale bio-digesters should generally be used. Because of the context, these digesters should be easy to install, simple to operate and the lowest in cost. Proper training should be provided to facilitate integration of schedules and alignment with the household's lifestyle. Although the design of this type of digester has evolved significantly in the last decade, making rural small-scale digesters feasible in purely financial terms is still a challenge (Smith et al. 2013). The full implications require further study, but the economic benefits of uplifting the living standards of rural agricultural households are substantial and make a compelling argument for government support (Smith et al. 2013). The financial and economic elements considered in the study by Smith et al. (2013) are illustrated in the Table 9.5.

While the study indicates that the positive economic assessment is robust, remaining positive (IRR=23%), in a more conservative case, with a 20% combined variation, the financial assessment is even better, with an IRR improving from 0%–6% in the positive case, using the same variation. The latter shows that there is potential to improve the financial case further, either with subsidies, as suggested in the study, or by reducing the cost of materials and implementation.

It is important to note that poor rural households will never be able to afford a bio-digester, whatever the payback might be. Hence, in order to make bio-digesters financially feasible, they need to be fully or partially subsidised to keep the monthly cost low – lower than the monthly cost of cooking fuels would be for a rural agricultural household.

FARM-SCALE DIGESTERS

Farm-scale digesters often lack the economies of scale to generate sufficient financial returns. Financial feasibility could be improved by increasing the profitability of the specific concept applied – reducing costs and increasing revenue, and with research and development of improved concepts that are less scale sensitive. A great deal has been done in this regard during the last decades, but this type of advanced smart engineering is highly case specific, however, and project

Table 9.5: Pricing of preferred biomass bidders in the small scale IPP programme

Project Name	Capacity	Fully Indexed Price* (Zar/Mwh)	Partially Indexed Price* (Zar/Mwh)	Portion Indexed
Busby Renewables	5 MW	R 1 400,00	R 1 939,52	30,0%
George Small Scale Biomass	5 MW	R 1 400,00	R 2 025,00	30,0%
TOTAL	10 MW			

Table 9.6: Pricing of preferred biomass bidders in the small scale IPP programme

RURAL AGRICULTURAL HOUSEHOLDS

Current Situation Preventing Uptake	Optimal
Negative financial performance	New localized low-cost household concepts
Lack of purchase power	Government subsidy for rural households
	Government programme
	New localized low-cost farm scale concepts
	Firm national base for small scale biogas/biomass preferential electricity pricing

developers do not easily share competitive information. The myriad of types of digesters and concepts under consideration indicate that optimal solutions have not been found as yet.

Maturing the industry by providing subsidies and/or preferential financing (long tenure, low interest) could provide opportunities for the industry to develop and gain experience. Insight into the performance characteristics of the different technologies and concepts in a South African context, and the development of new and improved concepts, could assist the industry in developing the solutions that are best for this country.

9.3.4 Revenue generated by biogas

As argued earlier in this study, the main case for biogas is the generation of electricity, with the option of heat generated as well, to increase the temperature of the bio-digester or fulfil other specific heat requirements. The price of electricity can range from as low as 67 Rct (Eskom Megaflex – bottom of range) per kWh up to 2R per kWh (municipal – top of range), depending on pricing schedule, monthly usage and grid connection (municipal or Eskom). The revenue potential of electricity generation is therefore highly dependent on the location of the owner (captive project) or the electricity off-taker.

An alternative revenue generation model is participation in the small scale IPP programme. Although no contracts have been awarded as yet and no biogas projects are in the pipeline, the pricing of the two biomass preferred bidders ranges from R1.4 per kWh to R2.0 per kWh, depending on whether the price is indexed or not.

The large overlap of grid price range 67Rct up to 2R per kWh, and the small scale IPP range of R1.4 to R2.0 per kWh, indicates that whether or not the small scale IPP electricity rates will be an attractive alternative for own use, or possibly wheeling, will be largely dependent on the circumstances. When assessing potential rates, project developers also need to take into account the chances of successfully achieving a certain rate, and the efforts required. The size of the two preferred-bidder biomass projects illustrates the importance of scale, as both projects are positioned at the top of the 1 to 5 MW range targeted. One could question, therefore, if an IPP programme is the correct approach for promoting small scale renewable biomass and biogas projects. As argued earlier in the study the biogas industry would benefit sicnificantly if the electricity grid was opened up for small scale biogas and biomass projects to feed into the grid at a preferential rate, or to allow wheeling to an off-taker at a transmission rate.

9.3.5 Gap analysis

A summary overview of the gaps identified regarding financial feasibility for rural agricultural households and farmers is provided in the Table 9.6.

SECTION SIX

REALISING BIOMASS TO ENERGY OPPORTUNITIES

10

INTRODUCTORY BRIEF – BIOMASS ENERGY

10.1 BIOMASS ENERGY SOUTH AFRICAN CONTEXT

Bio energy can be defined as 'energy derived from organic sources' encompassing all types of organic resources (for example, liquid, solid, waste stream or purpose grown, etc.) as well as all possible methods of extracting different types of energy (for example, electricity, steam, etc.) from organic sources. The South African National Terrestrial Carbon Sink Assessment (DEA, 2015) provides more focus by making the following distinctions:

- Biomass energy (invasive alien plants and bush encroachment).
- Biomass energy (bagasse).
- Anaerobic biogas digesters.

Climate change is caused by the emission of anthropogenic (man-made) GHGs into the atmosphere. Although there is a wide range of sources of GHGs, the majority come in the form of CO_2 and are the result of some form of combustion. It is important to make a distinction between two types of emissions:

- Long cycle: Where the carbon sequestered in organic material a long time ago (millions of years) is released into the atmosphere in a relatively short period, (primarily) in the form of CO_2, through the combustion of fossil fuels such as oil, coal, natural gas, etc.
- Short cycle: Where the carbon absorbed by organic material (biomass) such as bagasse, wood, manure, etc. over only the last few decades is released into the atmosphere when the biomass is combusted, resulting in emissions of (primarily) CO_2.

Irrespective of the timeframe over which the carbon was sequestered, emissions from both long and short cycle sources increase the concentration of GHG in our atmosphere and therefore contribute to climate change. However, if the biomass that forms the short cycle fuel source is replenished at the same rate at which it is combusted, the CO_2 emissions are 're-sequestered' within the growing organic material and can therefore be considered 'carbon neutral'.

For this reason, substituting the use of (long-cycle) fossil fuels with biomass energy – from sources that are replenished at the same rate as they are utilised – will reduce the country's carbon emissions. In contrast, all biomass that is used for the generation of energy, but not 're-grown', reduces the country's carbon reservoir, and increases the national carbon emissions.

For the purpose of this study, only the share of biomass energy derived from three sources – Invasive Alien Plants (IAP) and bush encroachment; bagasse; and anaerobic digestion – is taken into account. The cumulative biomass energy GHG mitigation potential for IAP, bush encroachment and bagasse is estimated to range from 2,3 to 2,8 million tCO_2e/year (DEA, 2015). Although wood waste from commercial forests operations was not included in the scope of this study, it is a potential sources of biomass energy that warrants future study.

The use of sustainable biomass as an energy source not only reduces the long term impact on global climate change, it also contributes to energy security, energy independence and energy (rural) proliferation.

Before going into the social context and governance of biomass energy in more depth, it is useful to consider the origins, relevant energy conversion technologies and current practical applications of the three potential biomass energy sources. To convert available biomass into energy it first needs to be aggregated at a central point where it can be pre-treated and combusted. This aggregation can happen in two ways: either it is aggregated as part of the primary production process (as with bagasse) or it is collected specifically for conversion into energy (as with IAPs and bush encroachment, for example).

10.2 INVASIVE ALIEN PLANTS (IAP)

10.2.1 What are invasive alien plants?

Invasive Alien Plants (IAP) are plants introduced to South Africa from other countries, which spread aggressively and threaten indigenous ecosystem functioning and biodiversity. IAP have been introduced into South Africa for commercial agriculture and forestry purposes, for the rehabilitation of drift sands and mine dumps, as garden ornamentals or, unintentionally, in imported animal feed.

About 750 tree species and around 8 000 shrubby, succulent and herbaceous species are recorded as having been introduced into South Africa (Van Wilgen et al., 2001). Of these 8 750 species, 161 are now regarded as invasive, 110 of which are woody, and therefore a potential bioenergy feedstock source.

This section of the report focuses upon the use of woody IAP, specifically trees, with biomass to energy potential. A number of exotic, fast-growing tree species of the genus Acacia, Eucalyptus, Pinus and Populus were introduced into South Africa, mainly to meet the demands of the forest and forest products sector. Certain Acacia species were introduced from Australia for dune rehabilitation, and Prosopis glandulosa, from Mexico, was planted to supply fuel and fodder. These tree species came as seed from similar geographic environments (climate, latitude, altitude) and became naturalised in their new environment. Without the host spectrum of pests and diseases, these species have reproduced prolifically and spread from forestry plantations into natural environments.

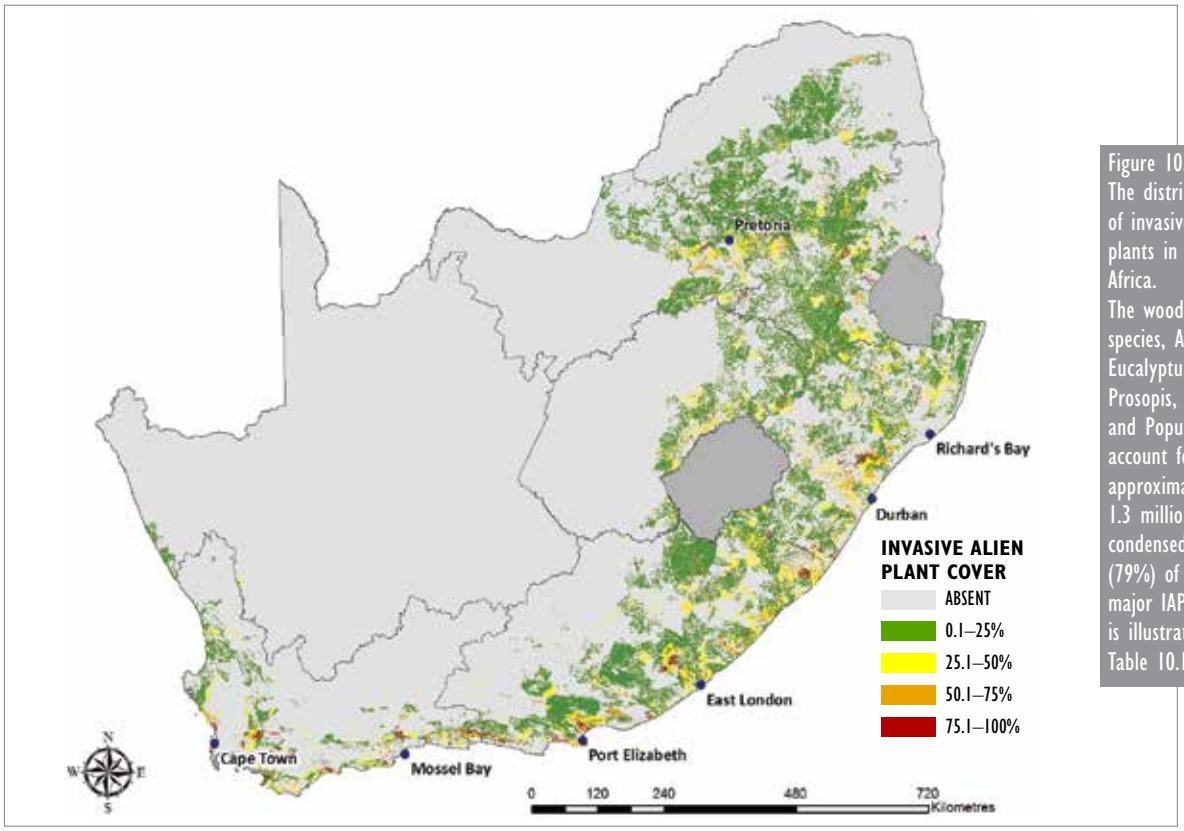


Figure 10.1: The distribution of invasive alien plants in South Africa. The woody species, Acacia, Eucalyptus, Prosopis, Pinus and Populus account for approximately 1.3 million condensed ha (79%) of the major IAP. This is illustrated in Table 10.1.

10.2.2 What is the environmental and economic impact of IAP?

The magnitude of woody IAP in South Africa has been shown to have the following negative effects:

- Reduced stream flow and available water.
- Loss of potentially productive land.
- Loss of grazing potential.
- Increase in damage from wildfires and increase in costs of fire protection.
- Increase in soil erosion following fires in heavily invaded areas.
- Increase in siltation of dams.
- Change in soil nutrient status.
- Loss of biological diversity and threat to native plant species.
- Change in biomass of ecosystems.
- Change in habitat suitability for native animal species.

Table 10.1: Prominent woody Invasive Alien Plants and their respective areas

SPECIES	CONDENSED AREA (HA X 1000)A	% OF TOTAL
Acacia	557	36
Prosopis	344	22
Eucalyptus	230	15
Pinus	63	4
Populus	45	3
Total	**1 238**	**79**

* Derived from van Wilgen et al 2012

In South Africa, services from the control of IAP have been estimated at US$6.6 billion (Stafford et al. 2017). The most valued ecosystem service benefit assessed was water, followed by timber products and wood-fuels such as biomass to electricity, and then grazing.

EXTENT

In South Africa, IAP occupy approximately 10 million ha of the country (8.28% of land area at average density of 17%). This is equivalent to approximately 1.7 to 1.8 million condensed ha being fully invaded by woody IAP (Le Maitre et al., 2000; Kotzé et al., 2010; Van den Berg, 2010 (in Van Wilgen, 2012)). The extent of IAP in South Africa is illustrated in Figure 10.1.

BIOMASS

In South Africa, the woody biomass of IAP ranges from 32 to 198 t/ha (Mugido et al., 2014; Van Laar and Theron, 2004; Le Maitre et al., 2000; Le Maitre et al., 2001). The woody IAP biomass is estimated at 168 million tonnes.

A key consideration when defining an IAP eradication strategy is that clearing IAP will result in a decreased carbon density. This is clearly illustrated in Table 10.3.

Table 10.2: Invasive Alien Plants – Biomass Stocks (Tg)q

PROVINCE	ACACIA	EUCALYPTS	PINE	POPLAR, WILLOW AND PROSOPIS	TOTAL
Eastern Cape	28.8	9.4	5.5	3.8	47.5
Free State	0.8	7.2	1.1	3.6	12.7
Gauteng	1.5	7.7	0.4	0.9	10.5
KwaZulu-Natal	15.1	16.5	2.7	0.7	35
Limpopo	1.1	3.7	0.8	0.7	6.3
Mpumalanga	6.4	18.1	2.8	3.6	30.9
Northern Cape	0	0	0	2.9	2.9
North West	0.4	3.1	0.1	0.5	4.1
Western Cape	6.6	2.8	8.5	0.4	18.3
Total	**60.7**	**68.5**	**21.9**	**17.1**	**168.2**

* Stafford 2014

Table 10.3: A comparison of biomass density (t/ha) between indigenous plants and IAP for the same ecosystem (le Maitre 2015)

INDIGENOUS	T/HA	T/HA	IAP	T/HA	MULTIPLE
Renosterveld	14.0	104	Pinus pinaster	104.0	7.4
Proteiod fynbos	17.8	58.16	Acacia saligna	58.2	3.3
Strandveld	18.0	57	Acacia cyclops	57.0	3.2

10.2.3 Social context and governance

Key objectives associated with the eradication of IAP and bush encroachment are increased land-use potential, water quality and quantity, biodiversity and creation job opportunities. From a governance perspective, there are potentially conflicting objectives with respect to the management of IAP and bush encroachment and it will be important to formulate appropriate management strategies to mitigate any perceived conflicts.

Removing barriers and identifying opportunities for the reduction of GHG in the AFOLU sectors is a prime consideration of this study, and the use of feedstock from IAP and bush encroachment as a bioenergy feedstock is one such opportunity. Although other major benefits are attached to the eradication of IAPs and bush encroachment, it does not, in itself, reduce GHG emissions. Key to a successful reduction in GHG using bioenergy is that the source of feedstock is renewable, and eradicating IAPs and bush encroachment may not provide a sustainable source of biomass for energy use. There is conjecture that the various initiatives to eradicate IAP have not been successful, and that IAP regrowth, either through seed germination or coppice regeneration, implies that it is indeed a renewable resource.

Since biological invasions are a pervasive threat to biodiversity, South Africa is under an international obligation to regulate IAP. Consequently, government has enacted a variety of national and provincial laws and regulations with the main aim of managing and conserving biodiversity, protecting species and ecosystems, promoting the sustainable use of indigenous biological resources, and ensuring benefits arising from the natural environment are shared fairly and equitably. The most relevant legislation on a national level includes:

- The Environment Conservation Act, No. 73, 1989 – which provides the legislative foundation for the protection and controlled utilisation of the environment. The Act mandates policy creation for the effective conservation of the natural environment in South Africa.
- The National Environmental Management Act, No. 107, 1998 – which institutionalises legislation regarding the environment by providing for cooperative, environmental governance. For example, through setting principles for decision making by creating the institutions that promote cooperative governance, and through procedures for environmental functions exercised by government.

- The National Environmental Management: Biodiversity Act, No. 10, 2004 (NEMBA) – which provides the legislative framework to regulate the management and conservation of South Africa's biodiversity within the context of the National Environmental Management Act, 1998. Among other things, NEMBA establishes and governs the functions of the South African National Biodiversity Institute (SANBI), which engages in restoration and rehabilitation of the ecosystem, advises on policy and best practices, coordinates research, and monitors and reports on the state of biodiversity in the country.
- NEMBA Invasive Species Regulation, 2014 – which, among other things, provides for the categorisation of invasive species and regulation on exempted species, develops monitoring, control and eradication plans, and sets up a risk assessment framework.
- NEMBA Invasive Species List, 2016 – which provides a full overview of invasive species, exempted and prohibited alien species.
- NEMBA Guidelines for Monitoring and Control Plans – which were circulated on 16 October 2016 by the Department of Environmental Affairs. These provide guidelines for managers of state land to document, monitor, control and manage invasive plants.

In addition, the Department of Environmental Affairs published the National Strategy for Dealing with Biological Invasions in South Africa (DEA, 2014), on 25 March 2014. The main objective of the strategy is to provide a comprehensive overview of biological invasions and to streamline the legislative framework so that the problem can be effectively managed. Attention is also given to awareness raising and capacity building.

On a decentralised level, the regulatory framework is complemented by legislation for IAP in several provinces and metropolitan areas. In some cases, this concerns policies to implement and/or enforce existing national legislation. In other cases, it expands on national legislation to provide further safeguards for local biodiversity and ecosystems. For example, the City of Cape Town has a framework in place for local needs and challenges pertaining to eradicating IAS (CoCT, 2008).

10.2.4 Prior and existing programmes

The Department of Environmental Affairs (DEA) administers twelve Natural Resource Management (NRM) programmes that have been designed to also create significant socio-economic benefits, including substantial job creation and poverty reduction outcomes. In this context, using biomass to generate electricity ,through the Working for Energy Programme under the auspices of the Department of Energy, also plays an important role.

WORKING FOR WATER

The eradication of IAP is mainly done through the Working for Water (WfW) programme, launched in 1995, with a contribution from the Working for Wetlands programme. The socio-economic component of WfW has been formalised as part of a national Expanded Public Works Programme (EPWP).

The initial focus of WfW was purely on the management of IAP known to have negative impacts on streamflow. Subsequently, other NRM programmes such as Working on Fire, Working for Wetlands, Working for Ecosystems, Working for Forests, and Eco Furniture programmes have been involved in employment and rural development as well as the restoration of areas cleared of IAP.

In addition to the Department of Environmental Affairs, Working for Water partners with other government departments including Tourism, Agriculture, and Trade and Industry, as well as with provincial departments of agriculture, conservation and the environment, research foundations and private companies.

One of the most important Working for Water partnerships is with local communities, working for job creation. Since its inception, WfW has intervened in more than one million ha of IAP, providing jobs and training to approximately 20 000 people per annum, from the most marginalised sectors of society. Of these, 52% are women. WfW currently runs over 300 projects in all nine of South Africa's provinces.

A range of methods are used to control invasive alien plants:

- Mechanical methods – felling, removing or burning invading alien plants.
- Chemical methods – using environmentally safe herbicides.
- Biological control – using species-specific insects and diseases from the alien plant's country of origin.
- Integrated control – using combinations of the above three approaches. Often an integrated approach is required in order to prevent enormous impacts.

By 2011, WfW had spent ZAR3.2 billion, more than half on eradicating Acacia, Eucalyptus, Prosopis, Pinus and Populus. Despite such substantial spending on the areas invaded by IAP, research shows that invasive alien plants may still be spreading by between 7.4% and 15.6% (DEA, 2015).

WORKING FOR ENERGY

Working for Energy is a new programme that the Department of Energy is implementing, with the South African National Energy Research Institute (SANERI) as the implementing agent. The programme will be closely aligned with the Working for Water programme. The basic principle behind this programme is to develop and implement labour intensive energy-related initiatives, focused in two main areas – Provision of Renewable Energy, and Energy Management.

The Renewable Energy programme is concerned with projects related to research and demonstration (as per the SANERI mandate) in the following focus areas:

- Biomass from invasive IAP and bush encroachment.
- Charcoal derived from IAP and grasses.
- Biofuels development and implementation in rural applications.
- Mini-Grid Hybrid and Smart Grid Systems.
- Solar power (Concentrated PV).
- Micro hydro systems.

When it comes to coordinating research, and monitoring and reporting on the state of biodiversity in the country, the South African National Biodiversity Institute (SANBI) plays an important role. The institute was established on 1 September 2004, following the enactment of the National Environmental Management: Biodiversity Act, No. 10, 2004 (see above). SANBI's key responsibilities include the provision of knowledge and information, planning and policy advice as well as best-practice management models in partnership with key stakeholders.

10.3 BUSH ENCROACHMENT

10.3.1 What is bush encroachment?

Bush encroachment can be defined as "the invasion and/or thickening of aggressive undesired woody species resulting in an imbalance of the grass:bush ratio" (De Klerk, 2004). In comparison to IAP, bush encroachment occurs through indigenous woody species as opposed to exotic invasive plants. It is a consequence of the mismanagement of rangelands including activities such as overgrazing, suppression of bushfires, and the exclusion of some browsing game species. (De Klerk 2004; Richardson, 1998; Richardson and Van Wilgen 2005; Walker et al. 2004; Kraaij and Ward, 2006). There is also compelling evidence that in South Africa, increases in CO_2 concentrations in the atmosphere further exacerbate the growth and spread of woody species (O'Connor, 2014). Bush encroachment impacts on the integrity of an ecosystem, decreasing its ability to deliver a range of ecosystem services (Stafford et al., 2017), resulting in a loss in economic productivity and sustainable development.

Bush encroachment in South Africa occurs mainly in grasslands and savannas (Kreuter et al., 1999; De Klerk, 2004; Ward, 2005). Dominant species are Acacia karroo, Acacia mellifera, Acacia nilotica, Acacia reficiens, Acacia tortilis, Dichrostachys cinerea, Terminalia sericea, Rhigozum trichotomum and Tarchonanthus camphoratus (Kraaij and Ward, 2006).

10.3.2 What is the environmental and economic impact of bush encroachment?

Bush encroachment affects the agricultural productivity and biodiversity of large areas of South

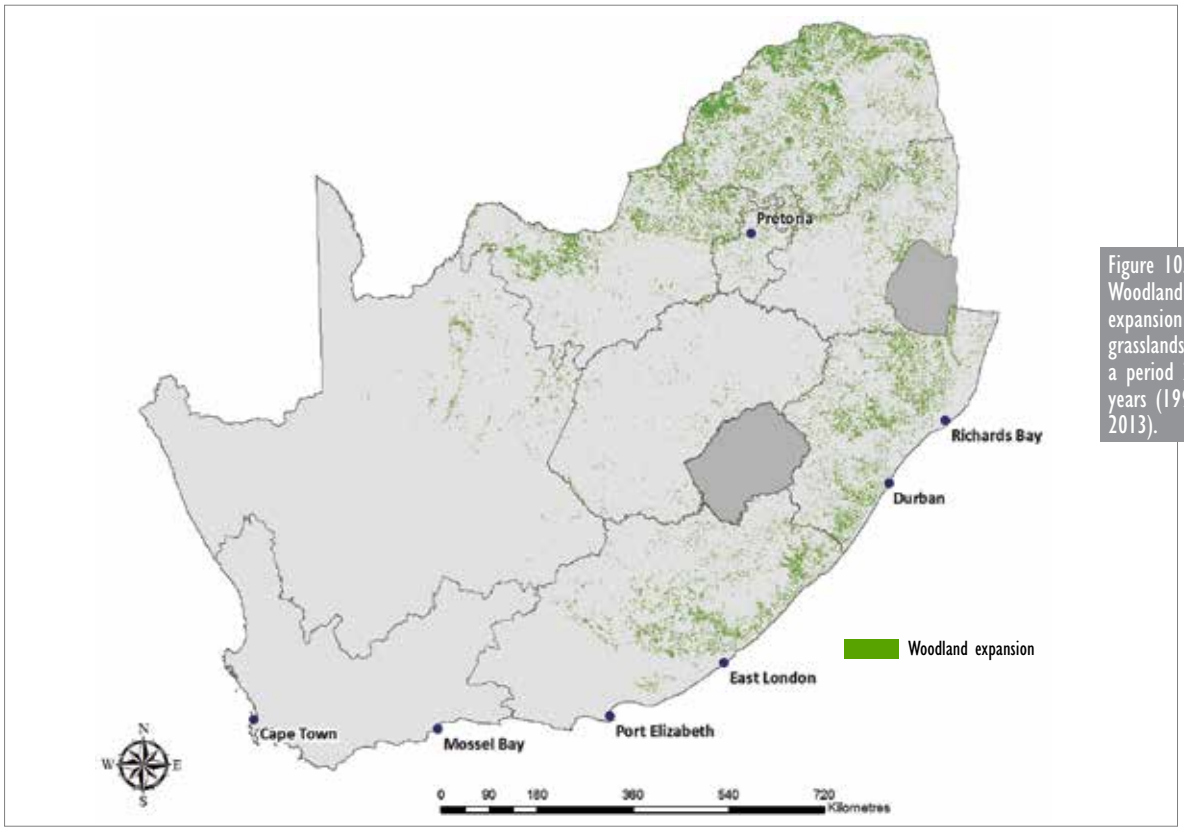


Figure 10.2: Woodland expansion from grasslands within a period 23 years (1990–2013).

Africa (Ward, 2005) and is therefore considered a material environmental and economic concern. Bush encroachment has the following negative effects:

- Loss of grazing potential and carrying capacity.
- Reduced stream flow and available water.
- Increase in damage from wildfires and increase in costs of fire protection.
- Change in soil nutrient status.
- Loss of biological diversity and threat to endemic plant and animal species.
- Change in biomass of ecosystems.
- Change in habitat suitability for endemic plant and animal species.

In South Africa, services from the reduction of bush encroachment have been estimated at US$2.1 billion (Stafford et al. 2017). The most valued ecosystem service benefit assessed was water, followed by timber products and wood-fuels such as biomass to electricity, and then grazing.

10.3.3 The magnitude of bush encroachment in South Africa

EXTENT

Bush encroachment in South Africa is greater in savanna bioregions than in grassland bioregions. Above the 500 mm mean annual precipitation (MAP) threshold, the rate of woodland expansion increases as rainfall increases (Skowno et al., 2016). In a review by O'Connor et al. (2014) it was concluded that bush encroachment was "most rapid on small protected areas, intermediate under commercial tenure, and slowest under communal tenure and [in] large, natural environments with mega-herbivores present".

The land area affected by bush encroachment in South Africa has been estimated at between 8 to 20 million ha (Kraaij and Ward, 2006, Stafford et al. 2017). In a recent study by Skowno et al. 2016, it was estimated that during the 23-year study period from 1990 to 2013, bush encroachment had replaced grasslands over 5.7 million ha and, conversely, that grasslands have replaced woodlands over 3.0 million ha, a net increase of bush encroachment by approximately 2.7 million ha. This has resulted in an annual increase of bush encroachment by 0.22%. The extent of bush encroachment is illustrated in Figure 10.2. Estimates of woodland expansion were similar

Table 10.4: Management considerations with respect to bush encroachment

RESTORATION OF BUSH ENCROACHED AREAS	MAINTAINING STATUS QUO OF BUSH ENCROACHED AREAS
• Increased stream flow and water availability	• Sustainable supply of fuelwood for bio-energy
• Restoration of ecosystem to previous state	• Increased fuelwood, poles and building material
• Increased carrying capacity for livestock and other grazing animals	• Increased carrying capacity for browsers
• Reduced risk of intense fires	• Decrease in biodiversity
• Job opportunities	• Land tenure

to those reviewed by O'Connor et al. (2014).

BIOMASS

Stafford et. al. (2017) estimated the biomass of bush encroachment to be 4, 8 and 12 t/ha for areas of light, medium and dense bush encroachment, respectively, with a total biomass of bush encroachment of approximately 58 million tonnes.

10.3.4 Social context and governance

As with IAP, there are potentially conflicting objectives with respect to the management of bush encroachment and it will be important to formulate the desired strategy to mitigate perceived conflict. Key objectives associated with the control of bush encroachment are increased land-use potential, water quality and quantity, biodiversity, and the creation of job opportunities. Unlike IAP where eradication is a key objective, key elements to consider with respect to bush encroachment are management objectives and the desired state one wishes to achieve. Integral to this is current land tenure. Management objectives on community land, commercial land and protected areas will be fundamentally different. Defining the correct, appropriate grassland to bushland ratio should take a number of salient considerations into account, see Table 10.4.

Removing barriers and identifying opportunities for the reduction of GHG in the AFOLU sectors is a prime consideration of this study and the use of feedstock from bush encroachment clearing as a bioenergy feedstock is one such opportunity. Key to a successful reduction in GHG using bioenergy is a renewable source of feedstock. Although there are major benefits of bush encroachment control, it may work against providing a sustainable source of biomass for energy use, and does not, in itself, reduce GHG emissions. A number of studies have indicated that bush encroachment is increasing (O'Connor et al., 2014; Skowno et al. 2016) in which case bush encroachment, either through seed germination or coppice regeneration, implies that it is indeed a renewable resource.

Apart from the National Environmental Management: Biodiversity Act, No. 10, 2004, the issue of bush encroachment is regulated by the following legislation:

- The Conservation of Agricultural Resources Act, No. 43, 1983 – which replaced the Soil Conservation Act, No. 76, 1969, and provides the legislative framework for the regulation of bush encroachment. More generally, the Act provides for control of the utilisation of natural agricultural resources in South Africa. Its main objective is to promote the conservation of soil, water resources and vegetation through combating weeds and invasive plants.
- The Conservation of Agricultural Resources Act, No. 43, 1983, Regulations – which aim to give substance to the main Act by, among other things, defining indicators of bush encroachment and listing indigenous plants that are regarded as indicator plants of such encroachment, listing the areas where they are most pervasive (in addition to listing non-indigenous invader plants and methods of combatting them).

Bush encroachment in South Africa is greater in savanna bioregions than in grassland bioregions. Above the 500 mm mean annual precipitation (MAP) threshold, the rate of woodland expansion increases as rainfall increases

(Skowno et al., 2016)

10.3.5 Prior and existing programmes

The most common methods of controlling bush encroachment mechanically are chopping, slashing, ring barking and felling. The stumps are then treated immediately with a chemical weed killer. As with IAP management and/or eradication, material volumes of biomass are left spread out in the open, sometimes covering substantial areas.

Utilising the biomass from bush encroachment controlling activities for energy purposes requires that the biomass is aggregated and this can be done either by transporting it to a central point as it is, or treating it in-field to increase the energy density and thereby increase the feasible transport distance.

As bush encroachment has different challenges to the eradication of invasive alien plants, government has implemented the Working for Land (WfL) programme, which aims to encourage and support sustainable land-use practices, raise awareness, and promote conservation ethics. One of the four pillars of the programme is the protection of grasslands through the curtailment of bush encroachment. This is done through:

- Small scale removal of invasive shrubs, weeds or grasses.
- Treatment of infested areas with herbicide.
- Demarcation of fire breaks on the perimeter.

As with the other 'Working for' programmes discussed above, addressing the issues of poverty though job creation, especially in rural areas, is emphasised, since the livelihoods of people in these areas strongly depends on the natural resources surrounding them. Rehabilitated lands will provide benefits ranging from better agriculture opportunities to increased energy supply.

10.4 BAGASSE

10.4.1 What is bagasse?

Bagasse is the fibrous matter that remains after sugarcane or sorghum stalks are crushed to extract their juice. For each 10 tonnes of sugarcane crushed, a sugar factory produces nearly 3 tonnes of wet bagasse as a by-product. It is best used as a fuel source for sugar mills – when burned in quantity, it produces sufficient heat energy to supply all the needs of a typical sugar mill, with energy to spare. Bagasse is also utilised in a range of other applications including the manufacture of pulp and building materials.

The South African sugar industry, agricultural cane growing and milling sectors are well established in KwaZulu-Natal and Mpumalanga. All of the 14 sugar mills, owned by six different companies, use bagasse to generate steam and electricity for own use and are energy self-sufficient (Conningarth, 2013). Through improved sugar mill energy efficiencies, technology and agricultural yield improvements, these factories can be modified to produce from 2 to 7 times more power, for export to the national grid (Govender, 2016). Over the period 2010 to 2014, the 14 mills generated an average of around 612,924 MWh/year, which indicates an available biomass to electricity potential of 195 MW to 681 MW.

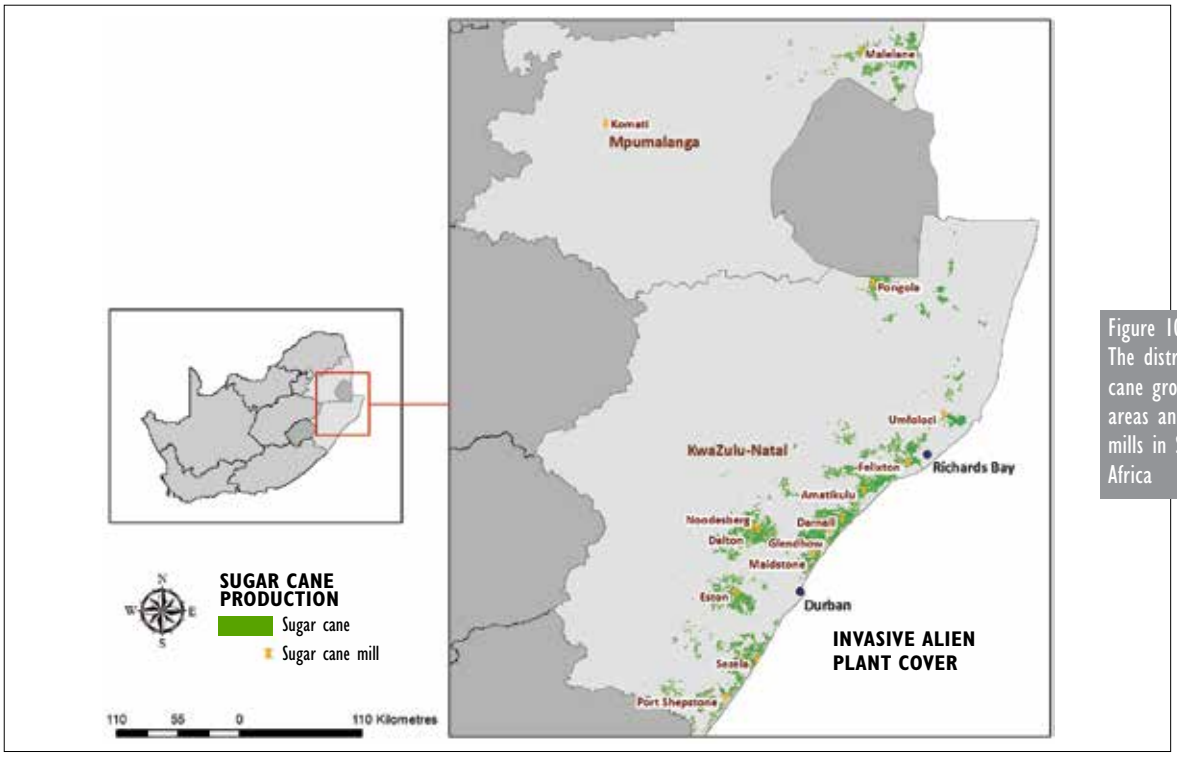


Figure 10.3: The distribution cane growing areas and sugar mills in South Africa

In addition to the bagasse-to-energy potential, an additional possible source of sustainable biomass is what is referred to in the industry as 'tops and leaves'. The tops and leaves are removed from the sugar cane and left in the field when the cane itself is transported to the mill. By expanding harvesting processes, the tops and leaves could be collected and used as a sustainable biomass, either at the sugar mill, or by the communities around the sugar fields. The biomass could be dried and used directly as fuel, or alternatively, it could be placed in an anaerobic digester to generate energy. Although still in the early stages of development, the Cane Growers Associations is currently running a pilot project for the anaerobic digestion of tops and leaves for rural applications.

10.4.2 What is the magnitude and impact of the South African sugar sector?

South Africa is one of the top 15 sugar producing countries in the world. The local sugar industry is significant in size, generating annual estimated turnover of approximately ZAR 12 billion, and making a substantial contribution to the South African economy. Sugarcane, from which dry, fibrous bagasse is derived, is grown by approximately 24,000 registered growers, responsible for creating some 79,000 direct jobs and an estimated 350,000 indirect jobs, especially in rural areas. Overall, the industry produces some 15 million tons of sugar, of which 75% is consumed within the South African Customs Union (SACU). The remainder is exported to world markets, generating substantial foreign exchange inflows for the country.

Although the industry is cost-competitive internationally, recent severe droughts have reduced yields and put pressure on margins. This has triggered a search by major producers for opportunities to reduce operating costs, for example, through co-generation and/or the development of renewable energy projects as Independent Power Producers (IPPs). For example, Tongaat Hulett currently produces 52 MW at its four plants and estimates a potential of between 320 and 360 MW. Illovo reports that in 2012/13 it exported some 36.95 GWh to the national grid. These developments not only reduce the carbon footprint towards climate change mitigation, but also contribute to energy security and electricity independence, and create new jobs .

10.4.3 Social context and governance

The Sugar Act, No. 9, 1978 as Amended, provides the legislative framework for the regulation of the sugar industry in South Africa and governs virtually every aspect of the market. The Act established the South African Sugar Association (SASA), which mandates the Sugar Industry Agreement that became effective in 2000.

The Sugar Industry Agreement fleshes out the various stipulations of the main Act, and together they provide the regulatory framework for the control of production, transport, pricing, quality, marketing and export of sugar. Every aspect of the national sugar market is tightly regulated. The most recent version of the agreement binds every grower, miller and refiner of sugar in the country and ensures equality of treatment. Importantly, the agreement establishes the functions performed by SASA and includes provisions determining the following:

- The selection and planting of approved varieties of cane.
- Pest and disease control measures.
- The production of cane, including the grower's right to supply cane to any mill willing to accept the product for crushing.
- The supply of cane to the mill, including provisions dealing with cane delivery estimates and cane supply agreements.
- The price of sugarcane paid by millers to growers on the basis of a formula that may include any factor relevant to the sale of sugar.
- Payment for cane, including the testing of cane for purposes of determining the recoverable value content.
- The determination and distribution of proceeds between growers and millers.
- Levies imposed upon growers, millers and refiners, and on the transportation of sugar cane from growers to millers.
- The volume of sugar supplied to local markets, based on consumer demand, with the remainder being exported to the world markets.

The main organisations that govern the sugar industry are:

- South African Sugar Association (SASA)
  - Administers the industry on behalf of the SA Cane Growers' Association and the SA Sugar Millers' Association.
  - It is an autonomous organisation operating free from government control.
  - Its affairs are administered by the council of SASA.
  - Activities are financed through the sale of sugar.

- South African Cane Growers' Association
  - The organisation was formed in 1927.
  - It is an apolitical representative of all cane growers.
  - Its mission is to lead, protect, communicate and serve the interests of cane growers.
  - It secures a sustainable SA cane growing sector.
- South African Sugar Millers' Association
  - It represents the interests of the sugar millers.
  - Its objective is to cover partnership administrative matters, legislative measures affecting the industry, and support training and research.

The Department of Trade and Industry (DTI), together with SASA and other relevant stakeholders, has created the Strategy for the Optimal Development of the Sugar Industry in SADC and SACU Context. One of the objectives of the strategy is to deal with the distorted nature of the world sugar market by taking action against unfair international pricing through tariff protection.

10.4.4 Prior and existing programmes

Unlike biomass sources derived from IAP eradication and the management of bush encroachment, bagasse does not have to be collected in the field for the purpose of aggregation as it is already transported to the various sugar mills and becomes available after the crushing process. This provides a material logistical and economic saving in comparison to the two other biomass sources.

The Mkuze biomass project, located on farm 13434 Alkmaar in Mkuze, KwaZulu-Natal, is the first base load biomass plant in South Africa. The project, valued at over ZAR 1 billion, is owned by a consortium of companies including Building Energy Development and the Charl Senekal Suiker Trust (CSST), which is the most important harvester of sugarcane in the country. The project was awarded preferred bidder status in Round 3 of the Renewable Energy Independent Power Procurement Programme (REIPPP) in October 2013. Power is generated by burning the tops and leaves of sugarcane from nearby plantations. The project has a capacity of 16.5 MW and aims to generate 118 GWh/year, which is enough to provide 40,000 households with electricity. Connection to the grid will be performed by Eskom.

The Cane Growers' Association is running a pilot rural bio-digester project specifically aimed at providing small scale farmers with the opportunity to generate electricity using tops and leaves from the sugar cane growing process. The plug-flow digester uses 1.2 tonnes/day of tops and leaves. The 200 m3 digester currently installed with a feed pump and storage of liquid digestate generates, on average, 8 Nm3/h of wet biogas with a 50% CH4 concentration. The project aims to stay below a capital cost of ZAR 1.5 to 2 million (about 1/10 of the cost in Europe) and construction is estimated to take approximately 600 man days to complete. The system requires two units for feed collection, operation and digestate distribution. The photograph above provides an aerial view of the pilot project in operation..

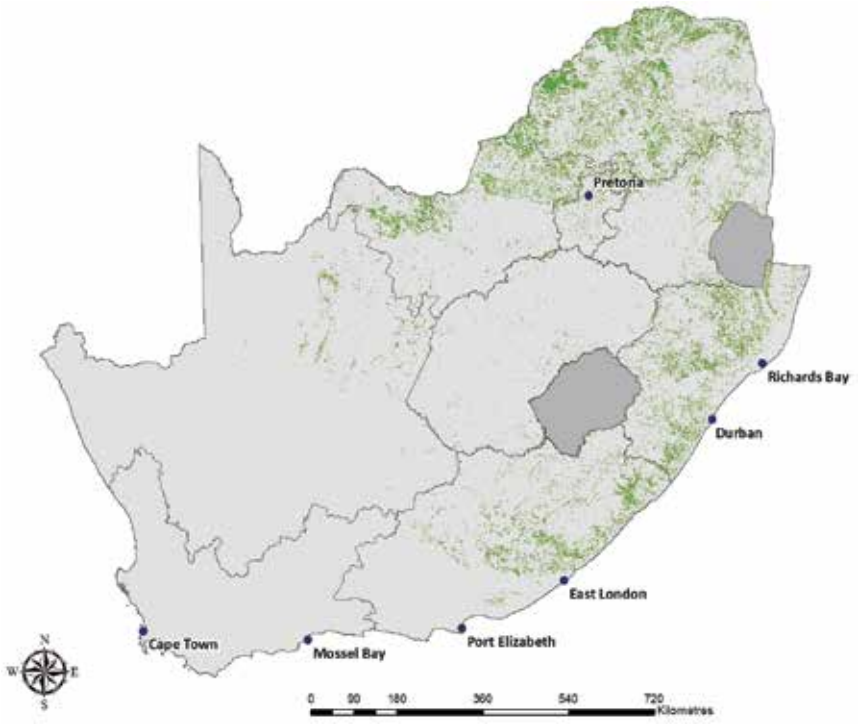


Figure 10.4: The distribution of forestry plantations in South Africa.

10.5 BIOMASS FROM FOREST PLANTATIONS AND PROCESSING

10.5.1 Sources of biomass

South African forest plantations occupy a net area of approximately 1.224 million hectares, or 1.0% of South Africa's land area. Annually, approximately 17.9 million m3 of wood from eucalypt, pine and acacia species is sustainably harvested from these plantations for the manufacture of pulp and paper, saw timber, plywood, panel board and woodchips (FSA 2017). The distribution of forestry plantations is illustrated in Figure 10.4.

South African plantation forests are carbon reservoirs, containing biomass of about 50% C. These reservoirs store significant amounts of carbon, estimated at between 110 to 120 million tC. Currently there is no clear evidence that the current South African plantation estate constitutes a net carbon sink (that is, it continually adds carbon to the carbon reservoir) and given the complex interaction between genotypes, site, climate and management regimes, it is best to assume that it is carbon neutral. It is better to adopt the position that plantation forests act as a carbon pump, adding continuously to the reservoir of carbon in wood products. Biomass residues from the harvesting of timber and subsequent processing are a significant resource.

HARVESTING AND THINNING RESIDUES

Forestry plantations in South Africa are managed on a rotation basis with harvested areas being replanted. The rotation length depends on the species, growing conditions, and the intended end product. For example, the rotation length for fast-growing eucalypts for pulpwood is approximately 7–10 years, whereas the rotation length for slower-growing pine for the saw-timber market is approximately 25–30 years.

WAITING FOR ILLUSTRATIONS

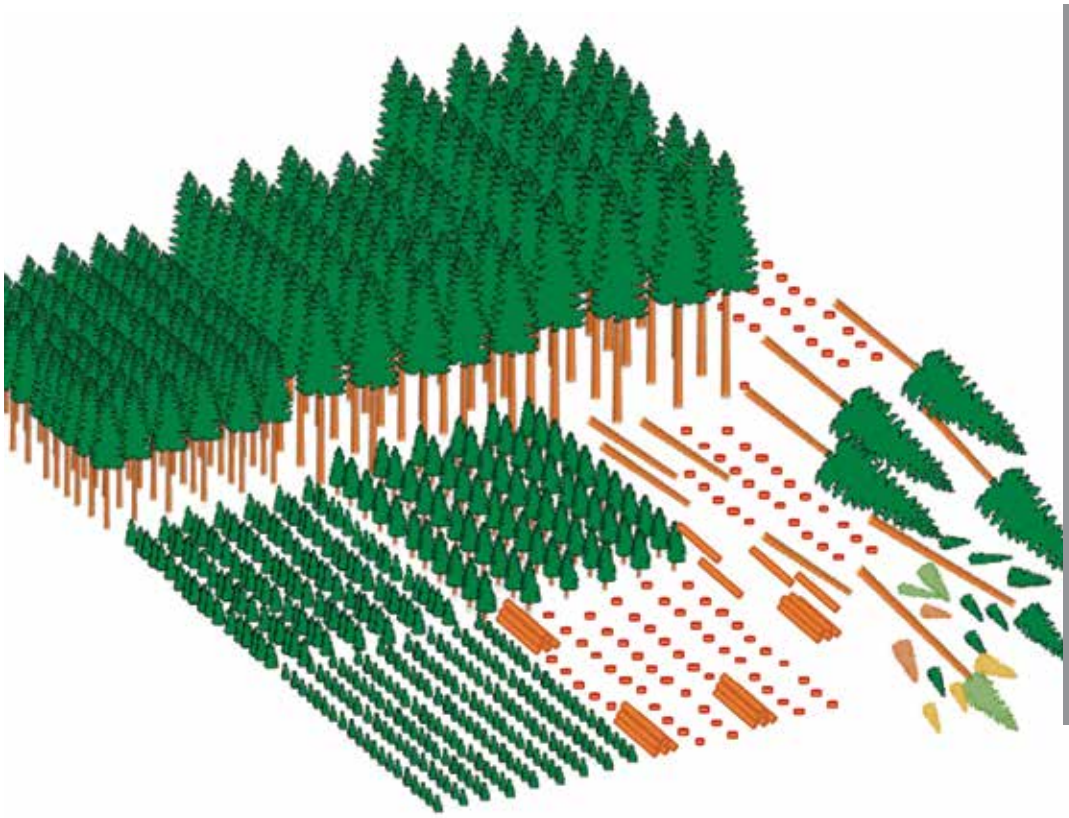


Figure 10.5: A simplified illustration of a plantation forestry operation, showing the various age classes, harvest trees and harvest residues. Branches and tops of trees removed during thinning operations are an additional potential source of biomass. Thinning is the selective removal of trees grown under a saw timber regime to improve the growth rate or health of the remaining trees.

During the harvesting process, trees are felled, debranched and the tops are cut off. Eucalypts are usually debarked during harvesting operations whereas pines are debarked at the processing facility. A simplified forestry operation, demonstrating the various age classes and harvest residues is illustrated in Figure 10.5.

PROCESSING RESIDUES

Wood grown in forest plantations is processed in mills to produce pulp, paper and sawn wood products. However, not all the wood processed in these ways, a certain portion is combusted to produce heat and electricity.

In the sawmilling/plywood sector, logs are debarked and sawn into planks or peeled to make veneer for plywood. During the process, sawdust, wood offcuts, peeler core or reject wood are also produced. Depending upon whether the wood is derived from pines or eucalypts, only 40 to 55% of each log entering the sawmill is converted into planks or plywood. The remainder (bark, sawdust, peeler core and wood offcuts) is combusted to produce steam and heat for drying wood in kilns, conditioning logs for peeling, manufacturing plywood, and generating electricity. The sawmilling process is illustrated in Figure 10.6.

In the pulp and paper sector, logs are debarked and the wood is processed either mechanically or chemically to produce pulp. In the manufacture of chemical pulp, chemicals are used to digest lignin and separate cellulose fibres. Lignin makes up approximately 30 to 35% of the wood. Following digestion, the lignin-rich liquid, known as black liquor, is burned in a recovery boiler to recycle the chemicals. The chemical pulping process is illustrated in Figure 10.7.

10.5.2 What is the magnitude and impact of the commercial forestry sector?

The National Terrestrial Carbon Sink Assessment estimated that South African plantations contain approximately 298 TgC, where 78 TgC is in tree and litter biomass, and the remainder in soil organic carbon stocks (DEA, 2015).

WAITING FOR ILLUSTRATIONS

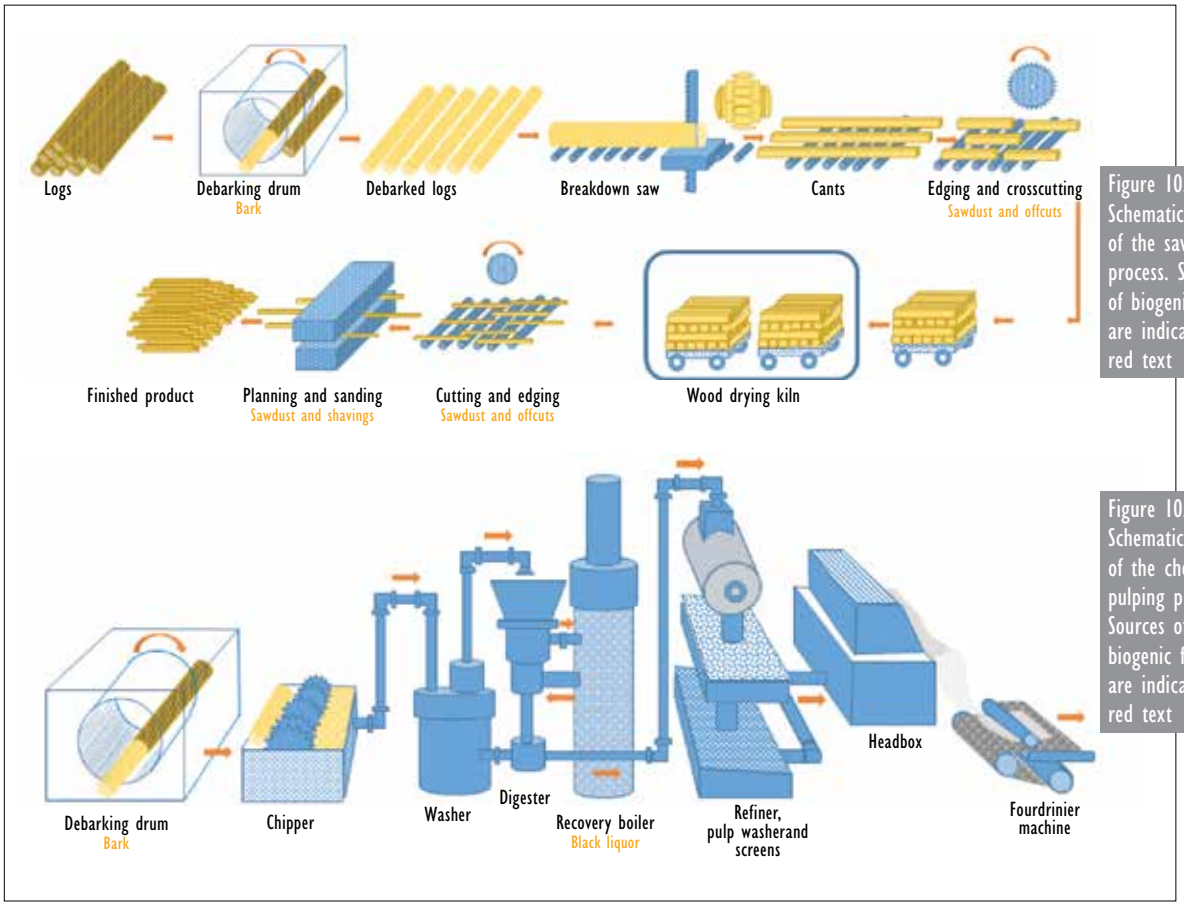


Figure 10.6: Schematic layout of the sawmilling process. Sources of biogenic fuels are indicated in red text

Figure 10.7: Schematic layout of the chemical pulping process. Sources of biogenic fuels are indicated in red text

Annually, approximately 8.8 million tons of wood is harvested from commercial plantations in South Africa (FSA 2017). The biomass potential from forestry plantations and processing facilities is illustrated in Table 10.5. During harvesting operations, approximately 2.2 million tons of harvest residues are produced. Not all of the harvest residue is available as a biomass resource – availability is determined by factors such as:

- The quantity of available residues (tonnes/ha).
- Residue collection and transport systems.
- The economics of collection and transport.
- Cost of power production.
- Site sustainability and productivity.

Sawmilling operations produced approximately 527,000 tons/annum of residues. A substantial portion of these residues is already used to generate process heat and electricity for own and third party consumption. Approximately 47,000 tons/annum of bark biomass is produced by pulp mills.

Table 10.5: The biomass potential from forestry plantations and processing facilities in South Africaa

	DRY MASS ('000 TONS)			
	SOFTWOOD B	HARDWOOD C	TOTAL	
Harvest residues	544	1 692	2 236	Tops and branches. Thinning's excluded
Saw and veneer mills	480	47	527	Sawdust, bark and offcuts
Pulp mills	47	-	47	Bark. Black liquor excluded
Total	**1 071**	**1 739**	**2 810**	

a. Derived from FSA 2017, Ackerman et. al 2013
b. Pine species; cEucalypt and acacia species

10.5.3 Social context and governance

The Department of Agriculture, Forestry and Fisheries (DAFF) is responsible for the sustainable management of the country's forest resources. The National Forests Act, 1998 (Act No. 84 of 1998); National Veld and Forest Fire Act, 1998 (Act No. 101 of 1998); Forest Laws Amendment Act, 2005 (Act No. 35 of 2005) and National Forest and Fire Amendment Act, 2001 (Act No. 12 of 2001) provide the legislative framework within which the forest and forest products industries operate.

The National Forests Act, 1998 (Act No 84 of 1998) promotes sustainable forest management based on the principles of sustainable development and therefore ensures the integration of ecological, social and economic values, in consultation with local communities and other stakeholders. The forestry resource base – natural (indigenous) forests, commercial plantations and woodlands – is spread over some of the poorest areas in South Africa and it therefore plays a significant role in terms of poverty eradication, through job creation and the supply of basic needs (DAFF 2009). In terms of Section 33 of the National Forests Act, 1998 (Act No 84 of 1998), a National Forestry Advisory Council has been established to advise the Minister of Forestry "on any matter related to forestry in South Africa".

The conclusion and signing of the Forest BBBEE Charter in 2008 and the recognition of forestry as one of the potential growth sectors in South Africa by the Department of Trade and Industry have created a need for strong partnerships between government and other stakeholders, including industry, with a view to sustainably growing and transforming the forestry sector.

The most important industry associations are:

- Forestry South Africa (FSA). This is an association representing the interests of large, medium and small-scale timber growers in South Africa. Over 90% of all timber growers in South Africa are members.
- Paper Manufacturers' Association of South Africa (PAMSA). This is an association representing South African pulp and paper producers. The current membership represents over 90% of the paper manufacturing capacity in South Africa.
- Sawmilling South Africa (SSA). This association represents 74% of the formal sawmilling sector.. Current membership covers some 38 sawmills throughout the country.

Table 10.6: Biomass projects utilising forest and processing residues submitted under REIPPP

COMPANY	OUTPUT (MWE)	BIOMASS (TONS/ANNUM)	BID STATUS
Sappi (Ngodwana)	25	275 000	Awarded
York (Sabie)	28	290 000	Submitted

10.5.4 Prior and existing programmes

The South African Integrated Resources Plan 2010 (IRP2010) outlines the proposed power generation mix for South Africa for 2010 to 2030. It proposes to increase South Africa's generation capacity by 40,000 MWe and seeks to increase the overall contribution of new renewable energy generation to 17,800 MWe (42% of new-build generation).

There are three components of this plan:

- Renewable Energy Independent Power Producer Procurement Programme (REIPPP).
- Cogeneration Independent Power Producer (IPP) Programme.
- Small renewable energy IPP's.

RENEWABLE ENERGY INDEPENDENT POWER PRODUCER PROCUREMENT PROGRAMME (REIPPP)

In order to develop solar, wind, biomass and land-fill gas renewable energy capacity in South Africa, the Department of Energy, in conjunction with the National Treasury's Public-Private Partnership Unit, launched REIPPP in August 2011. The programme is based on a system of 'procurement auctions' (bid windows) with the following basic stages:

- Issuance by government of a call for tenders to procure renewable energy-based electricity for each technology type (wind, solar, biomass, hydro) for each bid window.
- Definition by the government of the requirements for project
- Selection of engineering procurement and construction (EPC) as well as operations and maintenance (O&M) contractors, and prices for what they provide are negotiated.
- Securing of all funding requirements including equity and debt arrangements.
- Signing of successful bidders power purchase agreement (PPA) with Eskom (underwritten by National Treasury) and Implementation Agreement with the Department of Energy.

Table 10.7: Key elements of industrial biomass within the CoGen IPP programme

Description	Projects utilising an energy source which is a co-product, by-product, waste product or residual product of an industrial process and or sustainable agricultural or forestry activity, to produce an energy output.
Primary fuels	Sugar bagasse; field trash and other sugar related renewable wastes associated with the Host Facility process; and
	Mill wastes, including chips, saw dust, shavings, soaps, methanol, sludges, bark and black liquor.
	Agricultural or Forestry residue including alien vegetation clearing.
Exceptions from COFIT Guideline (primary fuels)	Bidders are not limited to primary fuels described in COFIT Guideline. The mill wastes described by the COFIT Guideline should merely be considered examples of the types of mill waste that may be utilised as a primary fuel.
Minimum % primary fuel	Minimum of seventy-five per cent (75%) of the primary fuel must be sourced from the primary fuel classifications above.
Supplementary fuel	1. All supplementary fuels must be sourced from any one (1) (or more) of the primary fuels listed for any of the Waste to Energy, Combined Heat and Power and Industrial Biomass Technologies above; and
	2. the aggregate of the supplementary fuels used cannot compromise the primary fuel minimum percentages for the respective Technologies, for example, for a Waste to Energy Project, a maximum of forty percent (40%) of the total fuel requirements of the Facility can be made up of supplementary fuels.
Efficiency requirements for the Facility	No minimum efficiency requirements, however, Bidders must inform the efficiency values in their proposal if the Facility produces Useful Thermal Energy.
Allowable technologies	Boiler and steam turbine.
Links with the Host Facility	All primary fuel must be supplied from or directly associated with the Host Facility.
Electrical Connection	Not stated

The updated RFP for Round 4 has removed certain requirements such as the submission of fully developed shareholders' agreements and Memorandum of Incorporation (MOI); detailed heads of terms to be entered into with contractors or equipment suppliers; and land use and environmental consent applications.

There has been a delay in the signing of power purchase agreements for 26 renewable energy projects, despite these already having been adjudicated under the REIPPP, and Round 4.5 bid announcements have been delayed.
Proposed and existing REIPPP projects are summarised in Table 13.6.

COGENERATION INDEPENDENT POWER PRODUCER (IPP) PROGRAMME

The cogeneration IPP procurement programme has been designed to procure a target of 800 MWe of energy-generation capacity from cogeneration. However, the energy minister indicated that the bidding process would be for 1,800 MWe and the department was seeking concurrence from the energy regulator to increase the size of the determination. The bidding process would be pursued under a revised model in an effort to 'expedite the approval process and financial close' Cogeneration under this IPP procurement programme encompasses:

- Simultaneous generation of energy and useful thermal energy (Combined Heat and Power – CHP).
- Generation of energy with possible generation of useful thermal energy (Waste to Energy).
- Industrial biomass.

The biomass component is summarised in Table 10.7.

SMALL PROJECTS IPP PROCUREMENT PROGRAMME

The Department of Energy has developed a Small Projects IPP procurement programme that seeks to procure renewable energy from small-scale independent

power producers. Projects must utilise onshore wind, photovoltaic, biomass and/or biogas technologies and be between 1 and 5 MWe in size. A procurement process, which commenced in 2013, is seeking to procure 50 MWe of the 200 MWe determined for small projects. Twenty-nine bids were received, totalling 139 MWe. Evaluations of bids was to be finalised during 2015 for subsequent announcement. The fully indexed price for biomass IPPs for the first round of bidding could not exceed R1.40/kWh.

The Department of Energy announced that there will be a new bidding round for small projects but the date has not yet been announced. The Small Projects RFP will be simplified in future to provide for a less complex and costly bidding process. In parallel, the Department of Energy and National Treasury have encouraged Development Finance Institutions and the private sector to develop a small projects funding mechanism. This mechanism will operate independently from government and is intended to provide funding to new small local developers (who may not otherwise receive funding from commercial banks).

The Sappi Tugela Mill Fuel Switching Project is an example of a cogeneration project that became economically viable as a result of the financial recognition of the project's contribution to climate change mitigation via the CDM.

The Tugela mill is located between Durban and Richards Bay near the Tugela River in KwaZulu-Natal. Operations at the mill generate some 70,000 tonnes of bark annually from the debarking of timber used to produce pulp and paper products. Sappi converted its boiler to enable co-firing of bark with coal and gas. Instead of landfilling the bio-waste as the company used to do in the past, it now uses the bark as biomass for steam generation in a biomass thermal energy boiler that has a capacity of 22 MWth. The biomass directly replaces coal for steam generation, resulting in a reduction of coal consumption as well as CO_2 emissions. Gas is used at start-ups and occasionally to stabilise the boiler bed condition.

10.6 CONCEPT AND CLIMATE VALUE

10.6.1 The biomass to energy concept

Biomass from IAPs, bush encroachment and bagasse can be used to generate different types of energy such as heat, steam and electricity. Since heat generation is easily achieved by combusting the biomass, and energy in the form of steam is primarily relevant in an industrial environment, this section focuses mainly on the generation of electricity from sustainable biomass.

In essence, after the biomass has been harvested and transported to the power generation facility, it is combusted in a boiler. The steam generated by the boiler is run through a steam turbine, which drives a generator that produces electricity for either internal consumption or supply to the electricity grid. The diagram below provides a schematic overview of the biomass to electricity process.

The infield processing stage is not necessary for a biomass source that is already centralised as part of the transportation of the primary product, such for bagasse that arrives at the sugar mill as part of the sugar making process. The primary driver behind infield processing is to increase the energy density (decrease the volume) of the biomass before transporting it. This not only makes handling the biomass easier, it also extends the range over which it can be transported economically.

10.6.2 The energy value

The South African National Terrestrial Carbon Sink Assessment (DEA, 2015) derives the annual

Figure 10.8: Biomass to energy process (electricity)

Table 10.8: Energy value of IAP, bush encroachment and bagasse sustainable biomass sources for the generation of energy.

Activity	Emission reduction p/year (tco_2e) (min)	Emission reduction p/year (tco_2e) (max)	Mwh/year (min)	MWh/year (max)	ZAR/year (min)	ZAR/year (max)
IAPs & bush encroachment	1,990,316	2,388,379	2,365,200	2,838,240	2,317,896,233	2,781,475,247
Bagasse	328,955	394,746	390,915	469,098	383,096,732	459,716,078
Total	**2,319,271**	**2,783,125**	**2,756,115**	**3,307,338**	**2,700,992,965**	**3,241,191,325**

mitigation potential for the use of AIP, bush encroachment and bagasse from the electrical energy that could be derived from these biomass sources instead of coal-based grid electricity. For this calculation it uses a conservative grid emissions factor of 85% of the Eskom grid factor (0.8415 tCO_2/MWh). Although the rates at which electricity can be purchased in South African vary depending on location and other characteristics of the offtake, the Mega flex rate published by Eskom yearly ranges between 670 ZAR/MWh and 1,200 ZAR/MWh. The table above uses the average of these two rates (980 ZAR/MWh) to determine the annual energy value of biomass from AIP, bush encroachment and bagasse for energy purposes.

The Renewable Energy Independent Power Purchase Procurement (REIPPP) programme is a competitive bidding process under which renewable electricity supplied to the national grid is procured at a preferential electricity rate. Only one biomass to energy project was successful in its application in the third bidding round of the REIPPP programme. Even though this REIPPPP project is large in size and forms part of an existing sugar production process, the project's rate lies just outside the high end of the Mega flex rates used in the calculation above, and is substantially above the average Mega flex rate. This indicates that it is unlikely that a business case can be developed for the generation of electricity from sustainable biomass at the current electricity rate.

From an energy value perspective, another way of looking at the feasibility of unlocking the potential of biomass to energy is by working out the costs of generating energy from sustainable biomass sources. In the study, Determining the Quantity and the True Cost of Harvesting and Delivering Invasive Alien Plant Species for Energy Purposes in the Nelson Mandela Metropolitan Area (Mugido, et al., 2013.) this has been done for a specific project using IAP as a sustainable source of energy.

The study looks at the costs of extracting approximately 551,000 tons of IAP biomass from an 8,900 ha area with an average of 62t/ha, in a number of different ways and transporting the biomass to a power generation facility. The investment

required to convert the biomass into energy is not taken into account as the study is concerned with the costs of replacing fossil fuel delivered to an existing power generation facility. The study shows an average cost of getting IAP to the gate of a power generation facility of 3.58 c/MJ, which is cheaper than the cost of a supply of coal, which the study indicates as being 4.9 c/MJ.

However, most of the scenarios in the study exclude the cost of harvesting AIP, assuming these costs will be borne by the Natural Resource Management programmes (such as WfW) as part of their objective to manage and eventually eradicate AIP from South Africa. The one scenario that includes harvesting costs shows a cost of 6.25 c/MJ, substantially higher than the coal baseline costs.

It appears then, from the scenarios discussed above, that in some cases the use of IAP as an alternative sustainable fuel can compete with fossil fuels for the production of energy, provided non-biomass to energy incentives are used (such as WfW harvesting IAP) In other cases, additional incentives such as a feed-in tariff from the REIPPPP for a biomass to energy project would be required. However, these scenarios do not directly consider other sustainable biomass benefits such as climate change mitigation, or other sustainable biomass co-benefits such as energy independence.

10.6.3 The climate value

Only the share of AIP and bush encroachment that is replenished on an annual basis can be considered as a sustainable biomass that reduces the country's GHG emission when used to substitute fossil fuel based energy.

South Africa is committed to moving towards a lower-carbon economy. At the 2015 climate change conference in Paris, South Africa submitted its Intended Nationally Determined Contribution (INDC), which commits the country to an emission reduction target in the effort to limit the increase of average global temperatures to 2°C. The South African government, like others, has three instruments at its disposal to change the behaviour of its industries and citizens:

- Command and control – where the emissions above a certain level are illegal, and exceeding the determined level of GHG could result in penalties and/or termination of the emitting activity.
- Stick approach – where the emission of GHG is not illegal but comes at a cost to industry and/or citizens. The penalty can be collected in a number of ways, one of which is the introduction of a carbon tax.
- Carrot approach – where an incentive for the reduction of GHG by industry and/or citizens is provided, and the desired behaviour is rewarded. This reward can be given in a variety of ways, one of which is the issuance and commercialisation of carbon credits.

With the ratification of the Kyoto Protocol, the South Africa Government adopted a carrot approach instrument in the form of the Clean Development Mechanism (CDM). Currently, the government is in the process of developing a stick approach instrument in the form of 'The South African Carbon Tax', scheduled for implementation by mid-2017. The legislation calls for a levy of 120 ZAR/tCO_2e emitted, which may be adjusted by the Minister of Finance as part of the annual budgetary process. Although the details are still being discussed, a basic tax-free threshold would be set at 60% to 70% for all sectors, with a maximum obtainable tax-free threshold of 75% to 95% when taking into account various adjustments to the basic threshold. The proposed carbon tax would effectively introduce a carbon price into the South African economy at an initial rate of 120 ZAR/tCO_2e. Although the tax targets

Table 10.9: Climate value of IAP, bush encroachment and bagasse sustainable biomass sources for the generation of energy.

ACTIVITY	EMISSION REDUCTION P/YEAR (TCO_2E) (MIN)	EMISSION REDUCTION P/YEAR (TCO_2E) (MAX)	ZAR/YEAR (MIN)	ZAR/YEAR (MAX)
IAPs & bush encroachment	1,990,316	2,388,379	238,837,920	286,605,480
Bagasse	328,955	394,746	39,474,600	47,369,520
Total	**2,319,271**	**2,783,125**	**278,312,520**	**333,975,000**

the GHG emissions of large carbon intensive industries, it can serve as a proxy for the economy-wide carbon price. This is because the introduction of such a legislation would have a ripple effect. For example, if a company uses coal in its operations it would be taxed at 120 ZAR/tCO_2e. However, if the company replaces part or all of its coal use with sustainable biomass from harvested AIP, for example, it would not have to pay carbon tax for the sustainable biomass used. In this way, the sustainable biomass for energy purposes represents a value of 120 ZAR/tCO_2e (assuming the Draft Carbon Tax Bill is aligned to the international practice of distinguishing between long and short cycle based emission types).

Table 10.9 uses the annual mitigation potential of the three-biomass sources this study is concerned with, as well as the carbon tax rate, to determine the climate value of these sustainable biomass to energy sources. Figures are sourced from the 'South African National Terrestrial Carbon Sink Assessment' (DEA, 2015).
The table shows that the average annual climate value of the three sustainable biomass sources is around 300 million ZAR per year. National Treasury has indicated that it intends to increase the rate on an annual basis, at a rate higher than inflation, to increase the price signal into the economy over time.

10.6.4 Biomass to energy co-benefits

There is a range of environmental and social co-benefits that can be derived from the management and/or eradication of AIP and the management of bush encroachment. In addition to the energy and climate value of the sustainable component of the three biomass sources – AIP and bush encroachment management and bagasse – the following co-benefits can be derived:

- **Energy proliferation**: Rural energy demand in South Africa is generally small and highly geographically disbursed. As a result, it is expensive to connect this demand to the national energy infrastructure, and it is unlikely to happen in the near future. However, the sustainable biomass sources available in rural environments potentially make the implementation of biomass to energy activities a way of distributing access to energy across the country.
- **Energy security**: The implementation of a sustainable biomass to energy activity in an area where energy infrastructure and supply already exists, increases the reliability of supply and thereby the user's level of energy security.
- **Energy independence**: At a national level, dependence on a third party for the provision of fuel and electricity runs the risk of supply interruption. At a local level, dependence on an energy provider that might terminate supply or increase the cost to an unaffordable extent is a risk. The implementation of sustainable biomass to energy activities can provide a higher level of energy independence in these instances.

Although these energy co-benefits are valuable attributes of sustainable biomass to energy activities, they are difficult to quantify in monetary terms in the way that has been done for the energy and climate value of these activities.

11

DEFINING THE GAP – STATUS QUO VS. NATIONAL-SCALE READINESS

SOUTH AFRICAN CONTEXT

Historically, coal has been an abundant and affordable source of energy in South Africa for both industrial and domestic use. Throughout the country there are examples of where coal or other fossil fuels are used for energy purposes even where biomass is readily available on industrial or other sites where energy is needed. Instead of being used as a fuel source, the available biomass is landfilled, burned or otherwise discarded.

Over the last decade or so South Africa's economy has developed more and more links to the global economy, resulting in a gradual increase in the cost of fossil fuels in alignment with international commodity prices. In combination with increasing concern about climate change, this has resulted in a drive to replace fossil fuels with sustainable biomass as an energy source. However, the uptake of sustainable biomass as a source of energy has been marginal in relation to its full potential.

11.1 TECHNICAL SCOPE

When looking at the technical scope of sustainable biomass for energy potential, it is evident that the gap between current use and total available biomass in relation to actual potential is overestimated, in some cases, grossly so. For this reason, distinctions are made:

- Theoretical potential is the total available volume of a source of biomass per year, and its GHG mitigation potential. An example of this would be the total amount of bagasse biomass that is produced per year.
- Actual potential, is the theoretical potential minus the volume that is either not extractable, is already used towards the main process, or does not result in direct or indirect GHG emissions.
- Current uptake is the volume of biomass and the mitigation contribution of biomass already used for the generation of energy outside of the primary process.

In essence, the gap or 'what we are missing out on', is the difference between the actual potential and the current uptake.

11.1.1 Potential

In this section, the theoretical potential, actual potential and current uptake of biomass for energy from IAPs, bush encroachment and bagasse in tonnes is provided, and their potential in tCO_2e per source is evaluated.

AIP POTENTIAL

The total volume of IAP biomass in South Africa is around 168.2 million tonnes (Stafford, 2014). Despite ongoing eradication efforts, the total AIP population still increases by approximately 11.5% per year. Only biomass that is regrown qualifies as sustainable, so although the theoretical IAP biomass is 168.2 million tonnes, the sustainable or actual potential according to the scope of this study is 19.3 million tonnes (that is, 11.5% of the theoretical potential). Although some project initiatives have been identified, at the moment the up take is limited in terms of tonnes of IAP biomass for energy purposes. Figure 11.1 provides a graphic overview of the potential.

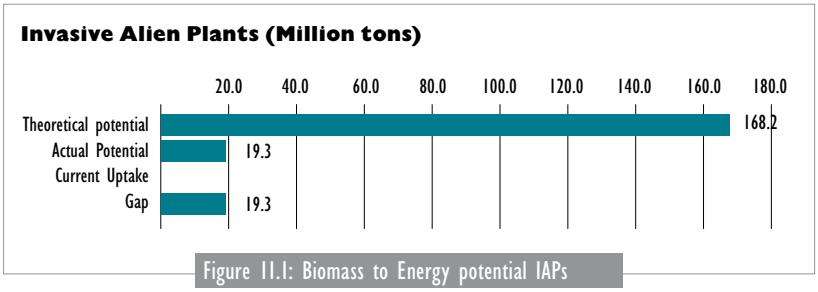


Figure 11.1: Biomass to Energy potential IAPs

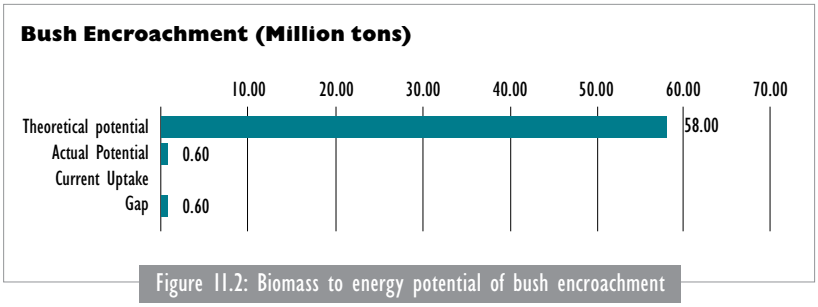


Figure 11.2: Biomass to energy potential of bush encroachment

BUSH ENCROACHMENT POTENTIAL

The total gross biomass volume of bush encroachment is estimated at 58 million tonnes (Stafford et al., 2017). The sustainable part of this biomass is limited to the annual 'regrowth', and accounting for the widespread distribution, accessibility and point of usage, it is assumed that 5% of the total volume is availabe as a sustainable source for biomass to energy purposes. There are numerous WfW activities in progress, but at the moment they focus on the management of bush encroachment and not on the utilisation of the biomass for energy purposes.

BAGASSE POTENTIAL

According to the South African Sugar Association, about 24,000 sugar cane growers operate in South Africa, farming in excess of 371,662 hectares of land, and producing around 19.9 million tonnes of cane annually. The harvested cane goes to the mills for sugar production, and waste consisting of tops and leaves is mostly left in the fields. The tops and leaves represent about one-third of the total mass of commercial cane and can be used for biomass to energy generation. Every 10 tonnes of sugar cane crushed for sugar production, results approximately 3 tonnes of wet bagasse (i.e. 30%) result. This bagasse is mostly used in the mills to produce heat in boilers and electricity for internal use. However, improvements in efficiency and the production of biogas or biomass to energy could generate electricity to be supplied to the grid.

Figure 11.2 shows available bagasse and its use as the primary energy source at the sugar mills. Taking into account the additional energy that could be produced and supplied to the grid by increasing the efficiency of the current bagasse to energy process, the actual biomass to energy potential within the scope of this study is derived.

FOREST PLANTATIONS AND PROCESSING

The total tonnage of plantation forestry in South Africa is approximately 596 million tonnes (DEA, 2015). Taking into account 10% availability based upon widespread distribution, accessibility and point of usage (FSA, 2017; Ackerman et al., 2013) and 50% of the available biomass from processing residues (FSA, 2017; Ackerman et al., 2014), the combined actual potential for biomass energy is around 5 million tonnes per year, of which, 2.2 million tonnes already forms part of on-going projects and activities. The theoretical and actual potential as well as the current uptake and gap are illustrated in Figure 11.3.

GAP ANALYSIS

In this section, the total gap between how much additional GHG mitigation (from a fossil fuel

replacement perspective) could be realised across the four sustainable biomass streams in relation to the actual potential, is assessed. The South African National Terrestrial Carbon Sink Assessment (DEA, 2015) provides mitigation potential ranges for biomass to energy from IAP, bush encroachment and bagasse. As the actual displacement of a tCO_2e from fossil fuel is subject to a wide range of activity-specific characteristics (such as boiler and turbine efficiency, grid electricity or onsite fossil fuel displacement, etc.), the average mitigation potential derived from the sink assessment has been used as the mitigation potential proxy across the four biomass sources outlined above.

Figure 11.4 shows that IAP have the greatest sustainable biomass for energy potential. However, this assumes that 100% of the AIP regrown annually can be extracted, processed and evacuated, first to the roadside and then to a facility where it can be converted into energy.

Figure 11.5 provides a geographical overview of the various areas where IAP grow in South Africa and their relative density. Although the greatest density of IAP on the map would seem to represent the highest biomass to energy potential, it is completely dependent on the ability to evacuate the biomass. For example, a canyon covered with IAPs would show up on the map as a high density area, but extracting biomass from the area could be practically impossible. Although the mitigation potential of IAP is the largest within the scope of this study, further research is required to determine whether or not the potential is practically realisable.

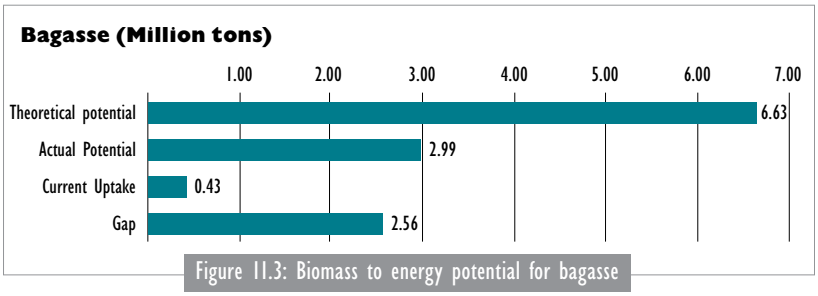


Figure 11.3: Biomass to energy potential for bagasse

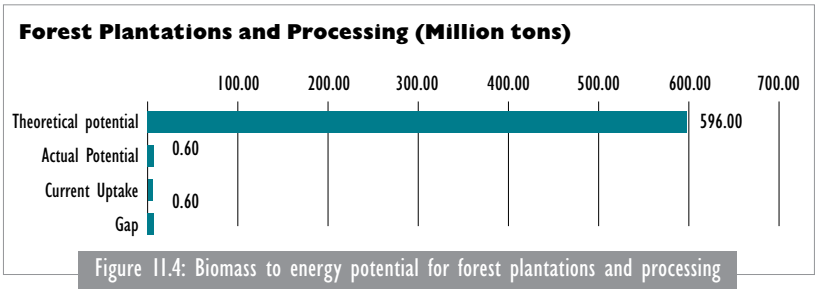


Figure 11.4: Biomass to energy potential for forest plantations and processing

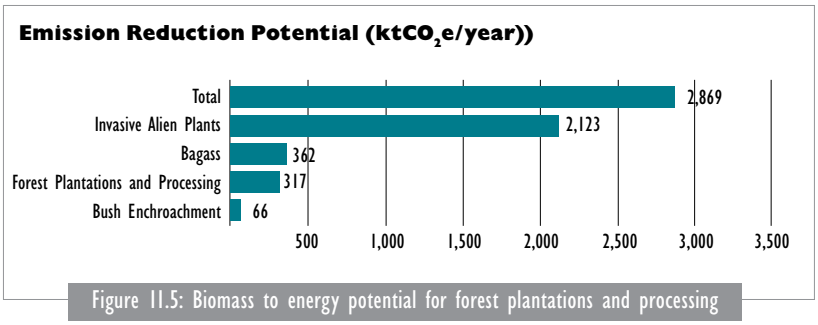


Figure 11.5: Biomass to energy potential for forest plantations and processing

11.2 FORMS OF IMPLEMENTATION

11.2.1 Implementation models

The conversion of biomass can be done in a number of ways depending on the type of biomass available and the type of energy required. Two types of implementation models have be identified for biomass to energy within the scope of sources covered in this study:

- **In process biomass supply**: The biomass is transported to a central location as part of the primary production process, for example, bagasse and the forestry and milling residue from wood processing.
- **In field biomass supply**: The biomass results from a range of activities that do not include transportation and centralisation of the harvested biomass, and it is available across (often) a wide area, for example, biomass from the management of IAP and bush encroachment.

This distinction is critical to the implementation model: In process biomass supply implies alignment with large scale, in most cases established, industrial operations. In field biomass supply is often dispersed, occurs in rural and sometimes remote locations, and so lends itself to small-scale rural applications.

There are, nevertheless, potential links between the two types of biomass supply. For example, the tops and leaves remaining in field after the harvesting of sugar cane could be made available for collection (in field or partially collected and transported) to small-scale farmers and communities for decentralised and small-scale

biomass to energy applications. Figure 11.6 provides a schematic overview of the dynamics that form the basis for different implementation models.

The diagram shows that links can be made in both directions between in process biomass supply to in field biomass supply sources. An example of this would by a forestry operation that receives biomass from IAP management, which is transported to a central location to be included in the process biomass supply.

A cross-over between the two primary biomass supply scenarios means that the one indirectly leverages the needs of the other in that it provides additional and differentiated biomass to a centralised facility, or logistical support for the aggregation and transport to the road side (the first mile) for further evacuation. Any implementation model in the sustainable biomass to energy sphere needs to cover some form of aggregation to make a facility feasible, from an economic and practical/operational point of view.

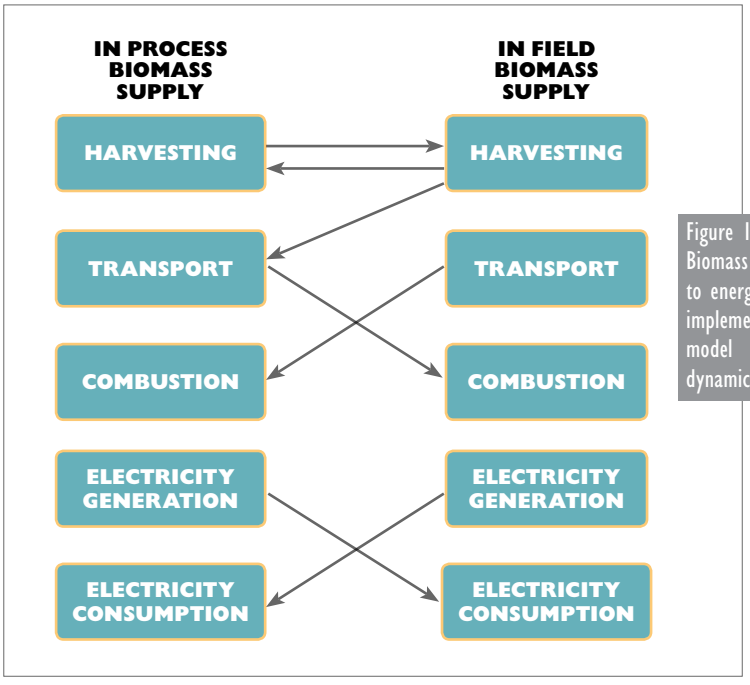


Figure 11.6: Biomass to energy implementation model dynamics

11.2.2 Financial feasibility (applicable to anaerobic biogas digesters as well)

Although sustainable biomass could replace fossil fuel (coal) or unsustainable biomass in some applications, this is unlikely to be significant in rural households as the economic situation there means that biomass, usually available for free, is already used in preference to unaffordable coal or other fossil fuel based energy. Except when biomass in the form of wood, charcoal, etc. is used on a small-scale to make fire for heating and lighting, an aggregation model for biomass for the generation of energy is needed, driven by the implicit need to realise economics of scale. The realisation of economics of scale is based on the assumption that biomass would be used to generate electricity as the primary energy form.

A consideration of electricity generation must take into account the different possible levels of quality. The quality of electricity includes both the technical quality (that is, voltage, frequency, etc.) and reliability (for example, a refrigerator needs a constant supply of electricity). The quality of electricity in a biomass to energy project is improved considerably if a connection to the national grid is also available, or can be established at reasonable cost, within a reasonable time frame.

A consideration of electricity generation must take into account the different possible levels of quality. The quality of electricity includes both the technical quality (that is, voltage, frequency, etc.) and reliability (for example, a refrigerator needs a constant supply of electricity). The quality of electricity in a biomass to energy project is improved considerably if a connection to the national grid is also available, or can be established at reasonable cost, within a reasonable time frame.

The financial viability (of both large and smaller-scale applications) hinges on two considerations:

- The investment and operating costs of the biomass boiler, steam turbine and generator, in relation to the costs of grid electricity.
- The affordability of the capital expenditure and operating costs of the electricity generation facility and local (island) grid for the household/community.

Except in cases where some of the costs can be allocated to others (for example, WfW pays for the harvesting of IAP biomass), the current price of electricity generally precludes an economically viable business case for the development of a biomass to energy facility.

The calculations and project examples given apply to large-scale facilities that have an electrical capacity of several megawatts. A biomass to energy plant costs around 1 million USD/MW installed capacity and requires dedicated operation and maintenance (O&M) of around 20,000 USD/year (that is, 2% of the capital costs). In South African Rand (ZAR) at an exchange rate of 13.41 ZAR/USD (as at 06/02/17), this equates to a capital expenditure of 13.4 million ZAR and O&M costs of 268,000 ZAR/year.

An average household uses between 400 and 800 kWh/month (SA Census, 2014) which amounts to an installed capacity required of 0.82 MW, assuming an average consumption of 7.2 MWh/year, requiring an installed capacity of 0.82 KW, assuming an average load over time. This means an investment of 11,021.92 ZAR and annual operating and O&M costs of 220.44 ZAR/year.

Although this sounds affordable for a household with funds available, this calculation assumes that the costs, both capital and O&M, can be downscaled in a linear fashion from 1MW, which is not the case. Not only is 1MW at the lower end of the scale of containerised power, but the capital plant cost below 1MW reduces by less than half in relation to the capacity between 1MW and 250 kW, and below that, by almost nothing. Which means that in practical terms the capital costs and O&M costs at a household level (in an optimal setup) are actually around 20,941.64 ZAR and 1,775.33 ZAR/year.

Running even a very small size biomass to electricity plant would require at least one skilled and qualified operator, who, even on a part-time basis, would cost more than 1,775.33 ZAR/year. The plant's maintenance costs would then still have to be taken into account.

Small-scale biomass to energy

facilities are therefore not economically viable with the current state of this type of technology and the associated costs. Accumulation of biomass is essential to realising economics of scale. However, this does provide government with the opportunity, firstly, of developing innovative community-scale initiative (>500 KW) and, secondly, of driving the development of small-scale biomass to energy installations at (closer to) linear costs up to 1MW.

This might seem like a unachievable target but there are many studies about societies (often in developing countries) 'leap-frogging' to more advanced technology and skipping the developmental stages in between (for example, some sectors such as rural South Africa skipped the roll-out a physical phone-line network and leaped directly into the mobile phone age). Making very small-scale biomass to energy facilities affordable might not be simple but it could just be the way for developing countries' governments to realise practical 'power to the people'.

11.2.3 Matching supply and demand

A 'merchant' power plant is different from a historical electricity supply utility in that it is funded by investors, on risk. It does not necessarily have long-term power purchase agreements in place at the start, or a captive customer base, and sells power in a competitive market. Avoiding mismatches of supply and demand is key to such a project's economic viability. To attract finance for a biomass to energy plant a reliable source of biomass needs to be established.

The supply of biomass is inherently unreliable, especially when considering unavoidable natural phenomena such as fire, drought, etc. This supply uncertainty can be mitigated to some extent by the diversification of biomass sources, but, in smaller applications specifically, and when considering transport cost constraints, the management of supply-side risk is complicated and proposals are sometimes unrealistic.

Although South Africa has experienced rolling black-outs on the demand side, there is no longer an acute shortage of electricity. However, considering future economic and population growth, new supplies to the grid and reductions in demand from the grid are important considerations that would make valuable contributions to a more balanced supply and demand situation. From a technical perspective, an offtake in addition to own consumption would assist in negotiating regulatory, bureaucratic, political and monopolistic barriers.

If the risks associated with sustainable biomass supply can be reduced by diversification of source, or if security can be provided against the risk, for example, by a government guarantee, then the investment risks can be reduced or possibly even eliminated

11.2.4 Gap analysis – determining financial feasibility gap

In summary, if the capital costs, especially for small-scale sustainable biomass to energy activities, can be reduced then sustainable biomass to energy projects become viable.

Alternatively, if the supply side risk can be mitigated and/or the revenue stream for biomass energy can be improved with respect to current power rates, either by a reduction of the electricity rate or a preferential rate of sustainable biomass to energy generated electricity, the gap can be closed.

The financial feasibility gap can therefore be summarised as follows:

- **Capital cost linear downsizing**: If biomass to energy plants could be scalable to a smaller size, from a capital and O&M perspective, biomass to energy would be a viable option for rural applications.
- **Supply side risk mitigation**: If biomass supplies could be more organised and structured on a national scale, biomass to energy activities would become more financeable. Small-scale applications of biomass to energy would require some form of (government) guarantee.
- **Revenue contribution**: Electricity was fairly cheap in South Africa in the past, but increased global exposure and local changes to the power sector mean that this is no longer the case. The 'pure' cost of energy still does not, however, justify investment in a large-scale biomass to energy power plant, let alone a small-scale plant.

Obviously, the financial viability of sustainable biomass energy is just one of the aspects to consider. The value of indirect benefits has to be quantified as well, for example, climate change mitigation and energy independence, and then the financial dynamics change somewhat.

11.3 MONITORING, REPORTING AND VERIFICATION (MRV)

Note: This exploration of drivers and barriers is applicable to the realisation of both biogas digester opportunities and biomass to energy initiatives. It is only considered once in this study to avoid unnecessary duplication.

The collection of reliable and complete datasets is a complex process in any type of research project and scientists, industry, and government all struggle to collect relevant data. The available data on sustainable biomass and biogas to energy activities (especially at a small scale) are limited and sometimes unreliable. Various sources of data are sometimes used to develop datasets for drawing conclusions and informing the decision-making process. However, to obtain detailed, purpose-specific, monitoring information that can be verified and used for reporting in a more meaningful way, it should be a requirement for projects to provide data, and some sort of incentive could be provided to make it worthwhile for the information provider to do so.

The South African government is in the process of introducing a carbon tax according to which the relevant sectors will be taxed on GHG emissions, derived from their total volume of fossil fuels consumed per year. This would provide government with revenue and data on fossil fuel use. A reduction in fossil fuel use over time would imply that the use of biomass or biogas to energy is slowly displacing fossil fuel consumption. It would not, however, provide an indication of the number and impact of specific sustainable biomass or biogas to energy activities. The design of the carbon tax includes the use of so-called carbon credits, which can be converted into carbon tax offsets, and (via offsetting), used to reduce the taxable volume of GHG emissions. The carbon tax offset records could be a source of reliable, verified data for reporting purposes.

A mitigation project is required to register under one of the international carbon credits standards and the carbon credits issued to them can be converted into carbon tax offsets provided they meet the eligibility criteria as defined in the draft carbon tax bill. Table 11.7 provides an overview of these eligibility criteria.

Biomass energy and anaerobic digesters (AD) are included in the positive list in the table. This means that sustainable biomass and/or AD projects will measure and report verified data to government via this process. According to the draft carbon tax offsets regulations, an entity within the Department of Energy (DEA), entitled the Designated National Authority (DNA), will be tasked with assessing the eligibility of carbon tax offset projects using the issuance of an Extended Letter of Approval (ELoA). Once an approved project issues carbon credits under a project that has received an ELoA, the DNA, upon receipt of a certificate of cancellation of the carbon credits under one of the international standards, will issue the owner of the carbon credits with carbon tax offsets. These carbon tax offsets represent an independently verified volume of tCO_2e that has not been emitted into the atmosphere.

Table 11.7: Eligibility of mitigation activities under the carbon tax offset regulations

OVERALL CRITERIA	
Mitigation activities eligible to offsetting should be in relation to economic sectors or activities that are not directly subject to the carbon tax. (Regulations: Preamble)	
Mitigation activities eligible to offsetting should be in relation to economic sectors or activities that are not benefitting from other government incentives. (Regulations: Preamble)	
Offsetting is only allowed in respect of certified emission reduction derived from the furtherance of an approved project "meaning – (a) a CDM project; (b) a VCS project; (c) a gold standard project; or (d) a project that complies with another standard approved by the Minister of Energy or a delegated authority." (Regulations: Part I, 1 and Part II, 2.1)	
Approved projects shall be carried on, on or after 1 January 2017. (Regulations: Part II, 2.1)	
Approved projects shall be wholly undertaken in the Republic (Regulations: Part II, 2.1)	
Special conditions for approved projects that were already conceived or in the process of being conceived before 1 January 2017:	
In case of an approved project in respect of which an offset is in existence prior to 1 January 2017: the approved project may only be utilised for the purposes of these Regulations until 31 December 2017. (Reg.: Part II, 2.2)	
In case of an approved project in respect of which an offset (a) is not in existence prior to 1 January 2017; and (b) of which registration has commenced before 1 January 2017: an offset may only be utilised as an offset for the purposes of these Regulations for a period of 6 months after that offset has come into existence. (Reg.: Part II, 2.2)	
Positive List	**Negative List**
Energy Sector • Energy efficiency not claiming the 12L tax incentive: – in the residential and commercial sector – in buildings – community-based, municipal energy efficiency and renewable energy – Fuel-switching projects – Electricity transmission and distribution efficiency (Note: Part II, Table 1)	A taxpayer conducting an activity in respect of the REIPPP. (Regulations: Part III, 4.1) A taxpayer conducting an activity in respect of which any allowance may be received in terms of the 12L Energy Efficiency Tax Allowance. (Regulations: Part III, 4.2) A taxpayer conducting an activity in respect of the destruction of industrial gasses HFC-23 and N_2O from adipic acid production. (Regulations: Part III, 4.2)
Transport Sector • Public transport – Transport energy efficiency (Note: Part II, Table 1)	Energy efficiency projects implemented on activities owned or controlled by companies that are covered by the carbon tax. (Note: Part III)
Agriculture, forestry and other land use (AFOLU): • Restoration: sub-tropical thicket, forests, woodlands; – Restoration and management of grassland; – Small scale afforestation; – Biomass energy; – Anaerobic biogas digesters; and – Reduced tillage. (Note: Part II, Table 1) **Waste Sector:** • Municipal waste projects (Note: Part II, Table 1)	Cogeneration of renewable energy projects implemented on activities owned or controlled by companies that are covered by the carbon tax; (Note: Part III) Fuel-switch projects implemented on activities owned or controlled by companies that are covered by the carbon tax; (Note: Part III)

Note refers to the "Explanatory note for the draft regulations on the carbon offset" (NT, 2016). 'Regulations' refers to "the Draft Regulations: Carbon Offsets" (NT, 2016). 'REIPPP' refers to Renewable Energy Independent Power Project Procurement Programme.

Via this channel, the South African government will receive accurate information about planned and operational biomass to energy and AD mitigation projects, and be able to determine the success of its initiatives around supporting biomass to energy and biogas project activities over time. However, the carbon tax offset eligibility criteria exclude mitigation activities by entities that are already covered by the carbon tax. The rationale for this is the prevention of double benefitting. When an entity implements an AD project, for example, it reduces its carbon tax as a result of reduced reliance on fossil fuel, and benefits from the commercial value that the ownership of carbon tax offsets represents. Industrial biomass and biogas sources are not required to provide government with this kind of critical data, and consequently, bagasse, feedlots and commercial forestry waste are some of the sectors that would fall outside of this monitoring, reporting and verification channel.

The sink assessment study points out that one of the main obstacles to the roll-out of projects to date has been the high transaction costs associated with MRV through international standards. To address this, a robust and transparent MRV system would need to be created for each of the principal implementation options. These MRV structures should dovetail with the national MRV programmes currently being developed by the DEA, and support existing capacity where possible. It is anticipated that the initial monitoring of activities in the field will be undertaken by the extension officer or established industry structures. The collected data will be managed and archived both at the Centres of Development level and at a Tier 1 level. At a national Tier 1 level, there will be

a dedicated MRV officer focusing solely on the collation and analysis of data, and its communication to stakeholders and investors. Although MRV traditionally focused principally on carbon-related metrics, the MRV unit would coordinate the monitoring of all ecological, operational and socio-economic metrics, and provide a data management and archiving system for the programme.

One of the measures that have been taken in line with the recommendations in the silk assessment (DEA, 2015) is the development of a Standardised Grid Emission Factor (GEF) for all projects that claim emission reductions under the CDM (Clean Development Mechanism) or one of the other standards that piggyback on this UN platform. This GEF (registration number: ASB0001) titled; 'Grid Emission Factor for the Southern African Power Pool (Version 01.0)' defined the carbon intensity of the southern African power grid covering the following countries:

- Botswana.
- Democratic Republic of the Congo (DRC).
- Lesotho.
- Mozambique.
- Namibia.
- South Africa.
- Swaziland.
- Zambia.
- Zimbabwe

Although this is a good example of lowering one of the implementation barriers of certain types of biomass to energy and AD projects, the standardised methodology is set to expire on 30 May 2017. It is therefore recommended that the GEF be renewed to prevent this barrier to implementation re-emerging.

SECTION SEVEN

INSTITUTIONAL AND FUNDING CONSIDERATIONS

12

INSTITUTIONAL AND FUNDING CONSIDERATIONS

12.1 REVIEW OF FINANCE AND FUNDING OPPORTUNITIES

Perhaps the most important element in a project development process is the identification of a source of payment for initial project development and especially the long-term sustainable implementation of all activities. Financial support for projects can be divided into two separate types of support: funding and finance. In general, funding refers to the donation of capital by government or individuals (including donations to larger funds). There are usually certain contractual requirements, although the recipient is under no obligation to pay back the capital. Finance is the provision of capital, usually by financial institutions such as banks and investors. The recipient is liable to repay the capital, with interest.

There are several multilateral funds supporting climate change adaptation and mitigation, with some dedicated REDD+ funds. Important multilateral funds to consider are the Green Climate Fund (GCF, USD 10 billion), Forest Carbon Partnership Facility – Carbon Fund (FCPF-CF, USD 750 million), GEF 6 Trust Fund (USD 1,101 million) and the BioCarbon Fund (USD 354 million). Bilateral funds are also significant contributors to REDD+ funding, with the most important ones summarised in Figure 12.1 (Well and Carrapatoso, 2016).

Although there certainly are substantial funds available, each source comes with specific rules that define the particular country, activity or stage of development

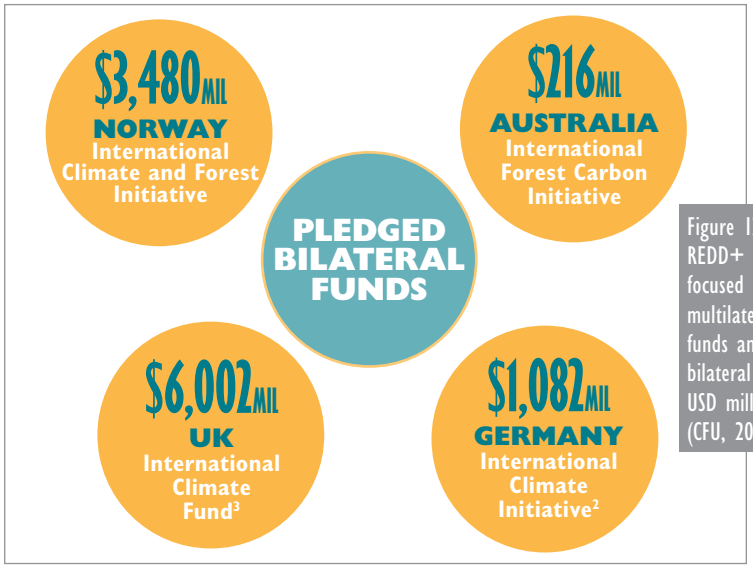


Figure 12.1: REDD+ focused multilateral funds and key bilateral funds, USD million (CFU, 2016))

that fund seeks to address. Consequently, the allocation criteria and process for funds can vary considerably.

The programme or project framework is divided into 3 distinct phases: Phase 1 (early preparation), Phase 2 (development and implementation) and Phase 3 (MRV and long-term implementation). Each phase has specific elements and tasks, which could potentially receive financial support from a range of sources. Table 12.1 summarises the key elements and tasks of each phase and provides an indication of the type of financial support they are likely to receive. A significant portion of finance is used to fund Phase 1 'readiness' activities. This preliminary phase involves the initial development of each of the elements of the phase, occurring within a 2 to 5 year timeframe. Readiness activities such as the project potential assessment, required capacity and MRV systems are preparatory and do not generate direct financial returns. As a result, this phase is likely to be funded by government funds and international public funds.

Phase 2 involves demonstration activities and piloting of the project strategy, occurring within 2–5 years. Demonstration activities and pilot projects may attract private finance, however the bulk of the funding will originate from public and government funds (Well and Carrapatoso, 2016).

Phase 3 includes the roll-out of project-specific activities at a national scale. There are two distinct elements to this phase, National Coordination Office and implementation. Phase 3 is likely to leverage more private finance than the initial two phases as it has the potential to provide financial returns, in the form of offsets, ecosystem services etc. Nonetheless, elements of this phase will still rely on government and public funding for implementation (Well and Carrapatoso, 2016).

The National Coordination Office would provide overriding support to project activities. There are several tasks this facility will perform and coordinate, summarised in Table 12.2. It is likely that most of the tasks under the National Coordination Office will be funded by government or public funding. However, it is possible to incentivise private financing for tasks that have a monetary outcome, for example income creation and management.

Project activities in South Africa will be implemented in various contexts: private land, communal land and government land. Projects occurring on private land are more likely to attract private investors than projects on communal and government land as the risks are significantly lower, with political risk and land-tenure issues identified as the two biggest risks for investment (Robles, 2013).

Although government can establish regulations for sustainable resource use, often state-owned land has inadequate management and enforcement. Monitoring sustainable resource use can become expensive and ultimately ineffective (Corbera et al., 2011). On communal land, resources are managed by the entire community, however the 'rights' to the resources are often differentiated socially (Corbera et al., 2011). Furthermore, land and resource use is regulated by customary practices and community institutions. As a result, it is

Table 12.1: Readiness funding and finance framework

PHASE 1

ELEMENTS	PUBLIC FUNDING	GOVERNMENT FUNDING	PRIVATE FINANCING
Potential Assessment	✓	✓	
Required capacities	✓	✓	
Policies and measures review	✓	National Treasury ✓	
MRV system	✓		
Safeguard information system	✓	✓	

PHASE 2

ELEMENTS	PUBLIC FUNDING	GOVERNMENT FUNDING	PRIVATE FINANCING
Demonstration activities and piloting of projecy strategy	✓	✓	✓
Further development of national strategy	✓	✓	
More capacity building	✓	✓	
Identification and initialization of pilot programmes.	✓	✓	✓

PHASE 3

ELEMENTS	PUBLIC FUNDING	GOVERNMENT FUNDING	PRIVATE FINANCING
NATIONAL CO-ORDINATION OFFICE TASKS:			
Strategic lead and champion	✓	✓	
Awareness and support services	✓	✓	
Extension services	✓	✓	
Cost-efficient MRV system	✓	✓	
Research and Development	✓	✓	
Strategy development	✓	✓	
Income creation and management	✓	✓	✓
Integration with policy and regional planning	✓	✓	
THREE IMPLEMENTATION CONTEXTS:			
Private	✓	✓	✓
Communal	✓	✓	Conditional ✓
Government land	✓	✓	Conditional ✓

necessary for potential investors to carry out a consultation process with local communities to discuss how the investment will affect their access to natural resources and to clarify who has the rights to the benefits and to what extent (Bernard et al., 2012).

In addition, changes in land use on both government and communal land are complicated by intersecting social and political processes, which require effective coordination and cooperation across government agencies and relevant local stakeholders (Corbera et al., 2011). This requires additional resources and both community and political willingness – a further challenge.

On the other hand, private land owners are likely to be interested in different programmes if they are economically attractive and technically feasible. In general, benefit sharing on private land is significantly less complex than in communal and government land tenure regimes (Corbera et al., 2011).

Nonetheless, if the implementation and management of activities on communal and government land generate a net benefit, that can be measured and evaluated, private investors may be enticed to invest in the programme. Carbon offsets are not the only marketable commodity from REDD+ programmes; other outputs include ecosystem services, improved reputation through corporate social responsibility, and green commodities (Bernard et al., 2012).

Besides the different allocation of funding and finance to various phases, funding agencies and private investors have other allocation criteria and project-approval processes that vary considerably. Allocation criteria have a bearing on the rate of project approval and on fund disbursement and accountability.

Table 12.2: Comparison between UN-REDD and FIP

	UN-REDD	FIP
Criteria	↓	↑
Indictors	↓	↑
Project approval	↑	↓
Funds disbursement	↑	↓
Accountability	↓	↑

Table 12.2 highlights the differences between the UN-REDD and FIP funds. FIP has 16 criteria and 29 indictors, whereas UN-REDD has fewer criteria, does not have specific indicators and tends to be more flexible.

Mobilising bilateral finance is contingent on good cooperation between the recipient and the donor countries. As with multilateral funds, bilateral funding initiatives are guided by various objectives applying to official development assistance (ODA) criteria. For example, Norway inclines to participation in large-scale funding in tropical countries (Brazil, Indonesia, etc.), Germany emphasises the connection between REDD+ and diversity conservation, and the USA's REDD+ funding initiatives focus on REDD+ and development goals (Well and Carrapatoso, 2016). Because the criteria of the various funds differ, a comprehensive analysis of each potential source, relative to well-identified and articulated needs, is required.

The Green Climate Fund (GCF) is a source of funding that is expected to play an increasingly important role in REDD+ finance in the future. The GCF is a multilateral financial mechanism under the UNFCCC, created with the aim of addressing both climate change mitigation and the adaptation needs of developing countries. The fund aims to mobilise USD 100 billion by 2020, with an initial contribution of USD 30 billion by 2012. A significant portion of the funds will be channelled towards low-emission and climate-resilient projects and programmes in Least Developed Countries (LDCS), Small Island Developing States (SIDS) and African states (GCF, 2016a). Given the ambitious target of USD 100 billion by 2020, it is of concern that recent data shows that total endowments to the fund currently only amount to USD 10,225 million (CFU, 2016).

Figure 12.1 provides an overview of the process of proposal approval. Proposals are submitted to the GCF though, and in consultation with, the National Designated Authority (NDA), which acts as an executing entity and the point of contact with the GCF (Schalatek et al., 2015). Project proposals are assessed against a set of 6 investment criteria and 15 sub-criteria (GCF, 2014).

These criteria include impact/result potential, paradigm-shift potential, needs of the country, country ownership and institutional capacity, economic efficiency, and financial viability (GCF, 2014). Medium and large-sized funding proposals are assessed and ranked using a pilot scoring approach (Schalatek et al., 2015). The GCF has identified 8 sustainable development and climate-related impacts areas. These include sustainable land use and forest management (including REDD+) (GCF, 2016a).

Readiness activities and preparatory support have been identified as crucial to enhancing country ownership and access, and enabling a country to building capacity in order to access GCF finance more effectively and efficiently (Schalatek et al., 2015). The GCF currently has USD 16 million available for providing early support for readiness activities, deployed either through NDAs or other institutions with experience in readiness activities (GCF, 2016b).

Programmes and projects funded by the GCF will be monitored using a result-management framework, using performance indictors to measure progress. One of the key metrics is tonnes of GHG emissions produced (the aim is to reduce emissions) in carbon dioxide equivalents. There is a separate performance measurement framework of REDD+ activities, required for results-based payments (Schalatek et al., 2015).

Finance from REDD+ funds, GCF and private investors, is disbursed though a number of different financial mechanisms, including

Figure 12.2: Proposal approval process (GCF, 2015)

taxes, carbon markets, auctioning allowances, grants, concessional loans, equity investments and guarantees, depending on the component and stage of the REDD+ development (Figure 12.2). The general terms and conditions of grants and loans for projects financed by the GCF still need to be finalised and so projects are currently assessed case by case (Schalatek et al., 2015).

Although there is interest from the private sector and international funds in utilising market-based mechanisms such as results-based finance to support programmes, the development of these mechanisms is limited and their future is unclear (Warnecke et al., 2015; Norman et al., 2014). REDD+ programmes financed by the GCF will operate on a results-based payments framework, although this is currently not operative (Well and Carrapatoso, 2016). Private sector investment remains low, and declining compliance and carbon markets, along with significant investment risks (political and land tenure risks, a viability gap, etc.) remain deterrents. In addition, most compliance markets do not accept forest and REDD+ emission reductions (Warnecke et al., 2015). Consequently, it is critical that risk mitigating mechanisms are put in place while innovative financial instruments are necessary to attract investment and create markets.

SOUTH AFRICA: CARBON TAX

South Africa is planning to implement, through the National Treasury (NT), a carbon tax pricing mechanism for all its large-emitting sectors in 2017. A carbon tax places a price on each tonne of GHG emissions generated from the combustion of fossil fuels. This will encourage consumers and businesses to choose less carbon-intensive alternatives, which will ultimately result in reduced emissions. A carbon tax approach is preferred over an emissions trading scheme (ETS) approach in South Africa because a carbon tax is generally easier to implement as it can build on existing taxation infrastructure (National Treasury, 2013). An efficient ETS would be difficult to implement because of the concentrated nature of South Africa's energy sector, a relatively small number of market participants, and small trading volumes (National Treasury, 2013).

In November 2015, the NT published the draft Carbon Tax Bill, which calls for a levy of R120/tCO_2e

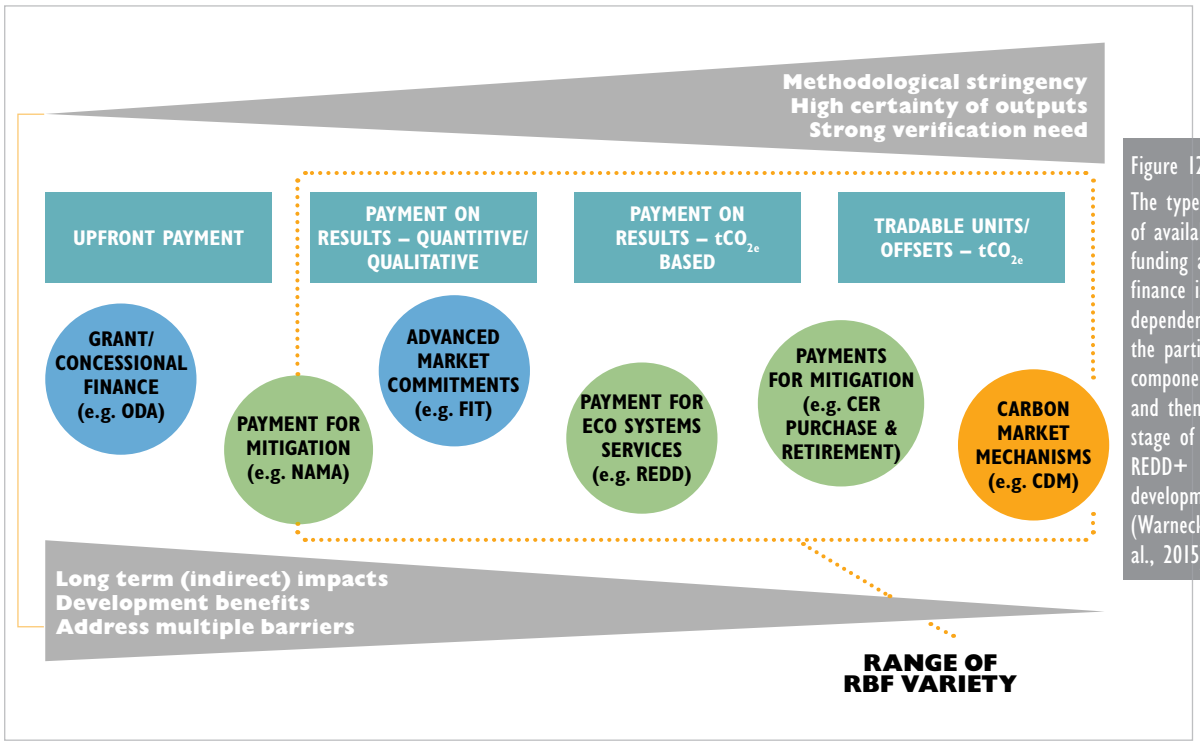


Figure 12.3: The type of available funding and finance is dependent on the particular component and then stage of REDD+ development (Warnecke et al., 2015)

(Rand per tonne of carbon dioxide equivalent) emitted, escalating by 10% per year. The Carbon Tax Bill contains a number of clauses that are of particular importance to the forestry and forest products sector. An inclusion within the most recent draft is the so-called 'sequestration component' (S) which enables the various sectors to deduct their sequestered GHG emissions from their fossil fuel combustion emissions. This is relevant, in the case of forests, to the capture of carbon through the process of photosynthesis and its storage as biomass. The bill could have important ramifications for the South African forest and forest products sector as GHG emissions from wood processing operations are liable to taxation under the Carbon Tax Bill but forestry operations are excluded in the initial phase (until 2020). Furthermore, within the 'sum of the percentage of allowances' (C), provision is made for an 'offset allowance' which could also has important consequences for the forest and forest products sector.

In June 2016, Carbon Offset Regulations were developed jointly by the NT, the Department of Energy and the Department of Environmental Affairs (DEA), in terms of the draft Carbon Tax Bill. The carbon offset scheme aims to encourage GHG emission reductions in sectors or activities not covered by the carbon tax, including agriculture, forestry and other land use (AFOLU), and waste sectors. The carbon offset regulations set out procedures for taxpayers to reduce their carbon tax liability using carbon offsets. Eligible carbon credits, issued under a number of global carbon standards, could be converted to Carbon Tax Offsets. It is proposed that businesses will be able to reduce their carbon tax liability by up to 10% of their actual emissions, using carbon offsets.
Offsets generated in the AFOLU sector as a result of the carbon tax need to be able to compete in terms of risks and returns. Existing international carbon offset standards such as the Clean Development Mechanism (CDM), Verified Carbon Standard (VCS) and the Gold Standard (GS), will be used. The specific eligibility criteria for carbon offset projects are proposed in the regulations.

Eligible carbon offset projects in the AFOLU sector (Republic of South Africa, 2016) include:

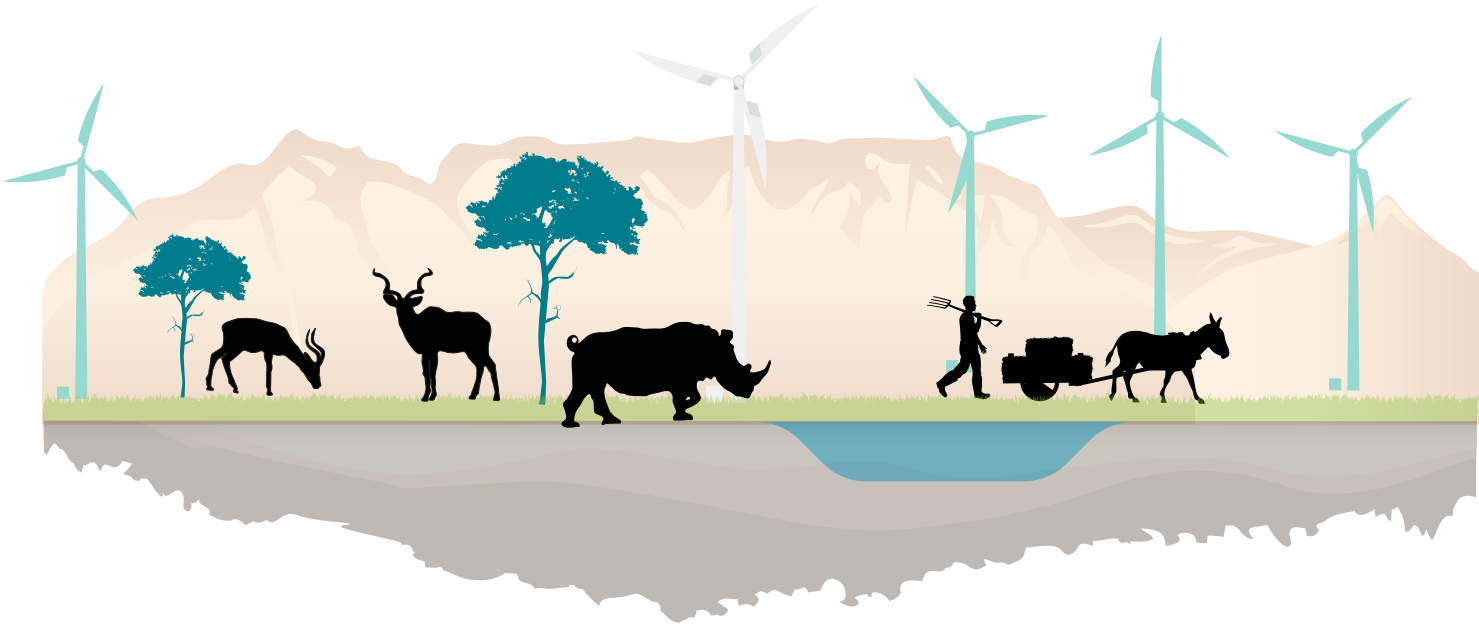
- Restoration of sub-tropical thicket, forests and woodlands.
- Restoration and management of grassland.
- Small-scale afforestation.
- Biomass energy.
- Anaerobic digesters.
- Reduced tillage.

12.2 INSTITUTIONAL READINESS ANALYSIS

The AFOLU institutional framework is based on a few key initial assumptions:

- To achieve its goals, the programme needs to have a clear policy direction and overall logic.
- The suggested framework should not start from scratch, but needs to build on current frameworks and initiatives already in place.
- Many of the AFOLU activities are not new to South Africa, and are already being performed by a number of different institutions. However, these lack an AFOLU focus, as they are currently driven by sectoral agendas. This puts the achievement of AFOLU goals in jeopardy.

- The establishment of new organisations is not currently feasible, given the current economic situation.
- While some complementary institutions or processes exist, they are currently either not fully functional, or have not been fully implemented. This challenge is faced across all sectors, but the proposed institutional framework is premised on the belief that these processes should be supported and strengthened. Consequently, this framework recommends working through existing channels, even where these are not operating at full capacity.
- Achieving the AFOLU agenda's goals will require the coordination and alignment of various departments and existing institutions.
- Successful implementation will require the support of different levels of government, including national, provincial and local.



12.3 CURRENT ANALYSIS OF **TIER 1** INSTITUTIONS

12.3.1 The context of the NDP and the Outcome Delivery Agreements

The National Development Plan (NDP) aims to ensure that all South Africans attain a decent standard of living through the reduction of inequality and the eventual elimination of poverty. The plan provides a common goal for the country to work towards, up until 2030, and identifies the steps that need to be taken and the roles that the various sectors of society need to play in reaching that goal. The 2014–2019 Medium Term Strategic Framework (MTSF)'s 5-year planning cycle identified ten strategic priority areas. Twelve key outcomes were developed, with accompanying outputs and strategic activities and metrics. These outcomes and the agreed implementation arrangements, as specified in the various delivery agreements, provide the basic building blocks for the AFOLU institutional framework.

Coordinating structures have been established to ensure that the key partners work together to achieve Delivery Agreement outputs. These structures are intended to coordinate the implementation of the outcomes, provide a reviewing progress, and facilitate decisions on interventions when required. The central outcome for the purposes of the AFOLU framework is Outcome 10, as described below.

OUTCOME 10: ENVIRONMENTAL ASSETS AND NATURAL RESOURCES THAT ARE WELL PROTECTED AND CONTINUALLY ENHANCED.

The lead department responsible for achieving Outcome 10 is the Department of Environmental Affairs (DEA), which is supported by other spheres of government (as management of the environment and protection of resources is a concurrent function) and other sector departments (Table 12.3).

Table 12.3: Outcome 10: Protect and Enhance our Environmental Assets and Natural Resources

SUB-OUTCOME 1: Ecosystems are sustained and natural resources are used efficiently

SUB-OUTCOMES & KEY RELATED ACTIONS	COORDINATING DEPARTMENTS	INDICATORS
Maintain or improve watershed services in key rural Strategic Water Source Areas	DWS, supported by DEA, DRDLR and DAFF	Number of significant, integrated water-related ecological infrastructure maintenance or improvement intervention
Integration of ecological infrastructure considerations into land-use planning and decision-making about new developments	DEA, Provincial departments, DRDLR, Local Government	Percentage of spatial development frameworks (SDF's) supported by a standard minimum environmental requirement
Combat land degradation	DAFF (Forestry areas) DEA (Working for programmes)	Hectares of land under rehabilitation/restoration

SUB-OUTCOME 2: An effective climate change mitigation and adaptation response

SUB-OUTCOMES & KEY RELATED ACTIONS	COORDINATING DEPARTMENTS	INDICATORS
Develop a Strategic Policy and Regulatory frameworks and programmes to promote a low carbon economy	Energy	Percentage of new build that is renewable power generation (to incorporate off-grid energy. Percentage of energy efficiency improvement
Develop and implement sector adaptation strategies/ plans	DWS, DAFF, DHS, Provincial departments, Local authorities	Number of adaptation plans completed
Undertake research in climate services	DST supported by DEA	Functional climate change research network formalised through MoUs.
	Environmental Affairs supported by South African Weather Services	National framework for climate services established
Monitor, report and verify sectoral carbon emissions	DEA	Framework for reporting on GHG emissions developed
	Energy	Biennial calorific value for all fuel carriers published

SUB-OUTCOME 3: An environmentally sustainable, low-carbon economy resulting from a well-managed just transition

SUB-OUTCOMES & KEY RELATED ACTIONS	COORDINATING DEPARTMENTS	INDICATORS
Promote a just transition to an environmentally sustainable economy	DEA, DST, and provincial departments	High impact environmental sustainability research
Progressively develop, compile, transparently & accessibility report on a set of sustainable development indicators and underlying natural resource emission indicators	DEA Economic & Social sector departments Provinces Public entities and state owned entities	Environmentally sustainable development performance indicators developed
Enhance environmental education; empowerment and job creation	DEA, Provincial departments and SANBI	Number of FTEs created Number of work opportunities created
Implement the Environment sector Skills plan to address capacity requirements	DEA, Provincial departments and SANBI	
Increase investment in research, development and innovation to support the transition to a green economy	DST, NT and DEA	Rand value of private and public investment in R&D to support a green economy

SUB-OUTCOME 4: Enhanced governance systems and capacity

SUB-OUTCOMES & KEY RELATED ACTIONS	COORDINATING DEPARTMENTS	INDICATORS
Enhance compliance monitoring and enforcements capacity within the sector	DEA Provincial department	Number of compliance inspections, enforcement actions undertaken for non-compliance
Less waste that is better managed	DEA Provincial departments Municipalities	

SUB-OUTCOME 5: Sustainable human communities

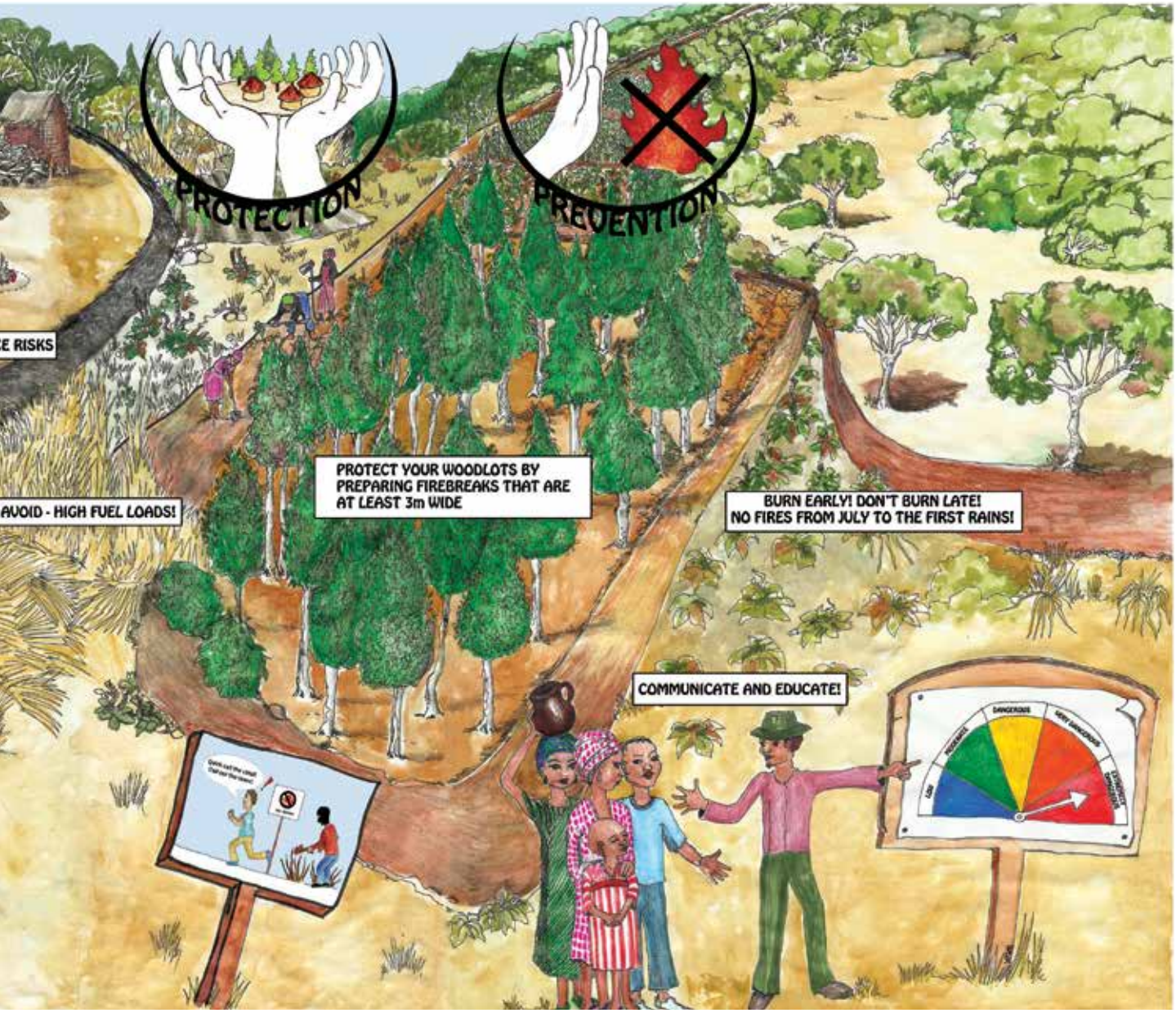
SUB-OUTCOMES & KEY RELATED ACTIONS	COORDINATING DEPARTMENTS	INDICATORS
Expand use of renewable energy through off-grid electrification	Energy	MW of renewable energy deployed off grid
Support and engage Local Government	DEA, Provincial departments	Implementation of the Local Government Support Strategy

Other implementation parties include: SALGA; Cities Network; SAWS; CSIR; WRC; ARC; SANBI; National Centre for Carbon Capture and Storage; National Energy Efficiency Agency (NEEA); SANParks; World Heritage Management authorities; and provincial conservation agencies.

One of the 6 impact indicators identified for Outcome 10 is Reduced total emissions of CO_2. The Minister of the DEA is responsible for reporting on this indicator on a national basis, and consequently, it makes sense for the DEA to assume overall responsibility for defining the metrics, baseline and information to be collected in support of AFOLU activities.

There are two other outcomes that provide complementary goals and programmes:

- **Outcome 4**: Decent employment through inclusive economic growth, aligned with the labour-intensive nature of many AFOLU activities.
- **Outcome 7**: Vibrant, equitable and sustainable rural communities with food security for all, with potential links between AFOLU activities and socioeconomic benefits in rural areas.



Ministers are to establish Implementation Forums for achieving each of these outcomes. These forums will draw up a Delivery Agreement between the Minister and all other parties – departments, agencies and levels of government – directly involved in the process of delivering and achieving outputs.

The Delivery Agreement will spell out who will do what, by when and with what resources. It will unpack each outcome and each output and the requirements to reach the targets. Aspects to be described in detail include the legislative and regulatory regime, the institutional environment, decision-making processes and rights, the resources needed, and the re-allocation of resources where appropriate. While many of these mechanisms may appear cumbersome, and will require significant coordination, remaining engaged with these processes is essential to reducing duplication, and maintaining awareness of related initiatives, and both complementary and competing agendas.

12.4 PROPOSED INSTITUTIONAL FRAMEWORK

12.4.1 Policy-level coordination

It is proposed that the National Outcomes and agreed Delivery Frameworks provide the top-down structure for the implementation of the AFOLU strategy. Matching of AFOLU activities to these activities and sub-outcomes will help to access available public sector funds, and provide an opportunity to mainstream AFOLU by making other sector departments aware of alignment where they might not previously have realised the full potential.

For the NDP and the Outcome 10 Delivery Agreements, the DEA is proposed as the primary lead department, supported by the other sector departments depending on the nature of the activity required. Table 12.4 provides an outline of the broad types of elements involved.

Supportive sector partners who can be engaged via the MINMEC and MINTEC forums include:

- DRDLR in terms of engaging with rural communities, including those in traditional communities.
- EDD in support of developing the green economy.
- DST to support research into new energy technologies.
- DAFF to support implementation of sustainable management of agricultural land.

12.4.2 Flexible implementation mechanisms

While Table 12.4, identifies departments responsible for policy development, reporting and coordination, the actual implementation mechanism requires a more flexible approach.
A strong national lead is required to provide national level MRV, and a strong policy logic. However, based on prior experience, successful AFOLU intervention programmes also require a strong local base and grounding to succeed over the longer term.

Table 12.4: Potential lead agencies for each required activity

AFOLU ACTIVITY TYPE	PROPOSED LEAD AGENCIES
Policy direction and champion for whole AFOLU sector	DEA
International reporting w.r.t international obligations	DEA
Climate change & GHG related research	DEA, DST, DAFF, DoE
MRV of AFOLU activities	DEA
Calculation of energy values from biofuels	DoE
Procurement of commercial scale energy from biogas	DoE (Integrated energy resource planning)
Measures affecting land-degradation and biodiversity	DEA
Measures affecting agricultural productivity	DAFF
Measures affecting water resources	DWS (currently NRM under DEA)
Measures affecting energy poverty	Local government (due to responsibility for achieving free basic energy), DoE
Landscape scale planning, to ensure alignment of sector priorities	Local and provincial government, through SDF's. Possibly Catchment Management Agencies

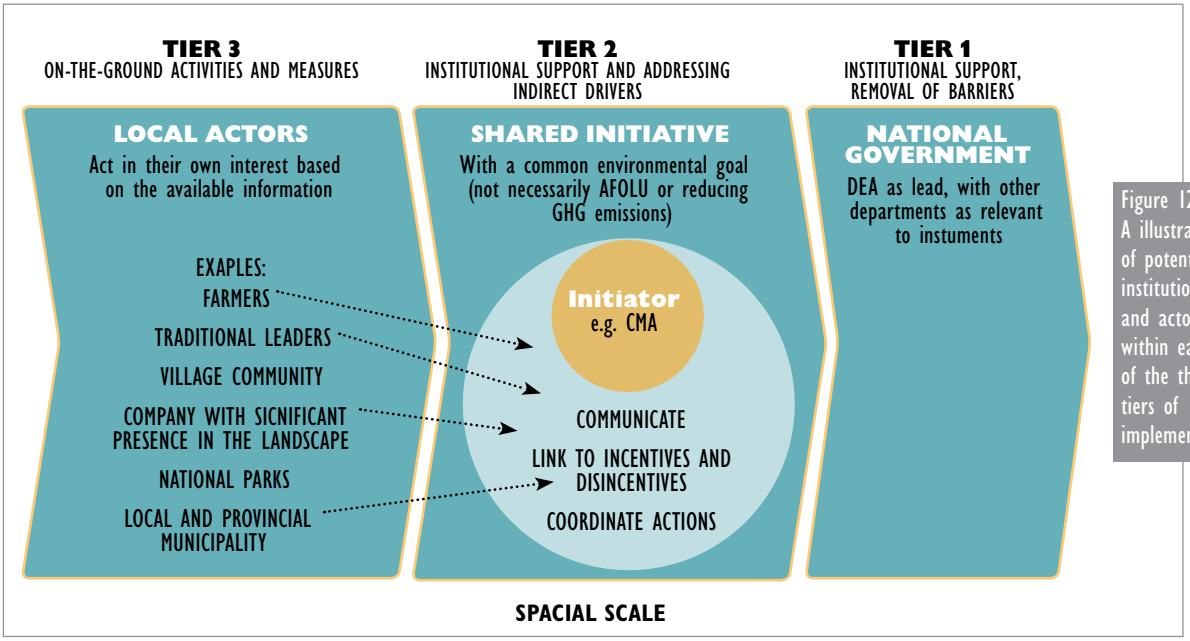


Figure 12.4: A illustration of potential institutions and actors within each of the three tiers of implementation

The 3 Tiers approach provides a flexible and responsive implementation framework. It does not require the establishment of any new institutions, but rather builds on established programmes and units as much as possible.

Tier 1 consists of the national departments that have primary responsibility for related outcomes, providing policy support as described in the previous section.

Tier 2 are sub-national-level initiatives which can oversee and guide on-the-ground implementation, reduce duplication, and identify and address indirect drivers of land degradation or deforestation. It is a core proposal of the AFOLU implementation framework that these initiatives be landscape based. Regional coordinating structures might include local authorities, CMAs, or provincial departments. These structures would be responsible for:

- Convening stakeholders (state and non-state).
- Sharing information on national law and policy.
- Facilitating landscape stakeholders' access to specific opportunities from Tier 1.
- Providing landscape-level communications (speaking with one voice as a stakeholder association: conducting research, polls, media campaigns).
- Building specific stakeholders' capacity to implement strategies (e.g. securing specific training for all farmers in an area).
- Negotiating, communicating, and managing conflict.

Tier 3 stakeholders are a variety of individuals, groups, NGOs and public entities with a stake in a local area. They might choose to participate in Tier 2 engagements, convened as described above. They are independent stakeholders that implement their own operations (government, private, civil society, community, etc.) in a way that responds to relevant law, policy, and incentives. They might not have a single, common reason for working together.

The goal of these initiatives should be to achieve some type of environmental goal that is complementary to the AFOLU goal, and not necessarily GHG reductions directly. It is important for any Tier 2 initiative to identify and accurately understand the interests and motivations of the main stakeholders in the landscape (Figure 12.4).

The choice of initiating stakeholder and the type of shared structure/ initiative will differ significantly from landscape to landscape, which is considered to be an inevitable part of mainstreaming, and the complex linkages that AFOLU activities have to the broader economy.

Most of these landscape-level associations/committees/networks are likely to focus on one strategy only (afforestation, land degradation, commercial energy generation, communal energy access), depending on the primary AFOLU problem in that landscape, and on what is currently driving the stakeholder actions affecting this outcome.

AN EXAMPLE OF WHAT A TIER 2, LANDSCAPE-BASED AFOLU ORGANISATION MIGHT LOOK LIKE

The uMngeni Ecological Infrastructure Partnership (UEIP) was formally established in 2001, with the signing of a Memorandum of Understanding (MoU) by key stakeholders from national, provincial and local government departments, business, academic institutions and civil society. The signatory partners committed to finding ways of integrating ecological infrastructure solutions to support built infrastructure investments in order to address challenges of water security in the uMngeni catchment area.

The partnership currently consists of over 20 organisations from national, provincial and local government departments, business, academic institutions and civil society; and is co-chaired by SANBI and eThekwini Metropolitan Municipality. SANBI has been the centre of coordination since the inception of the partnership. A appointed Programme Coordinator, Dr Pearl Gola, provides programme support and drives ecological infrastructure implementation.

The fundamental assumption is that each individual actor will respond according to its own particular interests, and that it will continue to do so. Consequently, the success of every Tier 3 activity depends on each actor considering the AFOLU activity as being in their own interest. For example, if the aim is to reduce the cutting down of trees, one strategy would be to make tree-felling illegal in certain areas. However, where the cut wood is being sold to generate an income , the prevention strategy is unlikely to succeed without costly law enforcement, resulting in greater hardship for the affected individuals in the community, and growing resentment.

In many cases the best strategy will simply be to maintain the affected actors' welfare at the same level (by providing EPWP employment in restoration activities), but in others there may be an opportunity to both meet the AFOLU goal, and develop plant nurseries for re-establishment).

12.4.3 Underlying rationale

The proposed institutional framework recognises the need for an adaptive structure that can be tailored to meet the needs of any particular community. A common goal is the best basis for local organisation, with established state institutions providing coordination support tailored to the specific intervention.

To achieve a specific environmental outcome such as a reduction in atmospheric GHG emissions from the AFOLU sector, stakeholders need only be invested in the intermediate or immediate results of the proposed intervention. A generic example of this logic is provided in Figure 12.5.

Figures 12.6 and 12.7 illustrate a key challenge and opportunity for the institutional framework. While the AFOLU logic must run through the whole project cycle, given its global implications, it does not always provide a strong motivational logic for most of the local stakeholders. There are many intermediate sector goals, which are aligned with the same outcomes, where specific sectors are best placed to take the lead.
Locally important issues such as water, energy, and rural development provide much stronger grounds for organisation at the local, Tier 3 level, than abstract issues of GHG emission reductions.

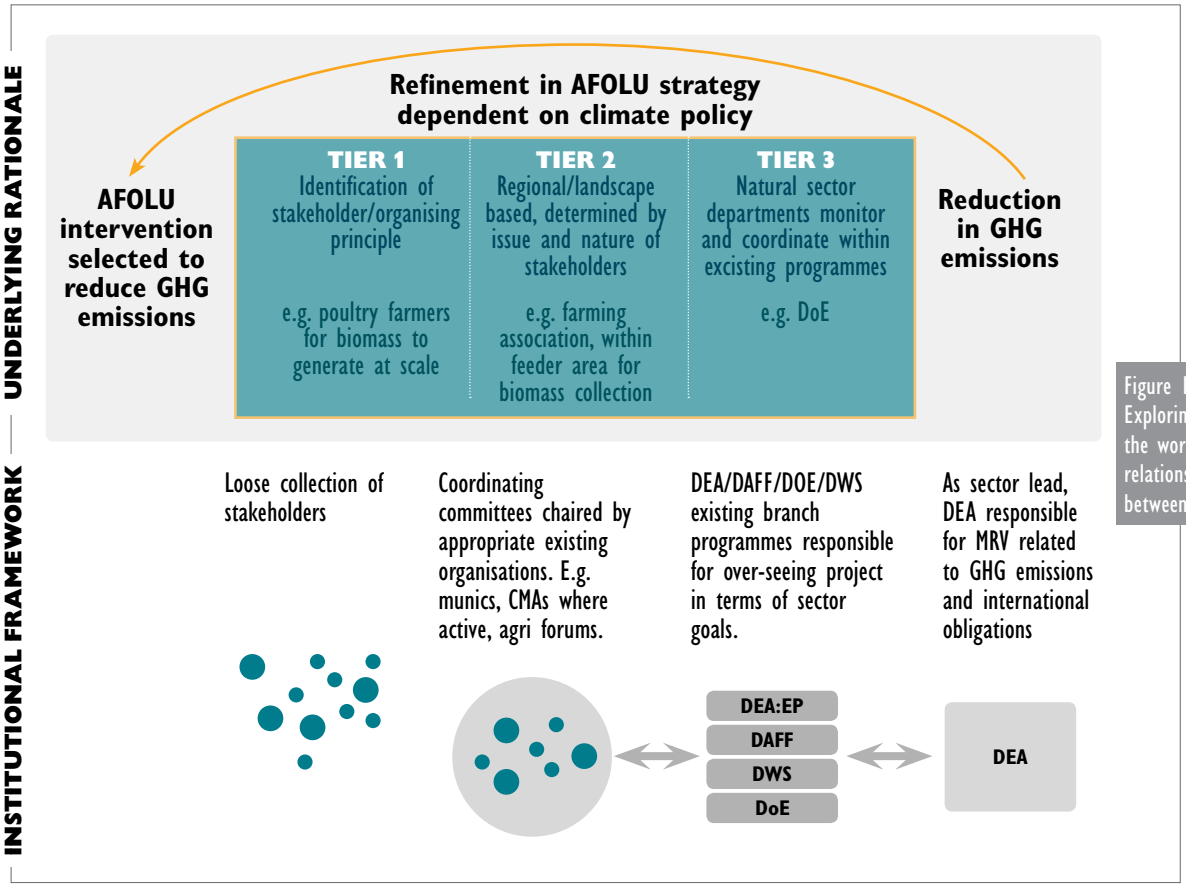


Figure 12.5: Exploring the working relationship between tiers.

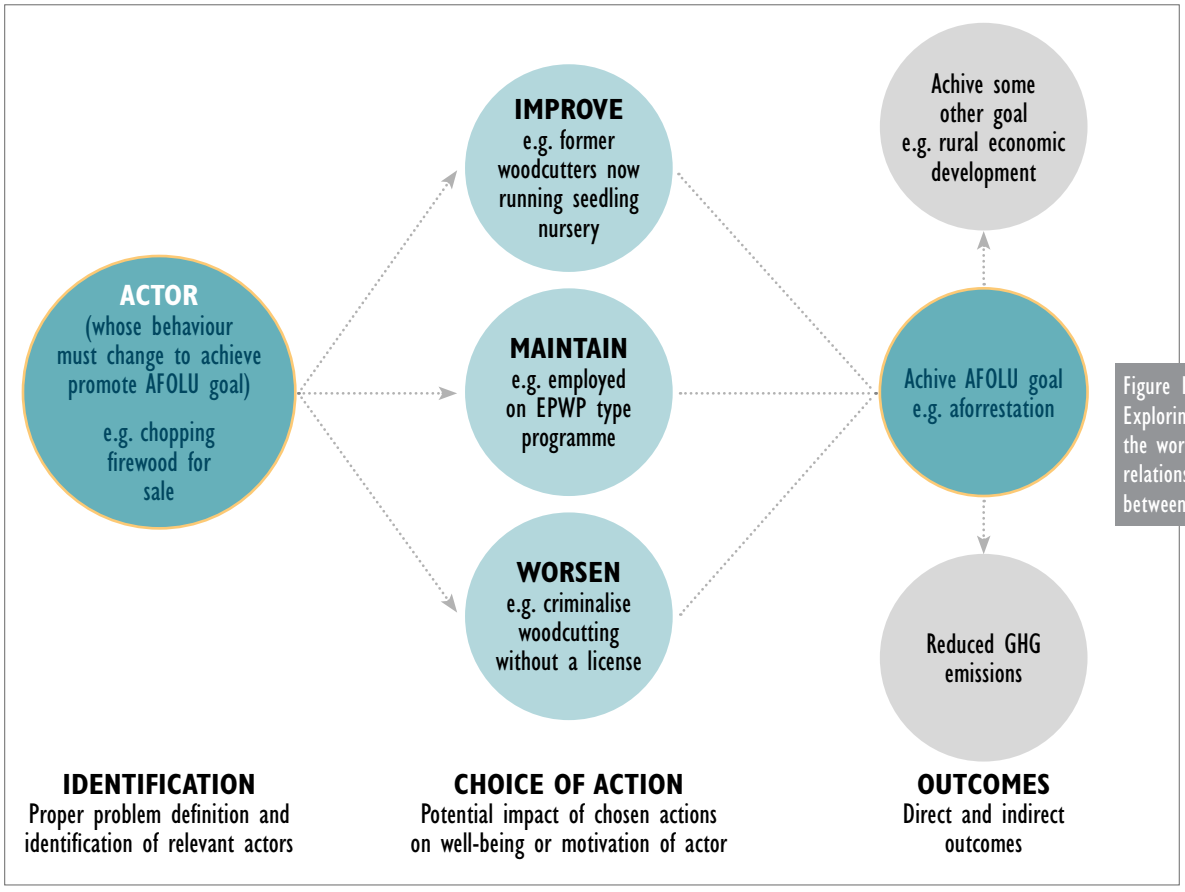


Figure 12.6: Exploring the working relationship between tiers

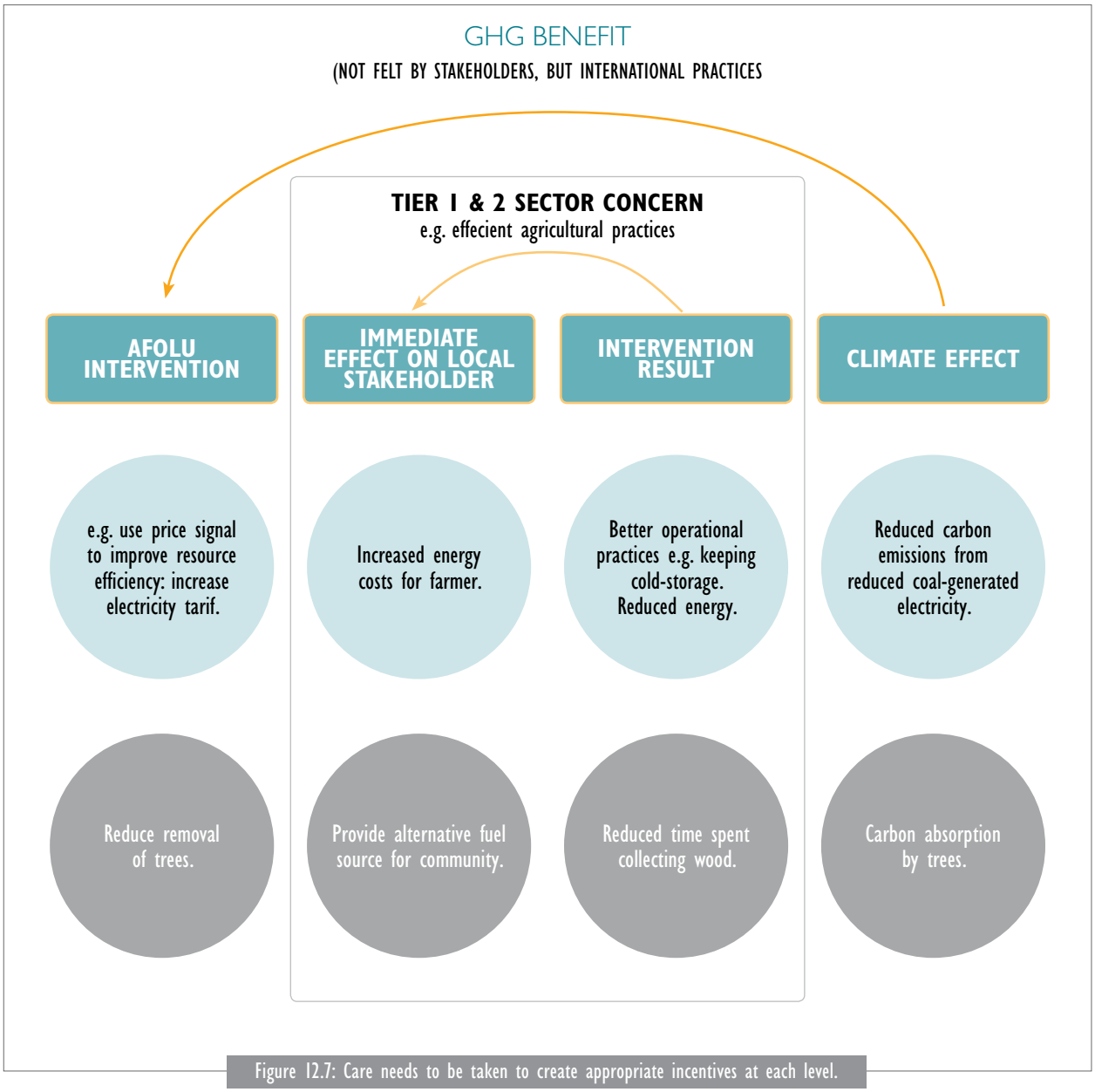


Figure 12.7: Care needs to be taken to create appropriate incentives at each level.

12.5 BOTTOM-UP INSTITUTIONAL FRAMEWORK

While the previous section laid out the national outcomes and key sector departments, a central element of the AFOLU institutional framework is the requirement for strong local engagement. However, the range of AFOLU activities is broad, and covers a wide range of possible actors.

Although local government in South Africa faces many challenges, and while it is not a substitute for civil society, it does have the following strengths:

- Understanding local concerns and priorities, as expressed in the Integrated Development Plan (IDP).
- Ability to provide formal structures for interacting with target communities, at least in the early stages of a project development.

Local government also has the following responsibilities and obligations:

- To develop a Spatial Development Framework.
- To prepare and implement adaptation and mitigation plans, and develop EPWP projects, making it a willing partner in many of these processes, particularly where there is a lack of local capacity.

However, local government boundaries can be a handicap for landscape-scale initiatives.

Possible actors, by AFOLU activity:

AFFORESTATION	GRASSLANDS	COMMERCIAL BIOGAS	COMMUNITY-SCALE BIOGAS/BIOMASS
• Landowners (public, private or communal) • Local government • Job seekers • Commercial forestry • Conservation agencies • Traditional leaders	• Landowners (public, private or communal) • Local & provincial government • Job seekers • Commercial farmers • Subsistence farmers • Traditional leaders • Agricultural extension workers • Conservation agencies	• DoE • ESKOM (i.t.o purchase agreements) • Renewable energy project developers • Local communities • Private companies/entities with useful biomass	• DRDLR, DoE, DEA • Local Government • Non-electrified communities • Remote communities/energy poverty

12.6 SUGGESTED IMPLEMENTATION FRAMEWORKS

NGO'S, LANDSCAPE SCALE ACTIVITIES, BOUNDARY MISMATCHES

Each of the AFOLU sectors are discussed in more detail below. Given the similarity in activities and stakeholders for afforestation and bush encroachment, these are dealt with together. Each section discusses possible arrangements for policy development, coordination, implementation, reporting on direct AFOLU activities, and MRV of the climate change related benefits of the activities.

12.6.1 Afforestation and Grasslands

POLICY DEVELOPMENT

DEA and DAFF are the key lead agents for policy development, with DAFF assuming the lead regarding activities related to agricultural activities (large-scale commercial, smallholder, or subsistence) and DEA assuming the lead for land which is not managed for agricultural purposes. DEA is sector lead in terms of employment opportunities generated under the EPWP programme, but both departments should be responsible for developing and maintaining the overall project logic.

COORDINATION

Coordination of activities will vary, but in all cases the DEA or DAFF provincial departments should be a key partner. Their primary role should be to ensure that programme guidelines around best-practices are shared among all relevant stakeholders, and that the key AFOLU objectives are not being compromised. Other key coordinating partners will vary depending on the basis of cooperation and the nature of the activity.

IMPLEMENTATION

Implementation may be carried out by a variety of private actions, EPWP implementing agents (municipal, provincial, or implementing agent), or NGOs.

	AFFORESTATION	GRASSLANDS/BUSH ENCROACHMENT
Directly relevant sub-outcomes	10.1: Ecosystems are sustained and natural resources used efficiently	
Supportive outcomes (with lead dept)	10.2: Effective climate change mitigation and adaptation response – DEA	10.2: Effective climate change mitigation and adaptation response – DEA
	10.3: Environmentally sustainable, low carbon economy (employment in environmental activities) – DEA	10.3: Environmentally sustainable, low carbon economy
	10.5: Sustainable human communities	10.5: Sustainable human communities
	4.5: Spatial imbalances in economic opportunities are addressed through expanded employment in agriculture – DAFF	
	4.9: Public employment schemes provide relief for the unemployed and build community solidarity and agency	4.9: Public employment schemes provide relief for the unemployed and build community solidarity and agency – DEA
	7.4: Improved employment opportunities and promotion of economic livelihoods in rural areas (DRDLR, DAFF)	7.4: Improved employment opportunities and promotion of economic livelihoods in rural areas (DRDLR, DAFF)
Lead Department per outcome	DAFF combat land degradation DEA ("Working for" programmes) DWS (Water resource protection, watershed services)	DEA "working for" programmes DAFF combat land degradation
Directly relevant unit if any	DAFF Prog 5: Forestry and NRM (explicitly works on land degradation & Outcome 10.1) Also Prog 2&4. Working for Forests Working for Ecosystems DEA Prog 6: Environmental Programmes DEA Land user incentive scheme People & Parks	DEA Prog 5: Biodiversity and Conservation DEA Prog 6: Environmental Programmes (NRM & EPIP) DEA Land user incentive scheme Working for Ecosystems Working for Land People & Parks
Other national departments	DRDLR, DWS	Tourism, DRDLR, DWS
Other relevant stakeholders/ groups	ARC, CSIR, commercial agriculture	SANBI, SANParks, provincial parks authorities, private landowners, CSIR, Traditional leaders

REPORTING ON DIRECT ACTIVITIES

Reporting on whichever direct sector activity is occurring will be required, and may be focused on non-AFOLU goals, such as job creation or agricultural productivity. This should be managed by the relevant sector department.

MONITORING, REPORTING AND VERIFICATION OF AFOLU BENEFITS

These activities are the specific mandate of the DEA.

DEA's Climate Change and Air Quality Branch (Chief Directorate -Climate Change Monitoring and Evaluation) is responsible for the MRV of GHG emission reduction activities, and should guide and inform the data collection process for this information.

There is also an opportunity to develop a specific on-the-ground monitoring EPWP programme as one of the environmental programmes, or 'working for' programmes.

	AFOLU MRV AND CLIMATE CHANGE POLICY
Directly relevant sub-outcomes	10.2 Effective climate change mitigation and adaptation response 10.4 Enhanced governance systems and capacity
Lead Department per outcome	DEA Climate change
Directly relevant unit if any	DEA Climate change and Air Quality Branch: Chief Directorate – Climate Change Monitoring and Evaluation
Other relevant stakeholders/groups	WWF, CSIR,

	COMMUNITY SCALE
Directly relevant Outcomes	10.1 Ecosystems are sustained and natural resources used efficiently 10.2 Effective climate change mitigation and adaptation response 10.3 Environmentally sustainable, low-carbon economy 6.2: Ensure reliable generation, distribution and transmission of electricity (DoE)
Supporting outcomes	10.5 Off-grid electrification – Energy 4.10: Investment in research, innovation and supporting the development of new industries. (led by DTI, supported by DoE and DAFF in this case) 4.2: Support green economy as a jobs driver – EDD 7.6: Growth of sustainable rural enterprises and industries (DTI and DoE?)
Lead Department per outcome	DOE for promotion of biogas/biomass production of commercial scale (above 1MW?) DAFF for assistance to agri-producers
Existing important programmes, branches and initiatives	DOE Programme 6: Clean energy To manage and facilitate the development and implementation of clean and renewable energy initiatives as well as EEDSM. (commercial scale projects)
Other national departments and involvement	**DAFF** has piloted a biogas production integrated crop-livestock system. **DAFF** also has an APAP (Agricultural Policy Action Plan). There is a sectoral intervention specifically around biofuels. **EDD:** Economic Planning and Coordination Programme. Green Economy sub-programme (jobs focus)
Other relevant stakeholders/groups	National Biogas Platform NERSA (registration of biogas projects)

12.6.2 Non-commercial biomass to energy

These projects are characterised as dispersed sources of energy, which generate less than 1MW of energy, or are not viable at a commercial scale. A useful approach for such projects is extending access to safe and sustainable energy services for poor households, particularly those in remote areas.

POLICY DEVELOPMENT

DoE and DEA are the sector leads with regard to policy development, with DoE taking the lead in terms of extending access to energy for poor communities. DoE should be responsible for the development of a programmatic approach to using biomass to generate safe, affordable energy sources for poor communities. The DEA and DST can assist from a piloting perspective to develop technologies suitable according to a programmatic approach.

IMPLEMENTATION

Local authorities are key implementation partners as they bear direct legislative responsibility for expanding access to energy services for all households in their jurisdiction. The Free Basic Alternative Energy policy may be of particular relevance here, as it is concerned with replacing unsafe and harmful fuel sources with safe, sustainable and affordable energy sources. Local government is also responsible for providing permission for any activities involving burning (in accordance with both public safety and air quality considerations).

REPORTING WITH REGARD TO ENERGY ACCESS, OR OTHER DIRECT PROJECT GOALS

Local government, the DoE and StatsSA are the primary channels for collecting information on household access to basic services. Programmes that target the paid collection of biomass would be suitable for EPWP funding, and would therefore fall under those existing reporting channels.

MONITORING, REPORTING AND VERIFICATION WITH REGARD TO AFOLU

DoE is responsible for determining the calorific values of fuel-sources. It should assist in the development of programmatic assumptions that may be used to assess the reductions in GHG emissions through the use of biomass to energy alternatives. This can be supported by 'Working for Energy' type teams that are trained to monitor and maintain the correct use of this technology to ensure that the emissions reductions goals are met.

12.6.3 Commercial-scale biomass to energy

Commercial scale biomass to energy has a highly developed institutional framework in place already, which will not be replicated in detail here. The scale of the project will influence the regulatory process required: Renewable energy IPPs wishing to generate electricity for sale into the national grid have to undergo the regulatory processes established under the Renewable Energy IPP process, and adhere to the requirements for environmental impact assessments, waste management licences, atmospheric emission licences, biodiversity authorisations, water use licences, and regulations regarding major hazard installations, Eskom grid connections and land-use planning. The regulatory process is outlined in Appendix A (p.226).

The regulation of small-scale embedded generation (entities that connect to the distribution system rather than the transmission system, less than 1MW) is under development, but is currently largely targeted at the roof-top solar market. However it does allow for generators of energy from biomass and biogas.

	COMMERCIAL SCALE
Directly relevant Outcomes	10.1 Ecosystems are sustained and natural resources used efficiently 10.2 Effective climate change mitigation and adaptation response 10.3 Environmentally sustainable, low carbon economy 6.2: ensure reliable generation, distrib & transmission of electricity (DoE)
Supporting outcomes	10.5 Off-grid electrification – Energy 4.10: Investment in research, and innovation… and supporting the development of new industries. (led by DTI, supported by DoE and DAFF in this case) 4.2: Support green economy as a jobs driver – EDD 7.6: Growth of sustainable rural enterprises and industries (DTI & DoE?)
Lead Department per outcome	DOE for promotion of Biogas/biomass production of commercial scale (above 1MW?) DAFF for assistance to agri-producers
Existing important programmes, branches & initiatives	DOE Programme 6: Clean Energy To manage and facilitate the development and implementation of clean and renewable energy initiatives as well as EEDSM. (commercial scale projects)
Other national departments & involvement	DAFF has piloted a biogas production integrated crop-livestock system. DAFF also has an APAP: Agricultural Policy Action Plan. There is a Sectoral Intervention specifically around Biofuels. EDD: Economic planning and Coordination Programme. Green Economy sub-programme (jobs focus)
Other relevant stakeholders/groups	National Biogas Platform NERSA (registration of biogas projects)

POLICY DEVELOPMENT

Aspects of the broad motivation for commercial scale biomass to energy:

- The policy goal of increasing the share of renewable energy, and the targets for renewable energy set in the national Integrated Energy Plan (still in development) and the Integrated Resource Plan, both the responsibility of the DoE.
- The development of a commercially viable project.

COORDINATION

The IPP Procurement programme and the DoE are responsible for the setting of renewable energy targets, and the procurement of that energy from Independent Power Producers (IPPs). The generation capacity allocated in the IPP Procurement Programme to biomass amounts to 210 MW, and 110 MW to biogas. Small IPP projects are classified as those between 1 MW and 5 MW, and are governed under a sub-component of the broader Renewable IPP programme

IMPLEMENTATION

Implementation will be carried out by private energy developers. The biogas industry is South Africa is already represented on the National Biogas Platform (Figure 12.8). The objectives of the 2nd National Biogas Conference, held in 2015, were to formulate the position of the DoE with respect to biogas industry development, get an update on current barriers faced by developers, and develop tangible biogas-related outputs for particular sectors such as rural areas, agriculture, abattoirs, applied research, and transport.

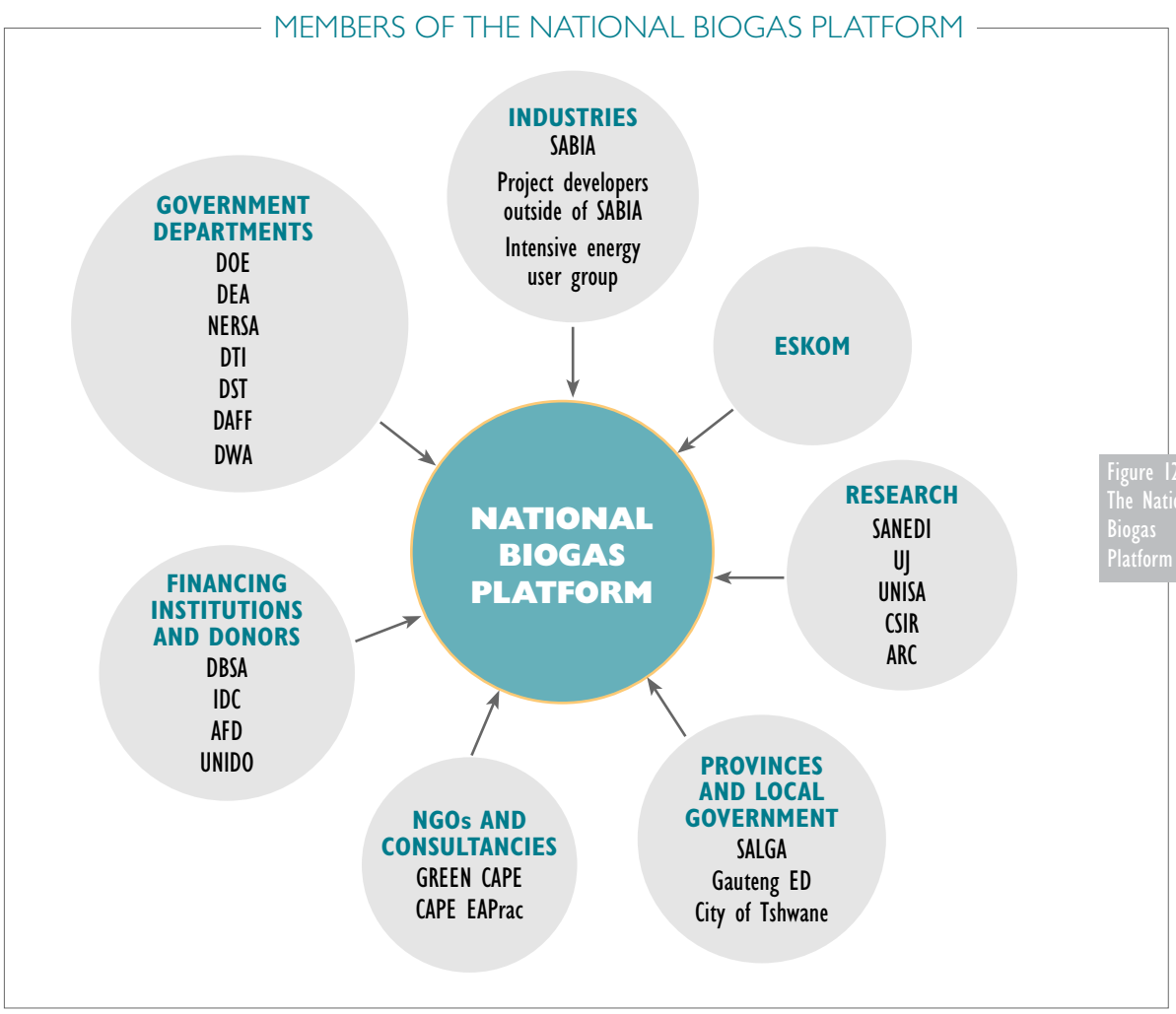


Figure 12.8: The National Biogas Platform

REGULATION OF SMALL-SCALE RENEWABLE ENERGY PROJECTS

NERSA is responsible for the regulation of IPPs, and varies the reporting requirements according to the type/scale of entity.

MONITORING, REPORTING AND VERIFICATION WITH REGARD TO GHG EMISSIONS

These tasks remain the same as in previous sections, with the DEA assuming responsibility through the National Greenhouse Gas Inventory. The National Atmospheric Emissions Inventory System/National GHG reporting regulations. Currently the department reports only on projects with over 10 MW capacity.

12.7 GAP IDENTIFICATION

Much of the institutional framework for AFOLU activities is already in place, with a few key exceptions. These include:

- The lack of a clear institutional home for coordination and tracking of activities at a landscape scale.
- The Catchments Management Agency described in the National Water Act of 1998 provides one interesting prospect which should be investigated further, given the proven links between land-use management and water resources. However the implementation of CMAs to date remains poor, and the scope of CMAs has been limited primarily to water licensing and compliance activities. Investigation into a possible expansion of their role to coordinate or at least track land-use activities in their jurisdiction would be of value to several sectors that depend on landscape scale, rather than provincial or municipal boundaries.
- A catchment management strategy must set principles for allocating water to existing and prospective users, "taking into account all matters relevant to the protection, use, development, conservation, management and control of water resources." For example, Part 4 of the NWA states: "The person who owns, controls, occupies or uses the land in question is responsible for taking measures to prevent pollution of water resources. If these measures are not taken, the catchment management agency concerned may itself do whatever is necessary to prevent the pollution or remedy its effects, and recover all reasonable costs from the persons responsible for the pollution." There is an important connection between water pollution from agricultural sources, and opportunities for bio-energy.
- Confirmation of the difference between communal, not for profit, energy generation aimed at meeting basic energy needs of communities is lacking.
- MRV for capturing small-scale energy projects, below 1 MW, is not currently happening. There may be scope for the development of a programmatic approach, to enable the use of generic factors, rather than costly MRV requirements, which may act as a deterrent to small generators.
- A 'Working for Data' programme could add value not only to the AFOLU sector, but to other stakeholders such as DWS (water readings), the research community, the weather community, and agricultural stakeholders. The creation of a new EPWP Environmental Programme for data-collection, which trains and employs workers to take field observations, and check on correct usage of installations (non-commercial) and practices, is a possibility.

12.8 SUMMARY OF CURRENT AND RELEVANT GOVERNMENT PROGRAMMES

At its simplest, AFOLU and its related GHG reduction activities are clearly a DEA function, and this ownership drives the overall project design and tracking. However, the current underlying institutional framework regarding AFOLU activities, stakeholders and agendas is complex, once all the different dimensions are taken into account. These include:

- Energy services (commercial generation and access to basic energy services for poor households).
- Sustainable land management practices (subsistence and commercial, conservation and production) under varying forms of tenure (public, communal and private).
- Economic development (encompassing energy security, innovation, rural livelihoods, and unemployment).

A variety of different government stakeholders are involved, depending on the specific issue under consideration. The various affected departments and their related focus areas include:

- DEA: biodiversity and conservation, air quality management, climate change policy, sustainable resource use.
- DAFF: agriculture (subsistence and commercial), sustainable land use practices.
- DWS: protection of water resources, watersheds key rural strategic water source areas.
- DOE: energy generation, distribution and transmission, energy access for the poor, renewable energy generation.
- DRDLR: spatial planning, rural development and land reform.
- DCOG and local government: energy services in rural settlements.
- DTI: energy prices, new economic opportunities.
- EDD: Green Economy.
- DST: Innovation.
- Tourism: employment, conservation.

Given this institutional complexity, and the 'remoteness' of the GHG reduction goal, it would be advantageous, generally, to have the various sector departments head-up the related initiatives. However, to maintain the overall logic, it is essential that DEA staff have oversight of the entire chain of activities from an MRV perspective and to enable reporting on international obligations. The challenge will be to ensure that DEA staff allow their sector colleagues sufficient leeway to meet their own sector goals, while still retaining enough influence to meet the GHG reduction targets.

12.8.1 Current institutional arrangements for biogas & biomass activities

OUTCOMES	BIOGAS & BIOMASS		AFOLU MRV AND CLIMATE CHANGE POLICY
	COMMERCIAL SCALE	COMMUNITY SCALE	
Directly relevant Outcomes	10.1 Ecosystems are sustained and natural resources used efficiently 10.2 Effective climate change mitigation and adaptation response 10.3 Environmentally sustainable, low carbon economy 6.2 ensure reliable generation, distribution & transmission of electricity (DoE)	10.1 Ecosystems are sustained and natural resources used efficiently 10.2 Effective climate change mitigation and adaptation response 10.3 Environmentally sustainable, low carbon economy	10.2: Reduced GHG emissions, climate change impacts and improved air quality
Supporting outcomes	10.5 Off-grid electrification – Energy 4.10 Investment in research, and innovation… and supporting the development of new industries. (led by DTI, supported by DoE and DAFF in this case) 4.2 Support green economy as a jobs driver – EDD 7.6 Growth of sustainable rural enterprises and industries (DTI & DoE?)	10.5 Sustainable communities & off-grid electrification 7 Vibrant, equitable and sustainable rural communities and food security for all 7.4 Smallholder production efficiencies – DAFF 7.5 Increased access to quality infrastructure and functional services, (incl energy – DoE, supported by DRDLR) Also Integrated Energy Centres (IECs) establishment in rural areas (DoE, supported by Local Govt) 4.9 Public employment schemes provide relief for the unemployed and build community solidarity and agency (DEA is the sector lead) 4.5 Smallholder production (DAFF is lead, supported by DRDLR) 8.2 Improving access to basic services (human settlements) 9.1 SUSTAINABLE AND RELIABLE ACCESS TO BASIC SERVICES	10.2 MRV: DoE responsible for biennial publication of the calorific value for all energy carriers Providing annual energy balances to support compilation of the GHG inventory
Lead Department per outcome	DOE for promotion of Biogas/biomass production of commercial scale (above 1MW?) DAFF for assistance to agri-producers	DOE energy access, supported by DRDLR and Local government DRDLR is the sector lead with respect to rural development/Outcome 7.	DEA
Existing important programmes, branches & initiatives	DOE Programme 6: Clean Energy To manage and facilitate the development and implementation of clean and renewable energy initiatives as well as EEDSM. (commercial scale projects)	Department of Energy (DoE) Programme 4: Electrification and Energy Programme and Project Management To manage, coordinate and monitor programmes and projects focused on access to energy. (relevant to small scale, non-commercial projects) DOE Community Upliftment Programmes & Projects Sanedi: Working for Energy EPWP	10.2 MRV: DoE responsible for biennial publication of the calorific value for all energy carriers Providing annual energy balances to support compilation of the GHG inventory
Other national departments & involvement	DAFF has piloted a biogas production integrated crop-livestock system. DAFF also has an APAP: Agricultural Policy Action Plan. There is a Sectoral Intervention specifically around Biofuels. EDD: Economic planning and Coordination Programme. Green Economy sub-programme (jobs focus)	DEA has a Biomass Energy programme	
Other relevant stakeholders/groups	National Biogas Platform NERSA (registration of biogas projects)		

12.8.2 Existing mechanisms that might aid tracking?

Under Outcome 10.2, the departments of Water and Sanitation, Agriculture, Forestry and Fisheries, Human Settlements, and provincial departments including local authorities are responsible for the development and implementation of sector adaptation strategies/plans.

These would provide a possible mechanism for tracking and reporting on AFOLU activities, but would require support to provide the correct information.

12.9 CURRENT GAPS IDENTIFIED IN THE INSTITUTIONAL CONTEXT

The current institutional framework is already clear for the following Tier 1 components:

- National strategy and co-ordination: DEA has been tasked and this current initiative is a key contribution to its development.
- Establishment of finance and funding with international parties: DEA is currently dealing with this, DoE hosts the CDM Designated National Authority.
- National MRV administration and alignment with M&E program: DEA for first part, unclear on 2nd part?
- Policy alignment and advocacy: this appears to be the main gap and challenge.

The current gap is ensuring that the AFOLU logic is maintained through the project chain. What capacity is there in provincial departments to track and monitor AFOLU projects implemented by other sector departments, with DEA/provincial staff engaging to ensure complementary GHG goals are achieved?

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FOOTNOTES

1 NERSA Consultation Paper, Cogeneration Regulatory Rules and Feed-In Tariffs. 2011

2 Works closely with GIZ

3 Managed by a cross-departmental project team from the Department for International Development (DfID), the Department of Energy and Climate Change (DECC), the Finance Ministry, The Department for Environment, Food and Rural Affairs (DEFRA), and the Foreign and Commonwealth Office (FCO) (CFU, 2016)

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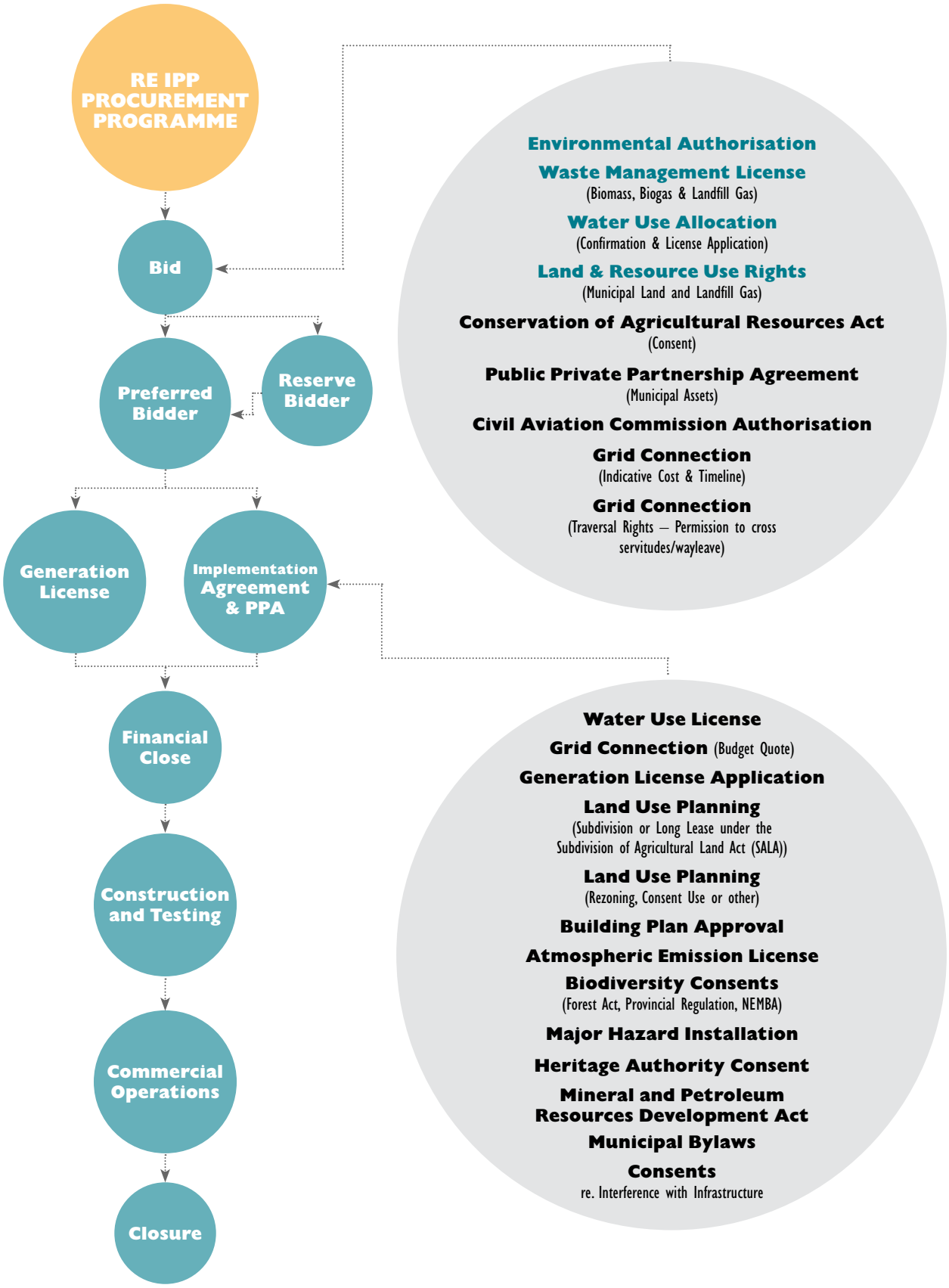
ANNEXURE

ANNEX A – RFP REGULATORY REQUIREMENTS



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