South African National Carbon Sink Assessment:

Phase II: understanding potential climate change mitigation opportunities

section TWO

Contents

Acronyms

AFOLU	Agriculture, Forestry and Other Land Use
CARA	Conservation of Agricultural Resources Act
CCBA	Climate, Community and Biodiversity Alliance Standard
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CO2	Carbon dioxide
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
DFID	Department for International Development
DRDLR	Department of Rural Development and Land Reform
EIA	Environmental Impact Assessment
EPWP	Expanded Public Works Program
ha	Hectare
IAP	Invasive Alien Plants
IDP	Integrated Development Plan
IRP	Integrated Resource Plan
MRV	Monitoring, Reporting and Verification
MWe	Megawatt electrical
MWh	Megawatt hour
NAMA	Nationally Appropriate Mitigation Actions
NCCRP	National Climate Change Response White Paper
NEMA	National Environmental Management Act
NFA	National Forests Act
NFU	National Facilitation Unit

NGO	Non-Governmental Organization
NPV	Net Present Value
PoA	Program of Activities
REDD	Reduced emissions from deforestation and forest degradation (through planning and regulation)
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
RRG	Rhodes Research Restoration Group
SANBI	South African National Biodiversity Institute
SANParks	South African National Parks
SMEs	Small and medium enterprises
SPLUMA	The Spatial Planning and Land-Use Act
tC	ton of carbon
tCER	Temporary Certified Emission Reduction
tCO2e	Ton of carbon dioxide equivalent
TOR	Terms of Reference
UMDM	uMgungundlovu District Municipality
UNFCCC	United Nations Framework Convention on Climate Change
UNREDD	United Nations program aimed at REDD
VCS	Verified Carbon Standard
VCU	Verified Carbon Units
WESSA	Wildlife and Environment Society of South Africa

Introduction

Research objective

The approach for this section was to conduct an assessment of the size and nature of the land based climate change mitigation. Consequently the following objectives were pursued.

Section 2 has five objectives:

- To identify the principal land-use based climate change mitigation opportunities in South Africa
- To understand the nature of implementation in terms of required capacity and the institutional and financial context of potential implementing agents
- To better understand the magnitude and structure of implementation costs
- To understand the co-benefits and trade-offs and co-benefits implementation, particularly employment opportunities and the effect of implementation on ecosystem services
- To identify clear roadblocks to implementation that could be addressed by Government in the near term Understanding the dynamics of field-based practitioners and their ability to implement projects, the economic contribution of land-use based climate change mitigation opportunities, and the potential for job creation, trade-offs, benefits and challenges particular to each of the principal implementation opportunities identified over the course of the team's research.

The Assessment stems from needs identified in the *National Climate Change Response White Paper* (NCCRP), particularly the identification of climate change mitigation activities that increase the size of the national terrestrial carbon sink and deliver sustainable benefits as captured in section six of the National Climate Change Response Policy (NCCRP).

The approach to the analysis

The study was designed to move beyond a broad general overview of implementation options, to a specific consideration of the magnitude and nature of all land-use based mitigation activities in South Africa. The rationale for this approach is driven by Government's mandate to implement appropriate mitigation activities at scale across the country. The first step towards meeting this mandate is an explicit exploration of each potential land-use based mitigation activity (beyond only afforestation and REDD+), including careful consideration of the nature of implementation – the context of implementing agents, required management, field and monitoring capacity, required institutional support, payment and incentive mechanisms, necessary supporting policy, and implication of different implementation models on job creation, permanence and sustainability over the long-term.

The concept of land-use based climate change mitigation is certainly not new in South Africa. Several parties located in the public and private sectors have extensive experience in implementing climate change mitigation and adaptation options. Moreover, substantial expertise exists in the development of related ecosystem service and ecological infrastructure activities. In addition to populating the analysis with data from published datasets, publications and established models, the team attempted to leverage the rich body of established expertise and experience in South Africa through a number of structure interviews with leading parties.

Eighteen interviews, typically lasting 3-4 hours, were held with the individuals listed in the table below. Individuals were primarily chosen based on robust experience in implementing or designing climate change mitigation in South Africa. In addition to prominent field practitioners, members of Treasury and the national monitoring, reporting and verification (MRV) group where interviewed to better understand how to align suggested implementation measures and structures with existing Government programs.

The Cirrus Group, Beatus and Mr. Barney Kgope and Mr. Itchell Guiney of the Department of Environmental Affairs conducted the interviews. Where in-person meetings were not feasible, interviews were conducted telephonically.

Participant	Entity	Location
National Government		
Peter Lukey	Department of Environmental Affairs	Pretoria
Sebataolo Rahlao, Oscar Mokotedi	Department of Environmental Affairs	Pretoria
Peter Janoska	National Treasury	Pretoria
Guy Midgley, Mandy Barnett, Mandy Driver and Jeff Manual	SANBI	Cape Town
Field practitioners (in Government, private and NGO sectors)		
Mike Powell	Subtropical Thicket Restoration Research Group at Rhodes University	Grahamstown
Bruce Taplin	SANParks	Addo National Park
Sarshen Scorgie	Conservation South Africa	Cape Town
Andrew Venter, Andrew Whitley and the Wildlands team	Wildlands Conservation Trust	Hilton
Ian Rushworth and Steve McKean	KZN Wildlife	Howick
Marilyn Govender	South African Sugar Association	Pietermartizburg
David Everard, Nico Hattingh, and Dutliff Smith	SAPPI	Pietermartizburg
Alan Manson and Cobus Botha	CEDARA	Hilton
Riaz Jogiat	uMgungundlovu District Municipality	Pietermartizburg
Christo Marais and Ahmed Khan	Expanded Public Works Program	Cape Town
Errol Douwes, Sean O'Donoghue	eThekwini Municipality	eThekwini

The interviews focused on understanding:

- The full suite of potential land-use based climate change mitigation activities in South Africa
- The true opportunity for implementation – why have certain initiatives succeeded and others failed?
- Existing implementation models – organizational structures, required capacity, skill-sets and logistics
- Human-resource requirements, in particular the opportunity to create employment and skill-development opportunity in rural areas
- The context of implementation – the land-tenure, social, educational and economic context
- Inhibitory factors limiting initial implementation or roll-out at scale
- The opportunity for partnerships between the public, private and non-profit sectors to facilitate implementation
- Monitoring, reporting and verification requirements and the potential to reduce MRV costs through national scale support and innovative monitoring techniques
- The magnitude and structure of development, implementation and monitoring costs
- The nature of existing funding and finance, incentive mechanisms and payment structures
- Required institutional support and other forms of assistance required to scale-up implementation
- Potential alignment between government programs focusing on climate change mitigation and adaptation as well as ecosystem services and ecological infrastructure more broadly

Report structure

The report is composed of six sections. First we broadly introduce South Africa land-use domain and the eight principal climate change mitigation opportunities that were identified during the course of the stakeholder engagement and supporting analyses. in South Africa. Thereafter, the eight options are compared in terms of their magnitude, readiness to implement, and their potential contribution to national social welfare and ecological infrastructure goals. Thereafter, the nature of each activity is considered in detail. The report is concluded with a potential strategy going forward, that includes the development of a potential National Facilitation Unit (NFU).

2. The nature of terrestrial carbon stocks in South Africa

The set of climate change mitigation activities in Section 5 were informed by the particular nature of the land-use sector in South Africa. In comparison to other countries in sub-Saharan Africa, where the emphasis is on avoiding deforestation (i.e. REDD+), South Africa has limited forest cover and the main conversion of indigenous landscapes has already occurred during the 1960s and 70s. Whereas there is certainly still scope for activities that avoid deforestation and landscape degradation, there is significant opportunity to sequestrate carbon through the restoration of grasslands and thicket, as well as to reduce emissions through energy related projects in the established agricultural sector. Here, we briefly introduce the biophysical, socio-economic and historical nature of land-use in the country.

The biophysical template – the nature of terrestrial carbon stocks

South Africa is a relatively dry country where most areas receive less than 650mm of rainfall per year. Certain pockets along the eastern seaboard may receive over 1000mm annual but in general, South Africa is a fairly arid country. This is reflected in magnitude and distribution of carbon stocks across the country, which is principally determined by annual rainfall, soil type and temperature (Fig 1).

Phase 1 of the National Carbon Sink Assessment focused on understanding the distribution of carbon stocks across the country and provided the first maps of terrestrial carbon stocks at a national scale. As expected, the areas with the highest carbon stocks per hectare are the coastal forests, followed by moist savanna and thicket systems, and then the drier areas of the northern Cape, western Free State

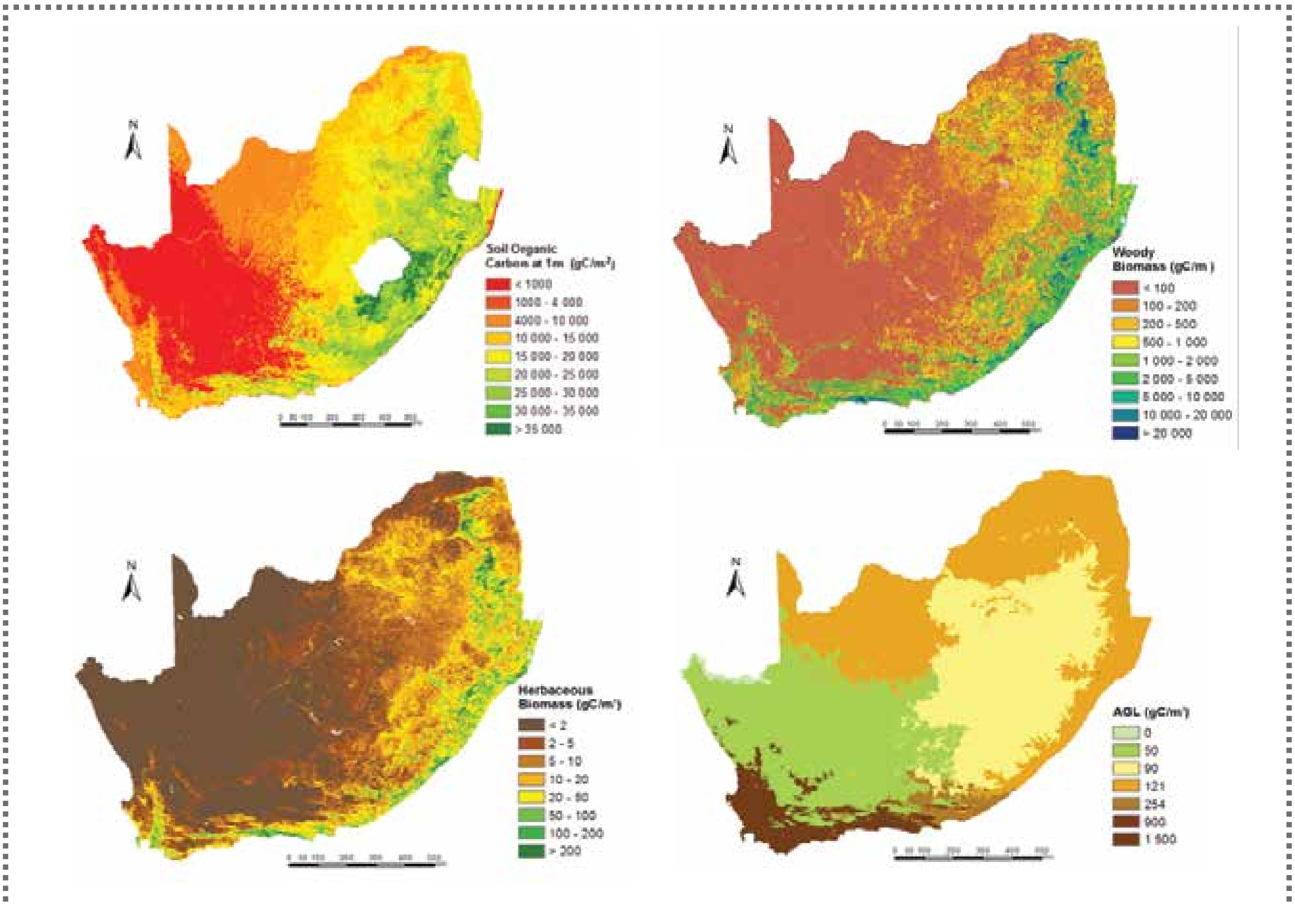

__Figure 1.__ The components of the terrestrial carbon stock of South Africa. Top left: soil organic carbon to 1m in depth. Top right: the above- and below-ground woody-plant biomass pool Lower left: above- and below-ground herbaceous biomass pool. Lower right: aboveground litter - AGL (Scholes et al. 2013)

and North-West Province (Fig 1). Less expected were the estimates of the proportion of the national terrestrial carbon stock that is located in each biome or land-cover type (Fig 2).

Approximately 30% of the national terrestrial carbon stock is located in grassland ecosystems and a slightly lower amount in the savanna biome (Scholes et al. 2013). In comparison, less than 5% of the national carbon stock is located in indigenous forest and sub-tropical thicket. This result is primarily due to the spatial extent of each land-cover type (Fig 2).

Furthermore, of particular interest in terms of developing national implementation options, is that over 90% of carbon stocks within the grassland and savanna biomes are located in the belowground soil organic carbon pool. Although this is largest terrestrial pool of carbon in the country, little priority has been placed on it, due to the historical emphasis on forests and REDD+. These results suggest that a better balance of effort is required between grassland, savanna and forest ecosystems. Whereas, restoration efforts and current progress with sub-thicket and forest biomes should not be curtailed, equal effort should be placed on maintaining belowground carbon stocks in grassland and savanna ecosystems.

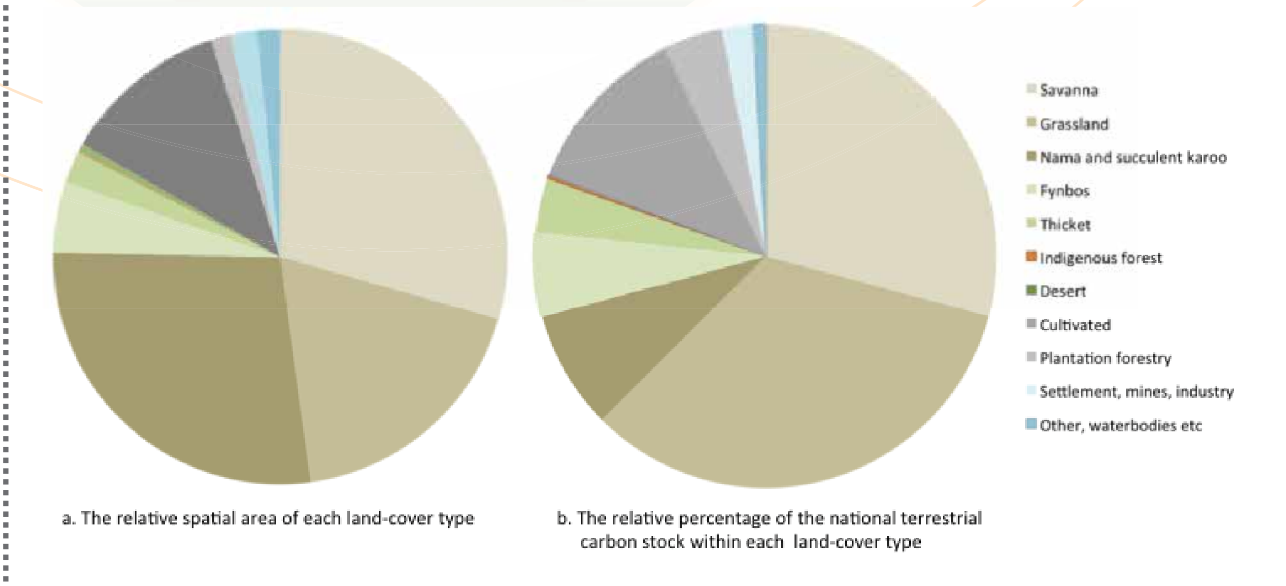

Figure 2. *The relative contribution of each of the principle land-cover types in South Africa in terms of (a) spatial area and (b) terrestrial carbon stocks (input data from Scholes et al. 2013)*

Socio-economic template – the need for broader inclusivity

Starting with the 1913 Land Act, successive laws and legislation determined that black South Africans were relegated to racially segregated “Bantustans”, “homelands” or “native reserves”. In these areas, land was communally owned and due to immense population pressures, was soon marked by overgrazing, soil erosion and poor soil fertility. During apartheid, these conditions were exacerbated by various “Betterment” schemes, which concentrated residence and centralized grazing- with disastrous ecological consequences (Bundy 1989).

While a democratically elected government started overturning racialised land legislation in 1994, South Africa still struggles with the legacies of land-use policies initiated during the colonial and apartheid eras. The country is marked by deep inequalities that still need to be addressed. In particular, a substantial section of the country’s poor, rural population still live on the most degraded land and have little access to capital, information or the carbon market.

Whereas comprehensive and robust project development, monitoring and reporting frameworks have been created under the Clean Development Mechanism (CDM) and Verified Carbon Standard (VCS), they inherently assume that the implementing agent is well resourced and has access to capital and markets. If implementation is to occur in degraded areas within homelands and other area communal land-tenure, alternative implementation and monitoring models need to be created. While opportunities within the established commercial sector need to be realized, they should be balanced with a national program that facilitates projects in communal areas at the same time. This is particularly pertinent in a period when previously disadvantaged communities are obtaining access to land and where clear incentives for climate change mitigation and broader ecosystem management could ensure the sustainable management of ecological infrastructure over the long term.

3. What are the principle land-use based opportunities in South Africa?

The type and magnitude of climate change mitigation opportunities

Eight prominent land-use based climate change mitigation activities were identified (Table 1, Fig. 3, 4). These include both activities that increase and sustain the size of the national terrestrial carbon stock (reducing tillage, applying biochar, and the restoration and management of grasslands, subtropical thicket, woodlands and forests) as well as activities that lead to a net decrease in GHG emissions (biomass to energy and anaerobic biogas digesters). *Each is described in detail in the 'Considering each activity' section below.*

Two estimations of each activity's contribution to reducing atmospheric GHGs are provided. The first "minimum" estimate is a robust, conservative estimate of the potential scope of the activity. However, certain stakeholders thought that these estimates may be too low and therefore an additional 20% has been added to this initial estimate in separate column to provide a range for planning purposes.

A total mitigation potential of between 14,1 and 16,9 million tCO_2e can be expected from the activities combined. Biogas has the largest potential (considering farm manure only, i.e. excluding household biogas digesters), followed by sub-tropical thicket and forest restoration, and then the restoration and management of grassland systems. In addition, the generation of energy through the combustion of bagasse and wood sourced from invasive alien species can also form a significant contribution. The activities' contribution in both absolute and relative terms is indicated in Figure 3 and 4.

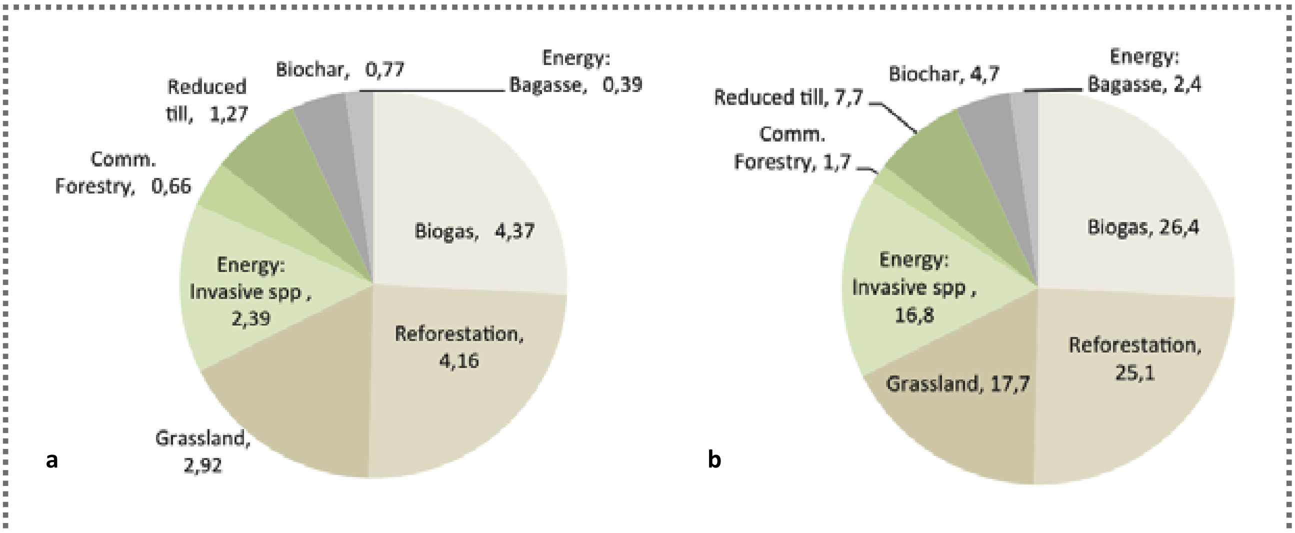

Figure 3. *Individual contribution of the various terrestrial activities towards carbon sequestration and mitigation in million tonnes of CO_2e (panel a) and in percentage contribution (panel b)*

The combined potential of all the activities are shown in Figure 4. A non-linear ramp-up or implementation period for each of the activities is assumed over various terms and indicated in the notes to Table 1. This implementation period explains the shape of Figure 4. It should be noted that different implementation periods are assumed varying from 5 years (for commercial plantation forestry), to 20 years (for the energy options). The assumed implementation period for restoration-related activities varies between 10 and 15 years.

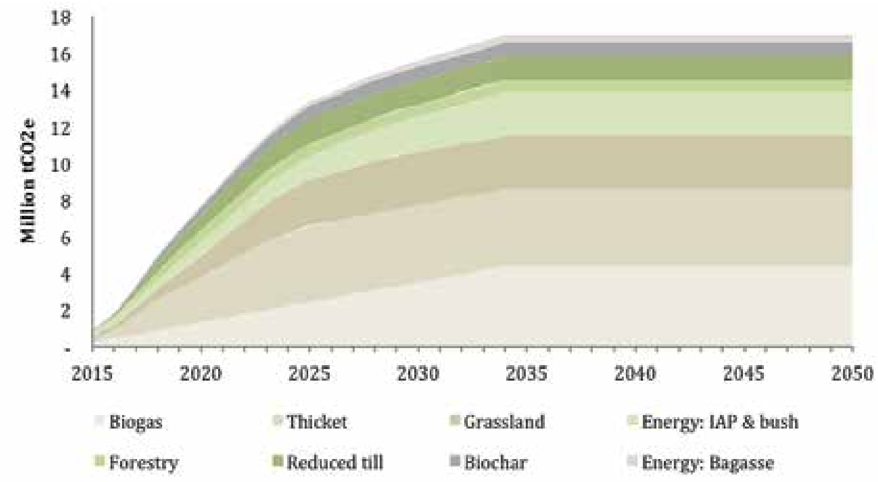

Figure 4. *The total terrestrial carbon sink potential by activity over time*

Table 1. *Contribution of terrestrial carbon sequestration and mitigation activities*

Activity	Sub-class	Spatial extent (ha)[1]	Reduction per unit area per yr (tC)	Emission reduction per yr (tCO2e) (min)	Emission reduction per yr (tCO2e) (+20%)	Reduction in emissions over 20yr (tCO2e) (min)	Percent contribution
Restoration of sub-tropical thicket, forests and woodlands	Sub-tropical thicket[2]	500 000	1,2	2 200 000	2 640 000	44 000 000	25,1
	Coastal and scarp forests[3]	8 570	1,8	56 562	67 874	1 131 240	
	Broadleaf woodland[4]	300 000	1,1	1 210 000	1 452 000	24 200 000	
Restoration and management of grasslands	Restoration - Erosion Mesic[5,6]	270 000	0,7	693 000	831 600	13 860 000	17,7
	Restoration - Erosion Dry[7]	320 000	0,5	586 667	704 000	11 733 333	
	Restoration - Grasslands Mesic[8]	600 000	0,5	1 100 000	1 320 000	22 000 000	
	Avoided degradation mesic[9]	15 000	1,0	55 000	66 000	1 100 000	
Commercial small-grower afforestation	Eastern Cape[10]	60 000	1,5	330 000	396 000	2 750 000	1,7
	KwaZulu-Natal[11]	40 000	1,5	220 000	264 000	1 833 333	
Biomass energy (IAPs & bush encroachment)	Country-wide[12]			1 990 316	2 388 379	39 806 316	14,4
Biomass energy (bagasse)	Country-wide[13]			328 955	394 746	6 579 099	2,4
Anaerobic biogas digesters	Country-wide[14]			3 642 408	4 370 890	72 848 160	26,4
Biochar*****	Country-wide[15]	700 000	0,3	641 667	770 000	12 833 333	4,7
Reduced tillage******	Country-wide[16]	2 878 960	0,1	1 055 619	1 266 742	21 112 373	7,7
Reducing deforestation and degradation	Through planning[17]						
	Through regulation[17]						
Total				**14 110 193**	**16 932 231**	**275 787 189**	**100,0**

Notes and references associated with the table above:

1. The spatial extent estimate should be viewed as a conservative estimate based on existing publications and expert opinion. A dedicated assessment of the potential spatial extent of each activity is still required that should not only assesses the ecological potential but economic constraints and social acceptance as well.
2. **Spatial extent:** Powell pers comm (based on Lloyd *et al*. 2002). Range depending on land-owner participation; **Reduction per unit area per year (tC):** Mills and Cowling 2006 (Great Fish River Reserve site) Ramp-up or roll-out period: 10 years
3. **Spatial extent:** Conservative est. of 10% of total forest area; **Reduction per unit area per year (tC):** Glenday 2007; Ramp-up or roll-out period: 10 years
4. **Spatial extent:** Conservative est. of 10% of savanna area, 10% of which is assumed to be degraded; **Reduction per unit area per year (tC)** Glenday 2007 and Knowles 2011; Ramp-up or roll-out period: 10 years
5. The national-scale assessment of gully erosion undertaken by Mararakanye and Le Roux (2011) provides an initial (conservative) estimate of degraded bare land that could be restored. It is reasonable to assume that the majority of soil carbon pool has been lost through the degradation process. In addition, the assessment is useful for identifying the location of 'degradation hotspots' across the country. It is however not a comprehensive assessment of grassland degradation. This analysis remains to be done.
6. **Spatial extent:** Mararakanye and Le Roux 2011; **Reduction per unit area per year (tC):** Watson *et al*. 2000, Conant and Paustian, 2002; Ramp-up or roll-out period: 15 years
7. **Spatial extent:** Mararakanye and Le Roux 2011; **Reduction per unit area per year (tC):** Watson *et al.* 2000, Conant and Paustian, 2002; Ramp-up or roll-out period: 15 years
8. **Spatial extent:** The mesic grasslands occupy a total extent of about 6 000 000 ha. It is conservatively estimated that 10% of this area is degraded; **Reduction per unit area per year (tC)** Watson *et al.* 2000, Conant and Paustian, 2002, Ramp-up or roll-out period: 15 years
9. **Spatial extent:** Conservatively, 5% of the mesic grasslands is at risk of degradation over the next two decades; **Reduction per unit area per year (tC)** Inferred from Knowles *et al.* 2007 (average over 20 yrs) Ramp-up or roll-out period: 15 years
10. **Spatial extent:** SAPPI pers comm (2013); **Reduction per unit area per year (tC):** SA Forestry Annual Statistics (E. grandis pulp on 8 yr cycle, 50t dry matter at end of cycle), Ramp-up or roll-out period: 5 years
11. **Spatial extent:** SAPPI pers comm (2013); **Reduction per unit area per year (tC):** SA Forestry Annual Statistics (E. grandis pulp on 8 yr cycle, 50t dry matter at end of cycle), Ramp-up or roll-out period: 5 years
12. Potential: Blignaut (2009); Emission reduction based on: Load factor = 75%; Emission factor = 85% of Eskom grid factor; Ramp-up or roll-out period: 20 years. It should be noted that at least three estimates of the potential of invasive alien plants and bush encroachment exist, all with different assumptions and constructed for different purposes. In this study we used the mid-estimate of Blignaut (2009). The estimates are:

IRP2010(rev2)				Blignaut et al. (2008)				Blignaut (2009)			
MW	MWh	tCO2/MWh	tCO2	MW	MWh	tCO2/MWh	tCO2	MW	MWh	tCO2/MWh	tCO2
25	164 250	0.8415	138 216	720	4 730 400	0.8415	3 980 632	360	2 365 200	0.8415	1 990 316

13. Potential: IRP2010(rev2); Emission reduction based on: Load factor = 85%; Emission factor = 85% of Eskom grid factor Ramp-up or implementation period: 20 years
14. Potential: 75% of the potential estimated in Blignaut (2009), supported by a conservative estimate by Burton et al. (2009); Emission reduction based on: Load factor = 75%; Emission factor = 70% of Eskom grid factor; Ramp-up or implementation period: 20 years
15. **Spatial extent:** The cultivated area is 14,394,800 ha and penetration rate is assumed to be 5%. **Reduction per unit area per year** 0.25 tC/y for 20 years.; Ramp-up or implementation period: 10 years
16. **Spatial extent:** Adoption is assumed to be 20% of the potential cultivated area. **Reduction per unit area per year** 0.1tC.ha^{-1}.yr^{-1} following the adoption of no-tillage practices based on study by Farage et al. (2007). Ramp-up or roll-out: 10 years
17. Although numerous stakeholders noted this opportunity, the spatial extent thereof is currently unknown. Please see a discussion focused on this activity in Chapter 3 of this report.

The contribution of activities to national GHG emission, social and ecological infrastructure objectives

Contribution to the national GHG emission goals

One of the objectives of investing in terrestrial carbon sink and mitigation activities is to reduce South Africa's overall GHG emission profile. The Long Term Mitigation Strategy differentiates between an emissions profile under a "Growth Without Constraints" scenario and a scenario entitled "Required by Science". This latter scenario is based on South Africa making a proportionate contribution to the global effort to reduce GHG emissions. This latter scenario forms the basis of South Africa's Peak-Plateau-Decline mitigation strategy. The strategy aims to stabilize emissions between 2025 and 2035 at an upper limit of 614 million tCO_2e per annum. Between 2035 and 2050 emissions are then expected to decline to reach a range between 428 and 212 million tCO_2 per annum in 2050. This enables an estimate of required annual emissions savings. Such an estimate is done by considering the difference between the mid-range of the "Growth Without Constraints" scenario and the maximum allowable emissions as per the "Required by Science" scenario. The estimates implies a saving of approximately 1,210 million tCO_2e per annum by 2050. The terrestrial carbon sink capacity to reduce atmospheric carbon emissions is estimated to be between 14,1 and 16,9 million tCO_2e, or about 1,4% of the required savings. This is illustrated in Figure 5.

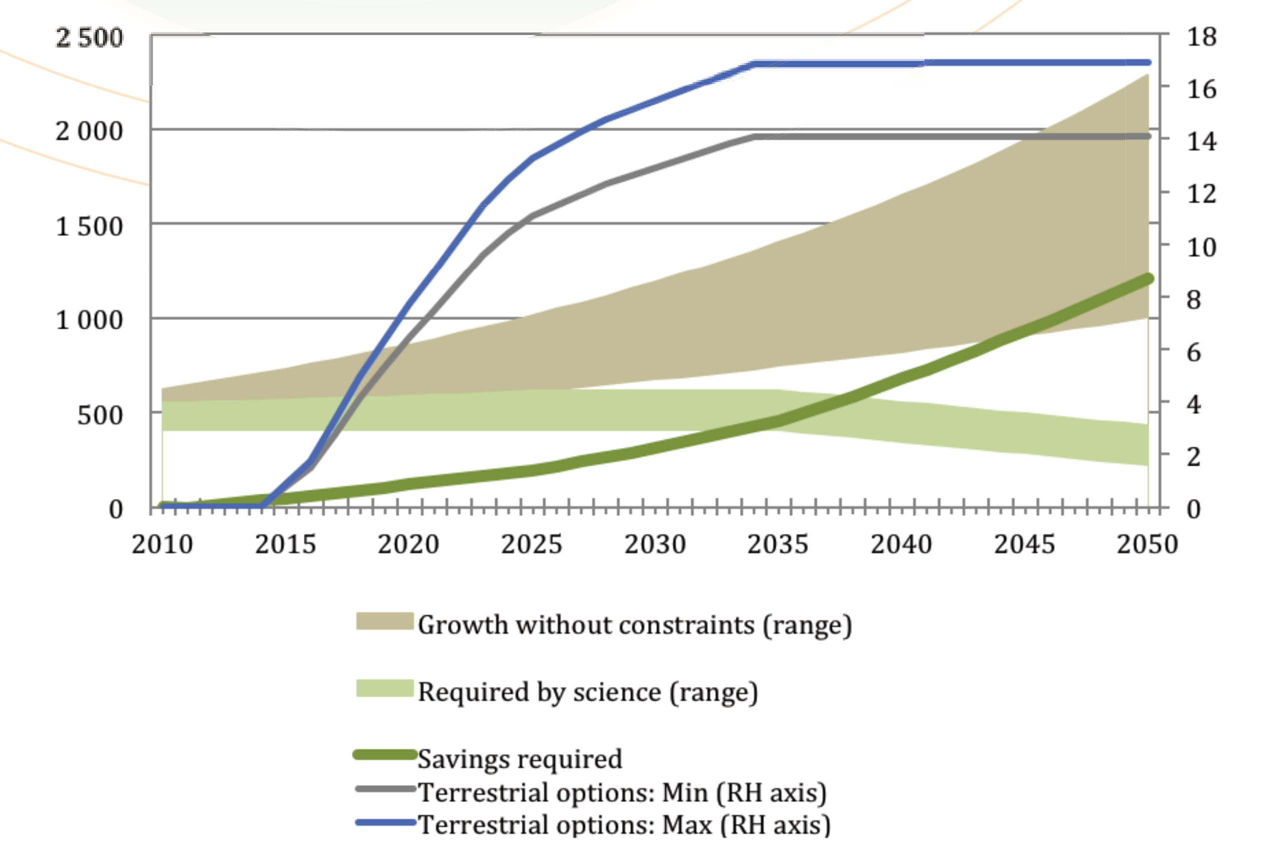

Figure 5: *Terrestrial carbon sink activities' contribution to South Africa's reduction in* CO_2

The crucial social, ecological infrastructure and climate change adaptation benefits of implementation

Casual observation of the contribution that terrestrial activities can play in reducing South Africa's overall Greenhouse gas emissions profile and the required savings would suggest that its contribution is minimal. Such an assessment would be erroneous for various reasons, namely:

1. Each sector, irrespective of which sector it is and how small its contribution in absolute terms might be, has to make a contribution towards reducing the country's carbon footprint. Since no single policy and/or intervention will achieve the total reduction, the achievement of the overall required savings will be a packaged deal. Furthermore, since the country's carbon profile is a matter of national strategic importance, all sectors and activities have to make a concerted effort in contributing to this goal.
2. By not being mindful of the contribution any activity can make, and/or to waive an activity's contribution under the pretense of it "being small and insignificant" will generate a national psyche of laissez faire pertaining to the issue of reducing the country's carbon profile. Not only will such an attitude fail to contribute to the required savings, it will propel the emissions growth under the "Growth Without Constraints" scenario.
3. Each of the activities listed offers multiple benefits. These include:

- job creation,
- opportunities for small business development,
- environmental awareness in general,
- water treatment,
- a contribution to water retention and base flows,
- water security in general, especially in periods of low flow and water scarcity, i.e. the times of high water necessity and hence an increase in the value of water,
- enhanced soil stability,
- the protection and enhancement of (endemic/natural) biodiversity,
- improved fire management and the reduction in fire hazards by reducing the biomass/fuel load, reducing the risk of damage to people, infrastructure and the environment,
- energy security by differentiating the energy mix,
- improved waste management, reducing not only the cost of waste management, but also reducing the load on the environment to assimilate and treat waste,
- food security by enhancing the productive capacity of the land
- contributes to the broader goal of sustainable development

1. Embarking on an effort to implement terrestrial carbon sink activities, see section 6, will therefore contribute far beyond carbon only. Making carbon a rallying point will assist in implementing the activities, while the activities will contribute to national welfare and development far beyond the scope of carbon only.

The cost of land-use based climate change mitigation activities

Cost is invariable a consideration when the implementation of terrestrial carbon mitigation and sequestration activities are considered. Here we performed a cost-effectiveness analysis comparing a selection of carbon mitigation activities. When considering this analysis, please note:

- This is a high-level assessment and the cost at local and/or at the level of implementation is likely to vary considerably given circumstances;
- Activities have been excluded from the analysis where some uncertainty exists pertaining to the scale of implementation and the degree and/or appetite for uptake;
- For the restoration-related activities and biogas, a time horizon of 30 years and a discount rate of 4% have been assumed in conjunction with the ramp-up period stipulated under Table 3.1. Costs were derived from stakeholder interviews;
- For the non-biogas energy-related options, the levelised costs as per the IRP (2011) have been used.

The results are provided in Table 2. The restoration-related options are considerably cheaper, by a factor of 10 or more than the energy options. The restoration-related options cost between R54 and R112 per tCO_2e whereas the energy options are between R926 and R1,054 per tCO_2e. This is mainly due to the capital intensity of the energy-related options.

Table 2. Cost of CO_2 reduction: Terrestrial mitigation and sequestration options

Project Activity	Cost (R)		NPV over 30 years (Rmill)	Mill tCO2 over 30 years	R/tCO2
	CapEx/ha	OpEx/ha			
Restoration of sub-tropical thicket and forests[1]	6 000	500	9 215	87,5	105
Restoration and management of grasslands[2]	250	200	3 081	57,2	54
Commercial small-grower afforestation[3]	10 000	550	1 681	15,0	112
	Levelised R/ MWh	MWh	Annualised Rmill	Mill tCO2/a	R/tCO2
Biomass energy (IAPs & bush encroachment)[4]	779	2 365 200	1 842	1,99	926
Biomass energy (Bagasse)[4]	869	390 915	340	0,33	1 033
Biogas (farm manures)[5]	730	5 256 000	3 838	3,64	1 054

4. Comparing the key characteristics of each activity

This section includes a comparative analysis of the key characteristics of implementation option. It seeks to describe the differences and similarities and the drawbacks and benefits of each individual implementation option. A second purpose of this section is to highlight the ways in which barriers to implementation might be addressed. Characteristics are assessed along three main criteria:

- Carbon market, governance and implementation measures;
- Social and ecological infrastructure measures; and
- Climate change potential.

Eight sub-criteria have been used to assess and compare each principle implementation option. The criteria were divided into a quintile ranking system, moving from *unfavorable* to *favorable* based on information gathered from stakeholder interviews and the project team's prior experience.

Description of the sub-criteria

Carbon market, governance and implementation measures

1. *Market acceptance:* Market acceptance is assessed according to several issues, namely the presence of a recognized legal counterparty, the ability to raise traditional forms of finance, the application of known and successful technologies, the ability to generate revenues, and the probability of receiving early government support.
2. *Readiness to implement***:** A number of activities have a well-documented track record of success in South Africa – examples include small-scale commercial forestry and restoration of sub-topical thicket. Several other activities have already been subject to pre-feasibility, feasibility and costing assessments. These types of activities are deemed more favorable due to their readiness for implementation compared to those that lack this preparatory work, especially where further extensive primary research is required
3. *Capital intensity:* The extent to which large sums of capital will have to be deployed, notably at project inception. For example, biomass–to-energy and anaerobic biogas digesters, require intensive injections of capital for upfront construction and early operational costs. In comparison, grassland rehabilitation and reforestation demand less upfront capital.
4. *Government support:* It is believed that government support is more likely for projects that are self-sufficient over time, and which adopt proven, known

1 Costs provided by Powell (personal comm - 2013) and SANParks – the mid estimates were used;
2 Costs provided by Ezemvelo KZN Wildlife (personal comm - 2013);
3 Cost provided by SAPPI (personal comm - 2013);
4 Based on IRP(2011);
5 Own estimates

technologies. In addition, activities that can raise external sources of finance and deliver local jobs and potential equity opportunities for previously disadvantaged persons are likely to be prioritized

Ecological and social characteristics

1. *Ecological risk:* The extent to which a project might be exposed to forms of ecological risk, for example, fire, pests and changes in climate.
2. *Ecological infrastructure:* The extent to which a project is expected to contribute to ecosystem services at landscape or catchment spatial scales.
3. *Contribution to social welfare and quality of life:* This rating aligns with the World Bank's Environment Strategy, where improving the quality of life is assessed by the contribution to: a) enhancing livelihoods b) reducing health risks and c) reducing vulnerability to natural hazards.

Contribution to carbon sequestration potential

1. *Potential to store carbon:* The potential to store carbon or reduce GHG emissions based on the results listed in Table 3.1.

Ranking results

Figure 6 illustrates the ranking of the eight proposed implementation opportunities on a five-tiered scale from unfavorable to favorable. The relative rating for each criteria, was determined based on stakeholder input and the team's own expert knowledge. It is important to stress that these are ***relative*** ratings of each activity as compared to the other activities considered, not absolute evaluations. Such analysis would need to be undertaken during the comprehensive assessment of each activity in a subsequent stage of the national carbon sink assessment. Figure 7 provides an illustrative example of the relative ratings of each activity in each of the three principle categories. The closer an activity is to the top-right quadrant (Q1), the better its climatic, ecological and social benefits as well as market-readiness, governance structures and implementation capacity. The size of the colored bubble represents the magnitude of the GHG benefit that could be realized through the implementation of activity – the larger the bubble, the larger the opportunity for sequestering or avoiding the release of greenhouse gas emissions.

Reforestation of thicket and forests is one of the only activities located firmly in the upper right quadrant (Q1), due to reasonable per hectare costs, substantial climatic, social welfare and ecological infrastructure benefits, and the substantial amount of research and development work that has been undertaken to date. To achieve a shift along the vertical axis will require additional government support focused on a more structured, bottom-up approach to identifying and working with landowners to restore and maintain thicket and forests over the long-term. Development of a Programme of Activities (PoA) approach modeled on the CDM guidelines and supported by government may increase the visibility of thicket and forest reforestation in the proposed domestic offset market and provide more certainty to project developers.

The **restoration and management of grasslands** provides substantial opportunity to reduce GHG emissions and sequestrate additional atmospheric carbon dioxide. In addition, it offers opportunities to increase social welfare and improve ecosystem services, especially water services to key economic hubs in the country. However, despite the climatic, social and environmental benefit, this opportunity has a low carbon markets, governance and implementation criteria ranking. This opportunity is not likely to scale independently without a high level of government or institutional support. A pioneering approach outside of the CDM and VCS standards may be required to realize grasslands projects.

Although **commercial small-grower forestry** ranks favorably in both the main categories, it will deliver only minimal increases in the size of the terrestrial carbon sink. This is due to the restricted area in which is can occur – only 60,000ha in the Eastern Cape and 40,000 hectares KwaZulu-Natal.

	Relative rating:	Unfavorable				Favorable
C. market, implementation and governance measures	**Market Acceptance** Low → High	Biochar Grassland	REDD-plan Agric		Reforestation CommForest	Biomass – Energy Biogas
	Readiness to implement Long-term option → immediate	REDD-plan	Biochar Agric	Grassland	Biogas	Reforestation Biomass-Energy CommForest
	Capital intensity High → Low	Biomass-Energy Biogas Biochar	Agric	CommForest	Reforestation Grasslands	REDD-plan
	Required Government support High → Low	Reforestation Grassland REDD-plan	Agric		CommForest	Biomass-Energy Biogas Biochar
Social and ecological infrastructure measures	**Ecological delivery risk** High → Low		Reforestation	CommForest Biochar Agric	Grassland REDD-plan	Biomass-Energy Biogas
	Contribution to social welfare and quality of life Low →High	Biochar	Biomass-Energy* Biogas* Agric		Reforestation CommForest	REDD-plan Grassland
	Ecological infrastructure Low →High	Biomass-Energy	CommForest Biogas		Biochar Agric	Reforestation Grassland REDD-plan
Climate change	**Impact on national scale sink** Low →High	CommForest	Agric** Biochar**		Grassland Biomass REDD-plan	Reforestation Biogas

*Both biomass to energy and anaerobic biogas digesters have the potential to improve in terms of social benefits if generated electricity serves rural communities and economies directly

**As carbon accumulation rates remain inconclusive for low-tillage systems and biochar use, this estimate is based on the opinion of experts interviewed during the engagement process

KEY

Reforestation: Reforestation of thicket and forests
Grassland: Restoration and management of grasslands
CommForest: Commercial small-grower forestry
Biomass-Energy: Electricity generation using biomass
Biogas: Anaerobic biogas digesters
Biochar: Biochar production and distribution
REDD-plan: REDD+ through planning and regulation
Agric: Improved agricultural practices (principally low till)

Figure 6. Ranking of principal opportunities: broken down by sub-criteria and ranked from unfavorable to favorable

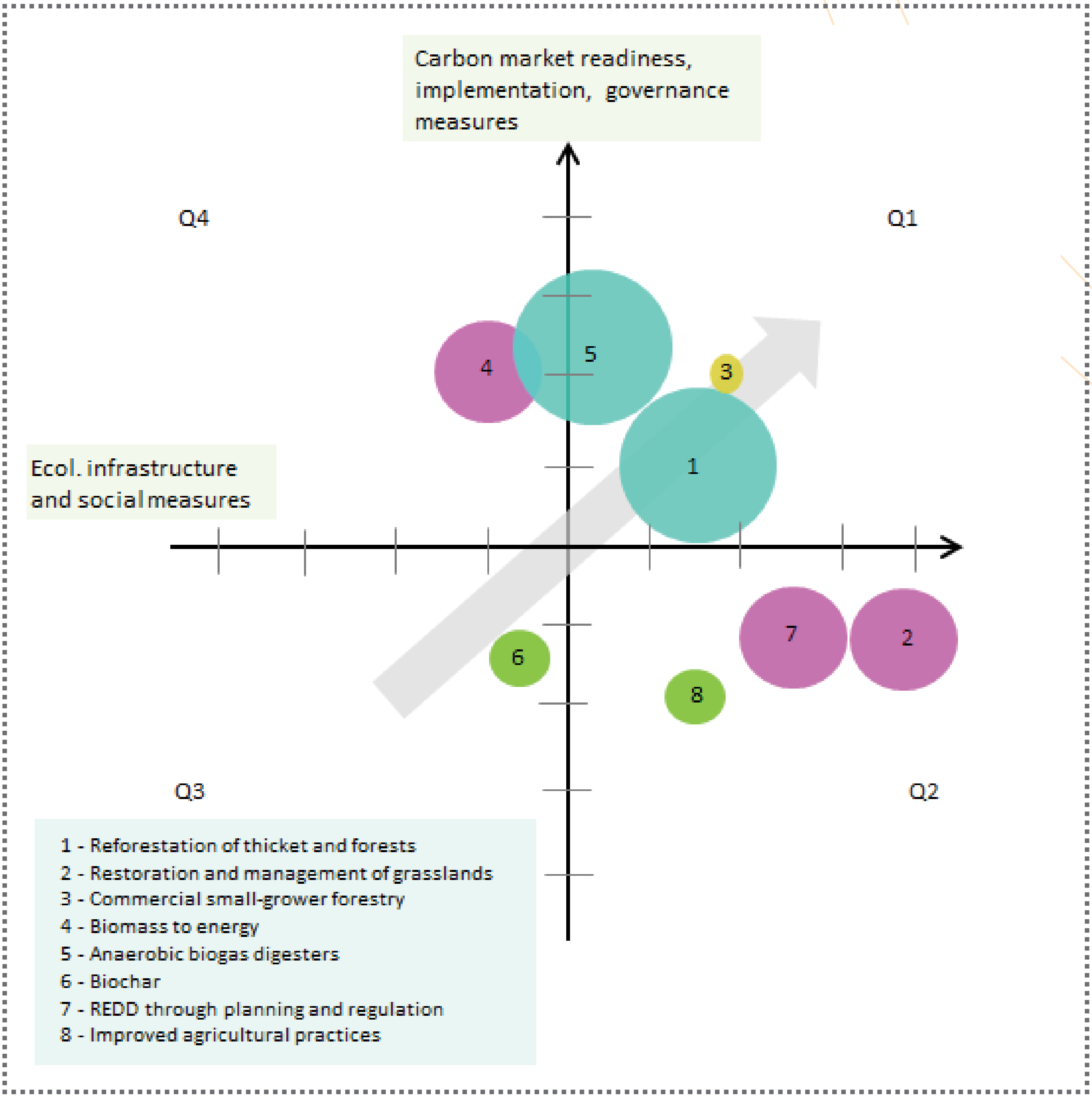

Figure 7. *The relative favorability of each land use based climate change mitigation activity*

Combined, biomass-to-energy and anaerobic biogas digesters could deliver approximately 40% of the total reduction in GHG emissions achievable in the land-use sector (Table 1). In addition, they rank high in the carbon markets, governance and implementation measures, although their social and ecological infrastructure contributions are considered to be limited. These energy projects are considered to have a high level of market readiness and appeal to investors, as they are proven technologies capable of delivering financial return under favorable electricity procurement prices, and would be managed by legally recognized entities. CDM and VCS methodologies exist for these types of initiatives, and there has been strong success in applying them internationally.

To move this opportunity up the vertical axis (markets and governance), government would need to ensure that viable and qualified biomass energy and anaerobic biogas digester projects would be prioritized for inclusion on the national grid. A shift along the horizontal axis (improving ecosystem services and social welfare) could be realized through alignment with the Working for Energy Programme. The creation of local jobs to assist in alien invasive removal would also deliver important contributions to rural economies.

Biochar receives one of the least favorable rankings of the project activities assessed. There are a number of unknowns around the application and climate change mitigation benefits of biochar. Due to the lack of clear understanding of biochar's contribution to carbon sequestration at scale in South Africa, it is unlikely to interest investors. An additional challenge is the current lack of methodologies available for its application through either the VCS or CDM standards. Furthermore, the cost of production, distribution and the potential provenance of the raw materials remain unclear. This casts considerable doubt on this activity's near-term viability. Considerable government support would have to be allocated to biochar to move it up the vertical axis (markets and governance).

During the stakeholder interview process, several individuals from government, the non-profit sector and private sector noted that comprehensive planning, regulation and enforcement could reduce degradation of natural landscapes and deforestation and deliver considerable environmental and social benefits. It is also one of the most cost effective approaches. Like the restoration of grasslands, REDD+ through planning may rate unfavorably under carbon markets, governance and implementation. Part of this is due to the lack of knowledge around the extent of the opportunity. To move REDD Planning and Regulation up the vertical axis would require significant government support.

In a similar manner to biochar, improved tillage systems on a large scale are an untested carbon sequestration approach in South Africa. Comparable to models in the United States and South America, where no-till is commonly used, local farmers have adopted it as a means for reducing soil degradation trends, as well as for its water retention benefits. In this sense it is a purely economic decision, focused on maintaining or enhancing soil productivity. It is assumed that the rollout of a reduced/no till programme would have a moderate adoption rate (20%), covering some 2.9 million hectares. This assumption is supported by a study by Bolliger (2007) on the adoption rates of no-till agricultural systems by smallholder farmers in South Africa, which indicated limited to no uptake of no-till practices despite many public claims to the contrary (Giller et al. 2009).

5. Important insights obtained through the stakeholder engagement process

Over the course of the stakeholder engagement process, a number of themes repeatedly emerged:

1. **The need to balance current top-down approaches with a bottom-up project development.** Stakeholders observed that the current top-down initiatives to land-use management should be complemented by bottom-up development if they are to be sustainable over the long-term. Typical interventions (e.g. tree planting, erosion control), need to be nested within 10-20 year business and land-use management plans if the measures are to permanent over the long-term.
2. **Maintain flexibility in model development and delivery:** Flexibility in the initial design of an implementation is crucial. The land-use domain is spatially diverse in terms of the ecology, systems of tenure, and socio-economic conditions. It is unlikely that a one-size-fits-all, pre-determined implementation model for national rollout will be successful. This is

especially true in areas under communal tenure where implementation models can only be developed once the priorities and preferences of local communities and traditional authorities are understood.

3. **A cost-efficient monitoring, reporting and verification (MRV) system is required.** High monitoring and verification costs were widely identified as a key roadblock to implementation. Further to reporting required by the carbon market, several stakeholders suggested an expanded monitoring program that would include a broader set of biophysical metrics (biomass, water, biodiversity, soil), social welfare measures, as well as operational metrics that would allow Government to improve implementation models over time.
4. **A progressive approach to auditing standards and processes is required.** Linked to the theme above, few of the eight identified activities can be realized at scale within the current constraints of the CDM and VCS standards. A progressive, cost efficient, national scale approach to auditing and incentive mechanisms is required if implementation is to occur at scale.
5. **Expand the focus beyond carbon to consider water, biodiversity, soil and other relevant ecosystem services.** While the development of a national programme focused on land-restoration may initially be based on carbon, stakeholders strongly encouraged the team to focus beyond only the climate benefit to a broader ecological infrastructure approach. For example, the climate change benefit of adopting reduced tillage practices may be marginal but the water, erosion and adaptation benefit is substantial and therefore the opportunity should not be overlooked.
6. **Creation of a clear incentive mechanism for investment in ecological infrastructure.** During the interviews, land-users ranging from municipal staff to private landowners stated that they are unable to commit to land-use activities based on current carbon market conditions. Given the vagaries of the international carbon offsets market, an alternative form of financial incentive is required to support activities, especially implementation at scale over the long-term. Stakeholders within Government indicated that there might be an emerging opportunity linked to the national carbon tax. It is vital that opportunities such as these are explore further to create a clear, long-term financial incentive for appropriate land-use management in South Africa.
7. **Development of primary ecological and economic research.** The majority of stakeholders noted that further primary research is required to support appropriate implementation. Sufficient knowledge exists to initiate activities, but dedicated applied research programs should complement this.

6. Considering each activity in more depth

6.1. Restoring sub-tropical thicket and forests

The opportunity to sequester carbon through the restoration of sub-tropical thicket and coastal forests is relatively well known and understood. To date, a considerable amount of work has been done on the science, implementation and financial aspects of sub-tropical thicket and forest restoration:

- *Sub-tropical thicket:* e.g. Aucamp 1979, Lechmere-Oertel et al. 2005, Marias et al. 2009, Powell 2009, Mills and Cowling 2010, Cowling and Mills 2011.
- *Coastal and scarp forests:* e.g. Wassenaar et al. 2005, Glenday 2007, Geldenhuys 2009, van Rooyen et al. 2012, Adie et al. 2013

Several entities are in the process of attempting to register projects through the VCS or CCBA. The carbon accounting, legislation and methodological issues are therefore relatively well understood. Due to the substantial amount of groundwork that has been done, the restoring of sub-tropical thicket and forests may be one of easiest mitigation activities to rollout in the near term.

Baseline without-activity scenario -

Approximately 4 million hectares of sub-tropical thicket located in the Eastern and Western Cape has been degraded to a certain degree through unsustainable pastoralism over the past century (Lloyd et al 2002). Of this degraded area, approximately 500,000-1,000,000 ha has been identified as suitable for restoration in the near term (Powell *pers comm*).

Additional with-activity scenario -

As sub-tropical thicket does not generally rehabilitate naturally, dedicated planting and long-term management programs are required to re-establish indigenous vegetation. The restoration process and accumulation of biomass and soil organic matter result in carbon sequestration rates of between 1.2-2.4 $tC.ha^{-1}.yr^{-1}$ (Powell 2009). If 500,000-1,000,000ha is suitable for restoration in the near term, assuming a conservative 1.2 $tC.ha^{-1}.yr^{-1}$, restoration would result in an average sequestration rate of 2,200,000-4,400,000tCO_{2e} per year.

Ecological infrastructure and ecosystem services

In addition to rural employment and skill-development opportunities created through the restoration and management process, local benefits include the restoration of livestock forage and farming industries, nature-based tourism, and the supply of wood, fruit and medicines to local communities for consumption and sale. One of the key benefits is the effect of thicket restoration on water services. Initial research indicates that degraded land results in nearly double the amount of runoff and almost a six-fold increase in sediment load compared to intact thicket.

Implementation Model 1: Private, commercial land: Emerging and established farmers

Typical example – Private land within the sub-tropical thicket biome that was previously heavily degraded through unsustainable livestock management practices.

Long-term planning elements – A 20-30 year business and land-use management plan needs to be created for each farm that includes ecological, financial, livestock management, and capacity requirements.

Implementing agencies – Existing extension officer systems or a new set of extension officers employed by a national implementation agency (Section 6) may need to assist farmers during the planning phase to compile long-term business and land-use management plans. During the initial 1-2 year land restoration phase, national programs, such as the Expanded Public Works Program would play an important role in providing required capacity and expertise.

Implementation Model 2: Government and communal land managed by local municipalities

- *Typical example* - Restoration of forest areas within the eThekwini Municipality through partnerships with local NGOs that specialize in community-based approaches to ecological infrastructure management.
- *Long-term planning elements* – Activities need to be nested within the ecological infrastructure and spatial planning components of local Integrated Development Plans (IDPs). This will ensure that reforestation activities are included in long-term spatial planning and capacity allocations, thereby increasing their permanence over the long-term.
- *Implementing agencies* - Stakeholders noted that if a particular land-use type is to remain in place for at least 20-30 years, it should be included in local long-term planning (IDPs) and at least be overseen and managed by a rural municipality. Implementation on the ground may well happen through local NGOs, which may be the preferred option in the short-term.

Implementation Model 3: Government land managed by conservation authorities

- *Typical example* - The restoration of sub-tropical thicket within the Addo Elephant National Park. In this case, the restoration activities form part of the "Working on Land" under the auspices of DEA's Natural Resource Management Program. SANParks is the implementing agency on the ground, ands recruits, trains and supports locally recruited teams to replant thicket.
- *Implementing agencies* - the primary agency is SANParks or the respective provincial conservation authority. In accordance with the "Working on Land" model, implementation on the ground occurs through locally recruited and trained teams.

Monitoring, reporting and verification

Within the sub-tropical thicket biome there are several entities in the advanced stages of validating projects through the VCS. Monitoring, reporting and verification (MRV) methodologies for reforestation activities are therefore well established. The limiting factor is the cost of verification and awareness of the process. For many landowners, emerging and established, the process is often viewed as too uncertain and expensive. A national facility could form an essential role in unlocking the expanded rollout of implementation across the biome.

Employment and skill development

The restoration of ecological infrastructure is proven to be an efficient vehicle through which to create job opportunities in remote rural areas. The EPWP, internal municipal programs and NGOs within the sector (e.g. the Wildlands Conservation Trust) employ a significant number of previously unemployed people. For this reason, many of these initiatives are noted in the President's annual State of the Nation Address and receive growing support from government.

Potential demonstration projects

- *Subtropical-thicket:* The greater Addo and Fish River area in the Eastern Cape. There are several early initiatives already underway in the Eastern Cape, which should be expanded and built upon. Researchers based at Rhodes University have undertaken the identification and mapping of an initial set of sites.
- *Woodland:* The EPWP has initial projects in the Bushbuck Ridge and Sekhukhuneland areas. These could be built upon and form good demonstration sites.

ACTIVITY SUMMARY

Key Positives	• High annual carbon sequestration potential per hectare • Combats soil erosion through improved root systems • Substantial rural employment and livelihood benefits • A relatively low risk carbon sequestration option • Availability of approved methodologies to support early roll-out
Key Trade-Offs and Concerns	• Implementation in communal areas may require a new, progressive approach to incentives and disbursements

6.2. Restoration and management of grasslands

Due to the international focus on REDD+ and forests, the opportunity for climate change mitigation within the grassland biome is often underestimated. Yet in South Africa, appropriate grassland management may be one of the principle climate change mitigation and adaptation activities within the land-use sector (Table 3.1, Figure 4.2). Grassland and rangeland ecosystems are often overlooked due to the majority of the carbon being located belowground (95% of total carbon pool).

Two primary mitigation activities are considered within the grassland biome:
Carbon sequestration through grassland restoration and long-term management
Reducing the degradation of grasslands and release of soil carbon into the atmosphere

Baseline without-activity scenario

- *Grassland restoration and long-term management:* The ploughing and turnover of soil leads to the release of soil organic carbon into the atmosphere. Overgrazing and the degradation of the herbaceous layer can also lead to a substantial loss of carbon, but over a longer period of time.
- *Reducing the degradation of grasslands:* Interviewed experts within academia, government and NGOs noted clear increases in the spatial extent of degraded grassland and erosion gullies in their focus areas. It was further noted that unless new measures are introduced, the trend would continue over time and may even increase in speed as drivers of degradation become more widespread and intense.

Additional with-activity scenario

- *Grassland restoration and long-term management:* The restoration of grassland requires a comprehensive set of complimentary measures that may include a reduction in grazing pressure, physical replanting and rehabilitation, together with erosion control measures.
- In dry grasslands, a conservative carbon sequestration rate of 0.5tC.ha^{-1}.yr^{-1} can be assumed. Sequestration in moister, mesic grasslands is more rapid due to higher productivity and cooler temperatures (0.7-1.0tC.ha^{-1}.yr). If restoration were to be rolled out across the 1.2 Million hectares, it would lead to the sequestration of approximately 2.3 Million tC per year.
- *Reducing the degradation of grasslands:* Depending on the driver of degradation (ploughing, overgrazing, erosion), the rate of release can either be rapid, over the period of a few years, or a gradual decrease through leaching over a much longer period. For planning purposes a conservative release rate of 1.0tC.ha^{-1}.yr^{-1} can be assumed (Table 3.1).

Ecological infrastructure and ecosystem services

The grasslands of South Africa provide a wealth of ecosystem services to both local communities as well as regional urban and industrial centers. For this reason, the restoration and long-term appropriate management of grasslands is highlighted as a key intervention in the proposed 19th Strategic Integrated Project (SIP 19) focused on ecological infrastructure for water security. At a local scale, grasslands are the second most biodiversity rich biome in the country (after the Fynbos biomes) and provide local communities and commercial farmers with water services, productive grazing land and support an active tourism industry. At a national scale, intact ecological infrastructure within the grassland biome is viewed as an integral part of long-term national development and resilience to climate change (LTAS, DEA 2013).

Implementation Model 1: Private, commercial land: Emerging and established farmers

- *Typical example* – Either a private farm that has been heavily degraded and needs to be restored or a farm that is ecologically intact where the intention is to incentivize the landowner to maintain ecological infrastructure.
- *Long-term planning elements* - There is a substantial number of established and emerging farmers who require assistance in developing 20-30 year land management plans that focus both on veld condition and ecological infrastructure as well as commercial viability. There is considerable scope to entrench the maintenance of ecological infrastructure as part of long-term planning, with associated incentives providing a baseline source of revenue that is independent for customary agriculture commodity markets.
- *Implementing agencies* – The primary implementer is the landowner and associated staff. In certain circumstances, especially during an initial 1-2 year land restoration phase, a farmer may need additional capacity that could be provided by EPWP or provincial conservation authorities.

Implementation Model 2: Government and communal land managed by local municipalities and conservation authorities

- *Typical example* – Areas under communal land-tenure within the greater Drakensburg area or municipal land within the eThekwini Metropolitan and Umgungundlovu District Municipalities. Within these areas there is a broad diversity of land-use types and governance structures that requires flexibility in implementation models and incentive mechanisms.
- *Long-term planning elements* – Interviewed stakeholders were quick to highlight the need for expanded land-use planning in each municipal and communal area prior to implementation. It was

strongly emphasized that a more 'bottom-up' approach is required, where long-term land-use plans are developed through a truly participatory manner, prior to roll-out of activities.

- *Implementing agencies* – Implementation on the ground could potentially occur through municipal capacity, provincial conservation organizations, the Expanded Public Works Program, community organizations, NGOs or the private sector. For example, eThekwini Municipality currently implements grassland and forest management measures through their own internal capacity as well as through Working on Fire (EPWP), Working for Ecosystems (WESSA -NGO) and the Wildlands Conservation Trust (NGO). Contracting external entities allows the municipality to use existing capacity and expertise, and allows for more flexibility over time as implementation needs may change. This approach should not, however, undermine the need for a core of expertise within municipalities and regional Government that coordinates matters.

Monitoring, reporting and verification

The high cost of quantifying changes in soil carbon stocks using the methods stipulated by the CDM or VCS, is one of the key reasons why the rollout of activities has been inhibited to date. If grassland management is to be pursued as a mitigation option within a national program, particular attention will need to be paid to developing a progressive monitoring, reporting and verification system.

Employment and skill development

The restoration of ecological infrastructure is an efficient vehicle through which to create employment and skill development opportunities in rural areas. This is particularly important in the remote areas of the Eastern Cape, KwaZulu-Natal, Free State and Northern Cape where additional grassland management measures are urgently required.

Risk considerations

As 95% of the terrestrial carbon stock in grasslands is located in the belowground soil carbon pool, there is little exposure to fire and many risk factors traditionally associated with land-use based climate change mitigation activities.

ACTIVITY SUMMARY

Key Positives	• The opportunity to restore 1.2 Million hectares of potentially productive grazing land • The provision of water services to key economic hubs in a cost-effective manner • Cost-effective adaptation to predicted climate change • Substantial rural employment and livelihood benefits • A relatively low risk carbon sequestration option
Key Trade-Offs and Concerns	• Implementation in communal areas may require substantial time to develop • A new form of monitoring, reporting and verification system will need to be pioneered.

6.3. Commercial small-grower afforestation

In the interests of creating rural jobs and economic activity, Government has proposed the expansion of small-grower forestry in areas of the Eastern Cape and KwaZulu-Natal, where there is sufficient water within catchments to accommodate plantations without significantly affecting base flows. Furthermore, if this is undertaken in areas that have been previously degraded, ploughed or have limited biodiversity, commercial small-grower forestry can be a long-term viable vehicle for providing rural jobs and income streams.

Implementation model: form and agencies

A review of existing literature and interviews with industry, have indicated that is approximately 60,000ha in the Eastern Cape and 40,000ha in KwaZulu-Natal that is suitable for afforestation activities. Since much of the proposed expansion of forestry in South Africa is on communal land under local tribal authority or on private farms that have recently been redistributed to emerging farmers, commercial forestry companies have proposed a community partnership model. In this model, ownership of the forest continues to reside with the community, while the forestry company initially provides seedlings, and then advisory and fire management services over the rotation period of the forest.

Extent and potential to scale-up

The availability of suitable land that meets required water and biodiversity regulations is a clear constraint on the potential to expand this activity. Although government policy has proposed expansion across 100,000 ha in the Eastern Cape, forestry companies engaged during the stakeholder engagement process objected that this goal might be too optimistic. The amount of land that meets required water regulation, biodiversity, and EIA requirements may only amount to 60,000 ha in the Eastern Cape and 40,000 ha in KwaZulu-Natal (Chamberlain et al. 2005). An additional 100,000 ha nationally should therefore be seen as the upper-bound of the scaling up potential.

Cost of implementation

Eucalyptus plantations, grown for pulp, are typically turned over on a 7-8 year cycle. At the start of the cycle, it costs ZAR 2,500ha^{-1} for seedlings, and ZAR 1,500 ha^{-1} for land preparation and weeding. Together with fire and forest management costs over eight years (which is undertaken by the community), the typical cost at rotation age is ZAR 9,000-12,000 ha^{-1}.

Incentive mechanisms and disbursements

At the end of a Eucalyptus rotation, the community is paid between ZAR 220 and 250 per ton of pulpwood, which equates to approximately ZAR 28,000 per hectare. However, upfront costs and accrued interest on those costs need to be subtracted from this amount. The industry highlighted this as a key area where government could provide catalytic support by assisting communities with favorable terms on these loan amounts. For emerging farmers and communities, this model provides an opportunity to produce a commodity and generate income at relatively low-risk and capital outlay, while leveraging the capacity and expertise of established industry.

Monitoring, reporting and verification

There are a significant number of established afforestation/reforestation projects around the world that have been validated and verified either through the CDM or VCS standards. There are thus a rich set of MRV methodologies in existence, with associated protocols and processes. At the same time, the commercial forestry companies concerned have extensive internal reporting structures that can be leveraged to supply operational, biophysical and spatial data.

Employment and skill development

The implementation of a community-based pulp production model provides employment and revenue streams not only to rural communities and emerging farmers who have recently acquired land, but to other individuals within the logistics, milling and delivery functions of the value chain.

Ecological infrastructure and ecosystem services

There are well-founded concerns regarding the water, biodiversity and soil impacts of commercial plantations, including the spread of exotic trees from the initial site of the plantation. For this reason, forestry companies must clearly document the net effect of a plantation on base water flow (in order to obtain a water license) and are required to undertake a full EIA for each plantation.

Risk considerations

The entire project process, from the choice of species and planting regimes, to the day to day management of the forest, to the harvesting, transporting, processing and sale of the pulp is well known and understood. However, there are particular risk elements, such as the establishment of a plantation in grassland systems marked by high rates of fire. Engagement with industry indicated that fire risk is actively managed, is within acceptable levels, and should not be viewed as an inhibitory factor to implementation.

Potential demonstration projects

Industry has identified 60,000 ha of potential land for commercial plantation use in the Eastern Cape and 40,000 ha in KwaZulu- Natal. Industry identified three potential bottlenecks for the realization of these demonstration projects. The first is the high interest rates on loan amounts to communities, which reduce the attractiveness of forestry projects. Road infrastructure was identified as a second impediment, the provision of which would not only facilitate transport of pulpwood, but also for development of the region generally. A third obstacle noted by stakeholders was the long time lags between application for EIA and water permits, and delivery of final approvals.

ACTIVITY SUMMARY

Key Positives	• A tested model that allows communities and emerging farmers to leverage the capacity and expertise of the commercial forestry industry, while fundamentally owning the project • Provision of a fairly low-risk income stream to communities and emerging farmers • Provision of jobs and skill development opportunities in remote areas of South Africa,
Key Trade-Offs and Concerns	• The impact of commercial forestry on water and biodiversity is a well-founded concern and it needs to be ensured that established guidelines are adhered to throughout the implementation process. • There is clear concern that exotic trees may spread from the initial plantation sites. • High retail interest rates will have an inhibitory impact on the financial viability of the plantation opportunity. A key catalytic intervention would be the provision of favorable loans to the smallholder industry.

6.4. Anaerobic biogas digesters

Anaerobic biogas digesters are fermentation tanks or sealed ponds in which biodegradable material ferments anaerobically, generating a composite gas of which methane is the most abundant. Methane is a greenhouse gas with a global warming potential 23 times that of CO_2. There are thus considerable benefits in reducing the release of gasses from biodegradable fermentation processes into the atmosphere. The benefits are at least three-fold:

- Biodegradable material suitable for biogas digesters, such as cow manure, will ferment aerobically unless they are placed in a digester. This means that valuable methane is lost to the atmosphere. A digester on the other hand would capture methane and reduce the uncontrolled release of methane into the atmosphere;
- Methane is combustible and when captured in a digester can be used either to power a biogas generator generating electricity, or for thermal applications like cooking, reducing the need for fossil fuel-based power; and

- When methane is combusted it emits CO_2 with a global heating potential 23 times less than if emitted otherwise.

Implementation model

Biogas digesters can be installed by:

- Virtually anybody as it is a relatively simple, do-it-yourself- type technology, or
- By small contractors who specializes in the construction of digesters, or
- By large engineering firms/outlets.

The level of technical capacity required is determined by the scale or size of the digester. Household-level units can be constructed either by the owners themselves or by small contractors. Large industrial and/or agriculture applications require special design features that makes engineering firms or the like better suited for the task.

Extent and potential to scale-up

In 2008, a national feasibility assessment of biogas in South Africa (Austin and Blignaut 2008) estimated that 310,000 rural households are eligible for biogas digesters by virtue of not having access to grid-based electricity, but having access to grey water and manure. Austin and Blignaut (2008) estimated the potential of agriculture-based biogas digesters based on the published number of cattle, sheep, pigs and poultry in the country, producing more than 156,000 tonnes of manure a day. The total power generation capacity of the methane gas, if between 25% and 50% of this manure is captured, is 280MW (for communal areas), and about 1,100MW for all animal-based agriculture operations.

Cost of implementation

Biogas digesters are capital and labour intensive to establish, but their operation and maintenance cost is insignificant as it essentially comprises the collection/removal of manure and the feeding of the digesters. In areas where people depend on fuel wood for cooking, lighting and heating and where their waste is not managed by municipalities, digesters save time and energy. Household digesters can cost between R15,000 and R35,000 for a 6m^3 unit, depending on whether it is self-built or installed by a professional. Large-scale digesters cost between R2million for a 500m^3 fixed-dome digester and R5million for a 1000m^3 continuous stirred-tank reactor digester.

Monitoring, reporting and verification

Calculation of baseline emissions and the determination of additionality as a result of the implementation of the technology are relatively straightforward. Both the CDM and VCS provide methodologies that project developers could adopt.

Employment and skill development

There is significant scope for the development of an entirely new economic activity in the construction sector as this technology is in its infancy and there are only a few applications of it to date in South Africa.

Ecological infrastructure and ecosystem services

In addition to the obvious carbon mitigation benefits, the introduction of biogas digesters will assist greatly in the management of waste. If designed appropriately, digesters will improve water quality by reducing the pollutants from dispersed sources into water bodies as digesters reduce the biological oxygen demand loads in effluent by up to 90%.

Risk considerations

In urban areas, the water effluent from digesters could contaminate and/or mix with the sewer system. This should be avoided. While human waste can be used in digesters to generate methane gas, it is not advisable to use the resultant effluent as fertilizer on vegetables. Since digesters operate at about 40^{o}C and blood and traces thereof are only sterilized at approximately 80^{0}C, such fertilizer could increase the risk of human-to-human disease transfer.

Potential demonstration projects

There are several digesters in operation in South Africa, such as in villages near Giyani, a few in Pretoria and its outskirts, Johannesburg, Richmond near Durban, and Cape Town, as well as on farms. During the stakeholder engagement process in KwaZulu-Natal, the uMgungundlovu District Municipality highlighted a substantial source of livestock manure and food waste in Estcourt, Midmar, Thornville, Albert Falls, Kamberg and the District Municipalities' urban centre. These six opportunities for anaerobic biogas production included piggeries, poultry farms, cattle feedlots/abattoirs, and urban food waste streams. The Municipality noted that, if adopted in full, their digesters would produce 43.3 MWe.

ACTIVITY SUMMARY

Key Positives	• Easy to implement and to maintain with direct benefits to people and the environment • Easy to monitor and well-established and relatively simple CO_{2-}baseline methodologies • Significant employment creation potential
Key Trade-Offs and Concerns	• Capital intensive • Potential skepticism of the use and/or introduction of a new technology

6.5. Biochar production and application

Biochar is a partially combusted form of charcoal, produced through the process of pyrolysis using organic materials such as vegetation waste, crop residues and woody biomass such as timber harvest wastes or alien invasive species. It is a carbon-rich material that can be mixed into the soils of agricultural or other lands for the purpose of increasing soil-carbon; it may also improve crop yields in previously degraded or sandy soils. Due to its strong binding effects, it is believed that biochar reduces fertilizer run-off, decreasing the net total farm needs for fertilizer, a significant cost-savings to farmers.

There are avid proponents and numerous skeptics of biochar. During the engagement phase, several stakeholders noted their concern over the enthusiasm and support it receives, despite the lack of clear scientific evidence demonstrating its carbon sequestration potential in South Africa. This absence of scientific analysis makes it very difficult to determine the extent to which this is a locally viable opportunity.

Baseline compared to with-project scenarios

Under a "without project scenario" it is assumed that the rate of carbon loss from soils will continue unabated. Under the "additional, with project scenario" it is possible that the rate of soil carbon loss would be reduced, abated or reversed with biochar amendment to soils. Added to this is the "avoided decomposition" of biomass stocks used in the pyrolysis process, which are assumed to otherwise release emissions as they break down through normal organic processes. No in-depth analysis of the spatial extent and carbon sequestration capacity of biochar amendment in South Africa currently exists. However, in the interest of providing an initial, rough estimate, it is reasonable to assume that biochar use could conservatively apply to approximately 700,000 ha (penetration fraction of 5% of agricultural lands), with an annual carbon sequestration rate of approximately 0.3 $tC.ha^{-1}.yr^{-1}$ or 641, 667 $tCO2e.yr^{-1}$ across the 700,000ha. A concern is the GHG emissions generated through the biochar production and distribution processes. Both the supply chain and pyrolysis methods need to be assessed carefully in a South African context.

Implementation model: form and agencies

Stakeholders identified two potential approaches. In the first approach, independent, commercial producers would manufacture biochar and oversee its delivery to interested end-users, such as commercial and small-scale farmers, or persons responsible for mine rehabilitation. In a second model, the EPWP would establish teams to remove alien invasives. The vegetation waste could either be transported to a central depot for biochar production, or combusted through the use of a mobile technology. The biochar could be sold at cost or subsidized for distribution amongst local, rural households practicing subsistence agriculture.

Cost of implementation

The cost of implementation is not well known. Since a moderately sophisticated supply chain is required – the collection of waste material, the combustion of waste in a controlled environment, the packaging, distribution and application of biochar in appropriate landscapes and soil types – it is assumed that this will not be one of the more affordable implementation activities. Sparrevik et al. (2013) note that advanced kiln technologies are the preferred pyrolysis device but these come at a higher cost. More crude, inexpensive kilns can be used for pyrolysis, such as earth-mound kilns traditionally employed across Africa for charcoal production (Sparrevik et al. 2013). However, the relative inefficiency of these kilns and associated GHG emissions, the quantity of greenhouse gases, particulate matter, and volatile organic compounds they release are not suitable for a national-level climate change mitigation initiative (Sparrevick et al. 2013). The costs of transportation are one of the most important factors in assessing the viability of a project.

Monitoring, reporting and verification

Directly monitoring changes in soil carbon stocks, especially at large scales, can be prohibitively expensive. This is one of the principle reasons for the limited uptake of activities that sequester soil carbon through the CDM or VCS, as the costs of quantifying changes in the soil carbon stocks is potentially more expensive than revenues that can be derived from the sale of offsets. However, if one were to step back from the CDM or VCS frameworks, a new approach can be taken, for example activity-based monitoring could be adopted instead of a carbon-stock based approach.

Employment and skill development

Employment could be generated from the harvesting of alien invasive species or the collection of other biomass waste resources required for pyrolysis (could be linked to the EPWP programme). Moreover, jobs at kiln production sites to manage the sorting and drying of biomass materials, to oversee the pyrolysis process, to maintain inventory and prepare shipments, and to oversee sales would be required. The biochar production and distribution network would likely lend itself to the establishment of small and medium enterprises (SMEs), many of which could be based in rural areas.

Ecological Infrastructure and Ecosystem Services

The removal of alien invasive species to supply biochar production will provide a significant ecological infrastructure benefit, notably in protecting important water catchments. The application of biochar, if proven effective in improving carbon absorption rates, should lead to improved soil nutrient density, water retention capacity, and limits to fertilizer run-off.

Risk Considerations

The unsustainable collection of feedstocks, through improper land-clearing practices or the allocation of high-production agricultural lands for the production of feedstocks, represents a risk in pursuing a national-level biochar programme.

ACTIVITY SUMMARY	
Key Positives	• Potential to contribute to climate change adaptation and mitigation through improved soil water retention, fertility and carbon sequestration • Potential improvements to subsistence farmer crop yields and rural food security • Means for adding further value to the alien invasives removal programme • Potential means of rehabilitating degraded soils
Key Trade-Offs and Concerns	• Limited understanding of the carbon mitigation benefits under South African conditions • Potentially prohibitive costs structure, which would have to be subsidized by government • Unclear level of potential uptake by commercial, emerging and subsistence farmers • Expensive, sophisticated biochar production technologies deliver the best health and greenhouse gas reduction outcomes, but require greater upfront capital cost

6.6. Reduced Emissions from Degradation and Deforestation (REDD) through Planning and Regulation

Conventionally, activities aimed at Reducing Emissions from Degradation and Deforestation (REDD) are primarily limited to forest ecosystems. For instance, UNREDD programmes in the Democratic Republic of Congo, Tanzania and elsewhere typically focus on halting the deforestation of large tracts of tropical forest or tall miombo woodlands. In a South African context, there is limited opportunity for this classical interpretation of REDD since most deforestation happened decades ago. In the context of the National Carbon Sinks Assessment, we have adopted a broader approach to REDD by including the reduction in degradation of all terrestrial ecosystems, be it grasslands, savannas, woodlands, fynbos, thicket and so forth.

During the course of the stakeholder engagement, numerous implementers – agricultural extension officers, academia, NGOs, municipalities and government – noted that landscape degradation of certain biomes in South Africa is still continuing due to a lack of local and regional planning and questionable regulatory practices. In terms of the potential climatic benefit, assuming a minimum degradation rate of 0.1% per year, a mean national carbon stock of 58 $tC.ha^{-1}$ and a 50% loss of above and below-ground carbon stocks in a degraded state, it is possible to avoid the release of 13 million tonnes of C02e per annum across the country.

Under the "**without project scenario**" it is expected that unchecked degradation of natural landscapes will continue in South Africa. For the purpose of describing the baseline, it is assumed that degradation is taking place, and that this degradation is not officially mandated but is rather the consequence of limited enforcement and local government oversight of the use of natural resources. Under the "**additional with-project scenario**", the degradation of critical above and below-ground carbon stocks would be avoided through rigorous application of environmental planning and regulations.

Implementation model: form and agencies

The planning and regulatory function needs to originate from government. At the local level, municipalities have a significant role to play in land-use planning functions through the annual release of an IDP. IDPs are to align with national level, binding policies, such as NEMA, and require that an environmental analysis be undertaken. This represents a critical opportunity for assessing current natural resource use at the municipal level, identifying thresholds for exploitation, and capacitating staff to enforce planning principles and objectives. These can align with Bioregional Plans and Environmental Management Frameworks, and can help inform the approval of EIAs, water permits, agricultural licenses and other activities impacting on the land-use sector.

Cost of implementation

Due to the progressive nature of this opportunity, there are no empirical examples on which to base a cost estimate. REDD planning and regulation would be implemented through existing institutions, and could leverage current budgets. But pursuing REDD Planning and Regulation would require a marginal increase in budget allocation in order to improve environmental planning functions at the local, provincial and national scales. Further funds likely need to be devoted to increasing the number of staff dedicated to ensuring legal compliance with policy and associated monitoring needs.

Monitoring, reporting and verification

As this is a progressive, blue-sky opportunity, a new MPV system would need to be created that adequately identifies a business-as-usual and additionality scenarios. An adequate MRV system would need to quantify the net effect of the planning process on carbon stock and associated GHG emissions.

Employment and skill development

It is anticipated that capacity within local and rural municipalities would need to be increased marginally. This will provide long-term job opportunities for skilled individuals in government. Compared to other mitigation activities that require active restoration and field activities, required capacity for the implication of REDD planning and regulation is expected to be far less.

Ecological Infrastructure and Ecosystem Services
REDD Planning and Regulation could form the broad planning foundation for ecological infrastructure management at a national scale, with the potential to deliver a substantial set of ecosystem goods and services over the long-term. This set would include: climate regulation, soil erosion prevention, habitat protection, medicinal plant protection, water catchment improvements and maintenance, stream flow improvements, soil nutrient and health improvements, biodiversity conservation, pollination services, and feedstock and fodder provision.

Risk Considerations
In terms of risk, a key consideration is the concept of reversibility. In order to manage this, one needs long-term, consistent planning priorities to ensure that the protection of ecological infrastructure is firmly entrenched in planning-related policies.

Potential Demonstration Projects
The intention would be to identify 2-3 rural municipalities in the country that cover a variety of land-use types, land-use drivers, land tenure systems, and biomes that will provide valuable lessons that are indicative and useful for the remainder of the country.

ACTIVITY SUMMARY

Key Positives	• Relatively cost-effective implementation with substantial ecosystem benefits and alignment with climate change adaptation priorities. • Potential to be one of the principle land-based climate change mitigation activities in the country. • Opportunity to create a framework for national ecological infrastructure planning across the entire country.
Key Trade-Offs and Concerns	• Improved planning and application of regulations for the protection of ecosystems is not currently compatible with CDM / VCS standards. • While potentially the most significant activity, it is a longer-term option, which requires new investment. In particular, considerable skills-development, training, and oversight would be required to ensure that government employees are properly capacitated to undertake enhanced planning and regulatory functions. • This is a novel concept, which requires the development of an entire concept from base principles, including implementation, an MRV system, and disbursements. While there are lessons that can be learned from related initiatives abroad, the MRV component would notably have to be developed afresh.

6.7. Reduced Tillage

As reported in the first phase of the National Carbon Sink Assessment, over 95% of the terrestrial carbon stock in grassland and savanna systems is located belowground, in the form of soil organic carbon – essentially the dark, organic matter in soil. Being below-ground, it forms a long-term, stable pool that contributes significantly to soil quality. It can, however, be rapidly released into the atmosphere through the process of ploughing, as soils are turned over and the carbon is exposed to the atmosphere. Together with this substantial release of carbon from the top 30 centimeters, there is also the loss of additional benefits that organic matter provides, in terms of soil nutrient, water retention and so forth. For this reason, much global attention has been paid to the possibility of reducing tillage, more as an exercise to protect soil fertility and health than a pure climate change mitigation activity.

Conservation or reduced tillage can generally be defined as any tillage technique (no-tillage, direct drilling, minimum tillage and/or ridge tillage) that leaves sufficient biomass residue in place to cover a minimum of 30% of the soil surface after planting. The net carbon sequestration benefit of reduced tillage may have initially been overestimated, and several recent studies (e.g. Loke et al. 2012, Baker et al. 2007) suggest that the net effect throughout the soil profile, down to 1 meter, may be lower than first anticipated. For this study, we have therefore taken a conservative approach, and estimated the net sequestration rate to be 0.1 $tC.ha^{-1}.yr^{-1}$ (Table 3.1). In terms of the potential future spatial extent of implementation in South Africa, it is conservatively assumed that reduced tillage practices could be adopted on 20% of South Africa's arable land in future.

Implementation model: form and agencies
Reduced tillage requires farmers to halt current ploughing, fertilization and planting practices, and to adopt a new suite of planting and pest control measures. The concept is relatively well-known in South Africa, to the extent that there are no-till "clubs" in certain provinces. The majority of the winter wheat area in the South Western Cape has also already adopted reduced tillage practices. A National Facilitation Unit could expand such measures, providing additional outreach and awareness services to farmers. It should be noted that substantial additional research is required into the net climate regulation impact of reduced tillage across the full range of South African soils and commodity types.

Cost of implementation

Interviewed stakeholders noted that the overall costs of reduced tilling, adjusting for initial changes in fertilizer, tractor and herbicide usage, should remain roughly the same as traditional farming practices over the course of several years. While labour and fuel costs are expected to decline as tillage is reduced, there is likely to be an equal increase in herbicide and equipment costs.

Monitoring, reporting and verification

Monitoring changes in soil carbon stocks across diverse landscapes can be prohibitively expensive. One of the reasons why there has been a subdued roll-out of climate change mitigation activities that focus on soil carbon stocks is due to the cost of implementation exceeding revenue from carbon offset sales. For this reason, an innovative, progressive monitoring approach will need to be pioneered for South Africa in which activity-based monitoring instead of carbon stock-based monitoring could be used.

Employment and skill development

Reduced/no tillage improves farming skills as farmers need to adopt various new pest and weed management strategies, including biological, physical and chemical measures to reduce the use of herbicides. The net impact on employment is unlikely to change.

Ecological infrastructure and ecosystem services

Reduced/no tillage systems can improve water infiltration, increase soil moisture and reduce runoff and water contamination as well as improve soil quality, reduce erosion and compaction, and increase surface soil organic matter. The water and soil quality and erosion benefits are often the primary reason for the adoption of reduced tillage systems, with carbon sequestration viewed as a marginal side benefit.

Risk considerations

As noted, an intact below-ground carbon pool is not exposed to typical risks associated with the land-use sector, such as fire and pests, being relatively stable over the long-term. The key risk is that the farmer may decide to return to or adopt traditional ploughing techniques.

Potential demonstration projects

As noted, there are substantial areas in certain provinces that are already under no till. Interviewed stakeholders advise that these be used as demonstration projects, on which to expand research and develop concepts for enhanced roll-out and adoption.

ACTIVITY SUMMARY

Key Positives	• A climate change adaptation measure; • Energy and labour across the total production process can be reduced; • Less amounts of fertilisers used and lower production costs; • Increases crop productivity; • Maintenance or increase in soil organic matter content (enhanced soil quality); • Soil improvement (chemical, physical and biological characteristics); no-tilled soils tend to be cooler than others, partly because a surface layer of plant residues is present. Carbon is sequestered in the soil enhancing its quality, reducing the threat of global warming; • Reduction in wind and water erosion; • Increased water infiltration into the soil and increased soil moisture.
Key Trade-Offs and Concerns	• Herbicides must be used often, but risks being overexploited and used in excessive volumes. Application of herbicides is critical in cases where the farmer does not plough or till to control weeds and grasses.

7. Providing required support for implementation

During the stakeholder engagement process, participants were asked what barriers exist to implementation, what is required to unlock projects, what capacity is needed and so forth. An almost universal response is that there is a clear need for a “national facilitation unit” (NFU) that would facilitate and support implementation. Its role would range from the initial creation of awareness of opportunities, to extension and support services, to the cost-efficient monitoring, reporting and verification of generated emission reductions, as well as the creation of cost-effective and dependable incentive mechanisms.

Stakeholders were also asked what principles should inform a national scale programme and associated strategy. The initial set included efficiency, robustness, and transparency, which are fairly common principles in the general global discourse relating to climate change mitigation frameworks. In addition to these more general principles, a set of more South African specific principles and concerns were raised. These focused on the need for the principle of inclusivity, where including emerging farmers and communal areas would be a priority regardless of immediate cost efficiencies. Another principle raised by South African stakeholders was the need to focus beyond the carbon benefit, to greater set of socio-economic and environmental benefits. In this case, while some activities may not deliver a substantial carbon dividend, it may still be appropriate to pursue them if the ecological infrastructure (water) and social benefits (employment) are substantial.

Key elements of required support

Informed by this set of principles, stakeholders suggested a set of elements that need to be undertaken to realize the full opportunity at a national scale. These included the typical components of a carbon project supply chain:

- Implementation on the ground
- Monitoring, reporting and verification
- Marketing and buyer-engagement, and disbursement of payments for qualified offsets

Stakeholders also included a broader suite of elements, which ensures that the programme is inclusive and that the full opportunity is realized at a national scale. These elements include:

- Awareness and support services
- A cost efficient national MRV system
- Research and strategy development
- Funds and disbursement management
- Integration with policy and regional planning
- The need for a champion and substantial operational capacity
- Third party accreditation

A potential institutional structure for a national programme

(Our intention here is to describe the roles and functions of potential national framework, but not to identify where the entity should be located in government or a parastatal).

Following a comprehensive review of required tasks and roles, as well as consideration of the guiding principles proposed by stakeholders, a two-tier structure is suggested (Fig. 8). The first is the "national facilitation unit", which would provide overriding strategic direction, support and governance at a national scale. At an elementary level, it is anticipated that the NFU would include a Chief Director and Operating Officer as well as directors of procurement, accounting and scientific services. The second is the establishment of a "Centre of Development" for each of the principal climate change mitigation opportunities that would focus solely on supporting the roll-out of a particular activity in terms of local planning support, awareness creation, extension services to communities and farmers, as well as research needs particular to the activity.

As there is understandable caution about starting new institutions, the intention would be to start with a small 4-6 person team that would initiate the NFU and focus on removing the key barriers-to-entry that are currently inhibiting the top 3-4 most promising land-use based mitigation opportunities. Thereafter, the intention would be to gradually increase the size of the unit based on needs and full comprehensive assessments of the remaining climate change mitigation activities.

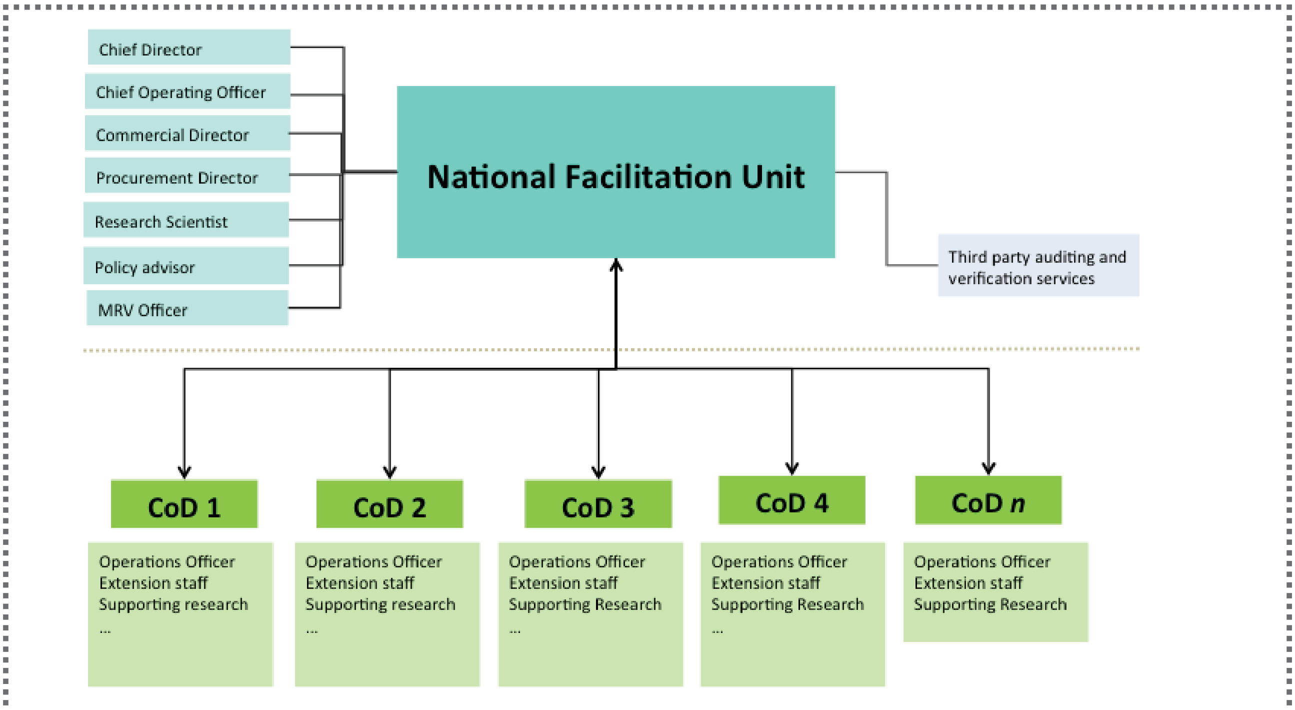

Figure 8. *Suggested organizational structure for a National Facilitation Unit and its Centres of Development*

Required functions and the suggested location thereof

- ***Awareness and support services**:* A pervasive issue continually raised by almost all practitioners, is that there is currently very little awareness of the opportunity on the ground. In addition, there is an important need to take a more balanced bottom-up approach through the development of long-term, comprehensive land-use and business plans that enable communities and land-owners to manage an area of land in a financially feasible manner over 20-30 years. It is anticipated that each CoD will provide a form of extension and support service.
- ***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 incurred associated with MRV through international standards. To address this, a robust, transparent and affordable MRV system will need to be created for each of the identified implementation options. These MRV structures should dovetail with the national MRV programme currently being developed by DEA, and support existing capacity where possible.
- ***Research development:*** Practitioners noted that despite early successes, there is a crucial need for further research into the ecological, operational and monitoring elements of implementation.
- ***Strategy development:*** It is anticipated that 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 of strategy development focuses on the realization of this vision, and how to strategically entrench that vision in a long-term roll-out plan.
- ***Income creation and management:*** An entity is required to manage the trade of generated emissions reductions that are generated from the entire programme, as well as to secure additional, alternative sources of revenue, for example payment for other ecosystem services (water), bilateral funding, disbursements from the national fiscus, accessing new international payment systems for climate change mitigation (Nationally Appropriate Mitigation Action - NAMAs), and government grants.
- ***Incentive mechanisms and disbursements:*** Once income is secured, an effective, cost-efficient, yet flexible disbursement and incentive mechanism is required. An entity is required to manage the cost-efficient and effective disbursement of generated income to implementation agents on the ground and to cover the operational costs of each of the Centres of Development.
- ***Integration with policy and regional planning:*** As noted in section 3's review of REDD through planning and regulation, integration with policy and regional planning needs to be addressed at two levels. At one level, the programme needs to be aligned with national policies and planning, to ensure that envisioned activities do not conflict with national land-use priorities in particular areas, and so that implementation can support broader national development goals. At the second level, Centres of Development should focus on activities that reduce emissions from deforestation and degradation through planning.
- ***The need for a champion and substantial operational capacity:*** In addition to this suite of functions and associated experts listed above, there is a clear need for core operational staff that, at a national scale, will take care of the day-to-day accounting, carbon offset registry and other operational issues. At the national office, it is anticipated that 2-3 individuals, led by a Chief Operating Officer, could undertake this work. An Operations Officer would manage each Centre of Development with supporting staff depending on the magnitude of the activity.
- ***Third-party accreditation:*** In line with the guiding principles, the program needs to be audited by a third party. The scope for auditing would include both the validation of activities on the ground, in a similar manner to the CDM or VCS validation/verification processes, as well as auditing of the internal registry and sale, transfer and retirement of generated emissions reductions.

This should be seen as an initial exploration of the functions required at a national scale. In the next phase of the national carbon sink program, it is anticipated that a dedicated assessment of both the NFU and each CoD will be made, including potential structure, capacity, roles, responsibilities, and governance.

Recommended next steps

We recommend that three principle elements be considered in terms of next steps:

The creation of long-term incentives for climate change mitigation activities

The realization of a national program as well as private and NGO sector activities relies on the creation of secure, long-term financial incentives for implementation. This is especially pertinent following the collapse of international carbon offset markets. The creation of a dependable, incentive mechanism within South Africa, for example, related to the National Carbon Tax, is vital to a national program and to encourage implementation within the private and NGO sectors.

It is suggested that a focused scoping analysis is undertaken that explores all potential sources of revenue for climate change mitigation activities in South Africa, including broader payment for ecological infrastructure, ecosystem services and climate change adaptation.

The development of a "National Facilitation Unit"

A "National Facilitation Unit" has been proposed as a solution to the needs and requirements raised by interviewed members of Government as well as field practitioners. Whereas this analysis provides good justification for the unit and suggests an initial structure, a more comprehensive assessment is required of its scope of activities, governance, location within Government or a parastatal, required capacity and how capacity would be increased over time in a financial sensible manner. An initial assessment is suggested that would be built upon over time as each of the implementation options are developed.

A comprehensive analysis of each climate change mitigation opportunity

This report includes an initial exploration of the eight principle land-use based climate change mitigation activities located in South Africa. The analysis provides a good foundation but a dedicated, comprehensive analysis of each opportunity is required as a next step. In terms of prioritization, it is suggested that Government focus on the first five activities in Table 1:

- Restoration of sub-tropical thicket and forests
- Restoration and management of grasslands
- Commercial small-grower afforestation
- Biomass energy
- Anaerobic biogas digesters

A substantial amount of work has been undertaken on each of these activities to date, with field practitioners ready to start implementation in the short to medium term (1-3 years). In certain cases, initial implementation has already begun.

The remaining three activities provide good opportunity but may require further research prior to their realization. One should not discount their potential value and especially over time, REDD through planning may form one of the leading mitigation opportunities in the country. At present, however, they are not as well known or as developed as the five activities listed above.

References

Adie, H., Rushworth, I., & Lawes, M. J. (2013). Forest Ecology and Management Pervasive , long-lasting impact of historical logging on composition , diversity and above ground carbon stocks in Afrotemperate forest. Forest Ecology and Management, 310, 887–895.

Al-Kaisi, M. M., & Yin, X. (2004). Stepwise time response of corn yield and economic return to no tillage. Soil and Tillage Research, 78(1), 91–101.

Aucamp, A. J. (1979). Die produksiepotensiaal van die Valleibosveld as weiding vir Boer- en Angorabokke. University of Pretoria.

Austin, G., & Bliqnaut, J. (2008). South African National Rural Domestic Biogas Feasibility Assessment: Prepared for Ministry for Development Co-operation, The State of the Netherlands. Cape Town.

Baker, J. M., Ochsner, T. E., Venterea, R. T., & Griffis, T. J. (2007). Tillage and soil carbon sequestration—What do we really know? Agriculture, Ecosystems & Environment, 118(1-4), 1–5.

Blignaut, J. N. (2008). Making markets work for people and the environment: Combating poverty and environmental degradation on a single budget while delivering real services to real people: The Second Economy Strategy Project, An Initiative of the Presidency.

Bliqnaut, J. N. (2009). Estimating the size of the renewable energy sector. Pretoria.

Bolliger, A. (2007). Is zero-till an appropriate agricultural alternative for disadvantaged smallholders of South Africa? A study of surrogate systems and strategies, smallholder sensitivities and soil glycoproteins. University of Copenhagen, Copenhagen.

Bundy, C. (1989). The rise and fall of South African peasantry. Johannesburg: David Phillip.

Burton, S., Cohen, B., Harrison, S., Pather-Elias, S., Stafford, W., van Hille, R., & von Blottnitz, H. (2009). Energy from wastewater - a feasibility study. Technical Report (p. 120). Pretoria.

Chamberlain, D., Essop, H., Hougaard, C., Malherbe, S., & Walker, R. (2005). Part I: The contribution, costs and development opportunities of the Forestry, Timber, Pulp and Paper industries in South Africa (p. 183). Johannesburg.

Conant, R. T., & Paustian, K. (2002). Potential soil carbon sequestration in overgrazed grassland ecosystems. Global Biogeochemical Cycles, 16(4), 90–1–90–9. doi:10.1029/2001GB001661

Cowling, R. M., & Mills, A. J. (2011). A preliminary assessment of rain throughfall beneath Portulacaria afra canopy in subtropical thicket and its implications for soil carbon stocks. South African Journal of Botany, 77(1), 236–240.

DEA. (2013). Long-Term Adaptation Scenarios Flagship Research Programme (LTAS) for South Africa: Climate change implications for the water sector in South Africa (p. 43). Pretoria, South Africa.

Farage, P. K., Ardo, J., Olsson, L., Rienzi, E. A., Ball, A. S., & Pretty, J. N. (2007). The potential for soil carbon sequestration in three tropical dryland farming systems of Africa and Latin America: A modelling approach. Soil and Tillage Research, (94), 457–472.

Gebhardt, M. R., Daniel, T. C., Schweizer, E. E., & Allmaras, R. R. (1985). Conservation tillage. Science, (230), 625.

Geldenhuys, C. J. (2009). Managing forest complexity through application of disturbance–recovery knowledge in development of silvicultural systems and ecological rehabilitation in natural forest systems in Africa. Journal of Forest Research, 15(1), 3–13.

Giller, K. E., Witter, E., Corbeels, M., & Tittonell, P. (2009). Conservation agriculture and smallholder farming in Africa: The heretics' view. Field Crops Research, 114(1), 23–34. doi:10.1016/j.fcr.2009.06.017

Glenday, J. Carbon Storage and Sequestration Analysis for the eThekwini Environmental Services Management Plan Open Space System (2007).

IRP. (2011). Integrated resource plan for electricity 2010-2030 (p. 73). Pretoria.

Knowler, D., & Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: a review and synthesis of recent research. Food Policy, 32, 25–48.

Knowles, T., & Pienaar, E. (2010). Enkangala Ecosystem Services Study: A field assessment of the effect of historical grazing and fire regimes on below-ground carbon stocks in temperate grassland systems (p. 42). Pietermaritzburg.

Knowles, T., von Maltitz, G. P., & Makhado, R. (2007). The uKhahlamba – Drakensberg Park World Heritage Site Carbon Sequestration Project Feasibility Study (p. 57). Pietermaritzburg.

Knowles, Tony. (2011). Realising REDD in Africa : Risk , feasibility and supporting policy. University of Stellenbosch.

Lal, R. (2003). Global Potential of Soil Carbon Sequestration to Mitigate the Greenhouse Effect. Critical Reviews in Plant Sciences, 22(2), 151–184. Retrieved from h

Lechmere-Oertel, R.G., Kerley, G. I. H., & Cowling, R. M. (2005). Patterns and implications of transformation in semi-arid succulent thicket, South Africa. Journal of Arid Environments, 62(3), 459–474. Retrieved from h

Lechmere-Oertel, Richard Geoffrey. (2003). The effects of goat browsing on ecosystem patterns and processes in succulent thicket , South Africa, (October).

Lloyd, J. W., van den Berg, E. C., & Palmer, A. . (2002). Patterns of Transformation and Degradation in the Thicket Biome, South Africa. Port Elizabeth.

Loke, P. F., Kotzé, E., & Du Preez, C. C. (2012). Changes in soil organic matter indices following 32 years of different wheat production management practices in semi-arid South Africa. Nutrient Cycling in Agroecosystems, 94(1), 97–109.

Luijk, G. Van, & Cowling, R. (2013). Hydrological implications of desertification : Degradation of South African semi-arid subtropical thicket. Journal of Arid Environments91, 91, 14–21.

Manson, A. D., Jewitt, D., & Short, A. D. (2007). Effects of season and frequency of burning on soils and landscape functioning in a moist montane grassland. African Journal of Range and Forage Science, 24(1), 9–18.

Marais, C., Cowling, R. M., Powell, M., & Mills, A. (2009). Establishing the platform for a carbon sequestration market in South Africa : The Working for Woodlands Subtropical Thicket Restoration Programme. In XIII World Forestry Congress (pp. 18–23).

Marais, C., Eckert, J., & Green, C. (2000). Utilisation of invaders for secondary industries, a preliminary assessment. Best management practices for preventing and controlling invasive alien species. In Working for Water Symposium. Cape Town.

Mararakanye, N., & Le Roux, J. J. (2011). Manually Digitizing of Gully Erosion in South Africa Using High Resolution: SPOT 5 Satellite Imagery at 1:10 000 scale. Pretoria.

Mills, a. J., & Cowling, R. M. (2010). Below-ground carbon stocks in intact and transformed subtropical thicket landscapes in semi-arid South Africa. Journal of Arid Environments, 74(1), 93–100. doi:10.1016/j.jaridenv.2009.07.002

Phillips, R. E., Blevins, R. L., Thomas, G. W., Frye, W. W., & Phillips, S. . (1980). No-tillage agriculture. Science, 208, 1108–1113.

Powell, M. J. (2009). Restoration of degraded subtropical thickets in the Baviaanskloof MegaReserve, South Africa. Master Thesis, Rhodes University.

Roberts, K. G., Gloy, B. a, Joseph, S., Scott, N. R., & Lehmann, J. (2010). Life cycle assessment of biochar systems: estimating the energetic, economic, and climate change potential. Environmental science & technology, 44(2), 827–33.

Scholes, R. J., von Maltitz, G. P., Archibald, S. A., Wessels, K., van Zyl, T., Swanepoel, D., & Steenkamp, K. (2013). National Carbon Sink Assessment: First estimate of terrestrial stocks and fluxes (p. 36). Pretoria.

Sparrevik, M., Field, J. L., Martinsen, V., Breedveld, G. D., & Cornelissen, G. (2013). Life cycle assessment to evaluate the environmental impact of biochar implementation in conservation agriculture in Zambia. Environmental science & technology, 47(3), 1206–15.

Van Rooyen, M. W., van Rooyen, N., & Stoffberg, G. H. (2012). Carbon sequestration potential of post-mining reforestation activities on the KwaZulu-Natal coast, South Africa. Forestry, 86(2), 211–223.

Wassenaar, T. D., van Aarde, R. J., Pimm, S. L., & Ferreira, S. M. (2005). Community convergence in disturbed sub-tropical dune forest. Ecology, (86), 655–666.

Watson, R. T., Noble, I. R., Bolin, B., Ravindranath, N. H., Verardo, D. J., & Dokken, D. J. (2000). IPCC 2000: Land Use, Land-Use and Forestry (p. 375). Cambridge University Press.

Woolf, D., Amonette, J. E., Street-Perrott, F. A., Lehmann, J., & Joseph, S. (2010). Sustainable biochar to mitigate global climate change. Nature communications, 1(5), 56.