mitigation REPORT

SOUTH AFRICA'S GREENHOUSE GAS MITIGATION POTENTIAL ANALYSIS

TECHNICAL APPENDIX G – AGRICULTURE, FORESTRY AND OTHER LAND USE (AFOLU) SECTOR

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On behalf of:
Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
of the Federal Republic of Germany

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The suite of reports that make up South Africa's Greenhouse Gas (GHG) Mitigation Potential Analysis include the following:

Technical Summary

Main Report

Technical Appendices:

Appendix A: Approach and Methodology

Appendix B: Macroeconomic Modelling

Appendix C: Energy Sector

Appendix D: Industry Sector

Appendix E: Transport Sector

Appendix F: Waste Sector

Appendix G: Agriculture, Forestry and Other Land Use Sector

List of Abbreviations

Acronym	Definition
AFOLU	agriculture, forestry and other land use
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
GHG	greenhouse gas
GVA	gross value added
IPCC	Intergovernmental Panel on Climate Change
$ktCO_2e$	kilotonnes of carbon dioxide equivalent
MAC	marginal abatement cost
MACC	marginal abatement cost curve
MCA	multi-criteria analysis
$MtCO_2e$	million tonnes of carbon dioxide equivalent
N_2O	nitrous oxide
NCCRP	National Climate Change Response Policy
NPV	net present value
STRP	Subtropical Thicket Restoration Programme
TWG-M	Technical Working Group on Mitigation
UNFCCC	United Nations Framework Convention on Climate Change
WAM	'with additional measures' scenario
WEM	'with existing measures' scenario
WOM	'without measures' scenario
ZAR/R	South African rand

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1. Introduction

This appendix covers projected emissions and mitigation potential for the agriculture, forestry and other land use (AFOLU) sector. Mitigation options covering the following IPCC emission categories have been considered in this assessment:

- 3A1 enteric fermentation
- 3A2 manure management
- 3B1 forestry land remaining forestry land and land converted to forest land
- 3B1b land converted to forest land
- 3B1-6b land converted into other land
- 3B2 cropland remaining cropland and land converted into cropland
- 3C4 direct N_2O from managed soils
- 3C1 biomass burning

Emissions projections consider all of these categories but, in the case of forestry, deal only with commercial forestry and not natural forests. In the case of natural biomes, only measures which can be undertaken through managed programmes are considered and broader shifts to these biomes resulting from unmanaged activities or climate change are not addressed.

The final list of mitigation options presented for the AFOLU sector (Table 2) was agreed after correspondence and collaboration with the AFOLU Task Team and other experts and specialists in the field.

2. Reference Case Projection

The structure for making projections for the GHG mitigation analysis as a whole provides for projections of emissions 'without measures' (WOM) and 'with existing measures' (WEM). The WOM projection assumes that no climate change mitigation actions are implemented between 2000 and 2050. The WEM projection incorporates the impacts of climate change mitigation actions including climate change policies and measures implemented between 2000 and 2010, and projects future emissions to 2050 on this basis.

In the case of the AFOLU sector, there are no major 'existing measures' which are significant enough to include and, therefore, the assumption is that the WOM and WEM projections are identical.

2.1 Approach

The starting point for this analysis is the concept of a projection of emissions from 2010 to 2050 'without measures'. From the point of view of GHG emissions, the division of the sector into productive activity (under the agriculture and commercial forestry sectors) and non-productive activity (associated with changes to natural biomes) needs to be recognised. In each case the emissions projections are driven by a different set of factors.

2.1.1 Projections related to productive sectors

In the case of productive activity, projections are driven by: economic growth which may lead to higher levels of production changes to production due to technology and management practices which are not related to mitigation measures constraints to production which limit growth of the sector the balance between local production and imports.

Based on an analysis of land use data, the opinions of land use sector specialists and the AFOLU Task Team, discussions, an important assumption has been made: that land areas under crop production and commercial forestry are stable.[1] Therefore, economic growth is not a driver of emissions in this sector. While the demand for agricultural products continues to grow, this demand is being met through production on areas which remain largely the same, complemented by growing imports.

1. In addition, data on croplands is too unreliable since the Abstract of Agricultural Statistics (DAFF, 2012) reports a decreasing trend, while satellite imagery shows that croplands are increasing. It is therefore assumed that cropland and the related indirect emissions from managed soils are stable.

This implies a reference case with stable emissions of nitrous oxide (N_2O) from cropland, both direct and indirect. It also implies zero carbon emissions (or carbon sequestration) from the commercial forestry sector for the reference case.[2] This is based on the assumption that the area under commercial forestry is stable with harvested timber replaced continuously by new growth.[3]

In the case of the livestock sector, the reference case projections are driven by the declining trends in herd numbers (DAFF, 2012) and increases in location of cattle on feedlots. Herd numbers are declining hence emissions from enteric fermentation decline. Increasing use of cattle feedlots leads to increases in emissions from manure management for the reference case (Scholes pers. comm., 2013; SA Feedlot Association, 2013).

2.1.2 Projections relating to natural biomes

The changes in emissions from natural biomes relate to changing land areas under various vegetation types and the change in plant and soil carbon density on these land areas. There is data on land area change but, at the time of writing, this was not considered reliable enough to make projections of carbon stock trends.[4] However, the Department of Environmental Affairs has acknowledged the importance of having a better understanding of carbon stock changes and hence has initiated a 'Sinks and Sources' study which will address these data gaps. In the interim, and for the purpose of this reference case projection, zero net emissions are assumed from natural biomes, other than through biomass burning.

Emissions from biomass burning show a marginal decrease over time and existing data has been used to project the level of current emissions and the trend (Archibald pers. comm., 2013).

2.2 'Without Measures' Reference Case Projection

The reference case for the AFOLU sector is based on a 'with existing measures' projection that is identical to the 'without measures' projection. The single reference case projection is shown in Figure 1 and Table 1 below. The figures for emissions are calculated based on the IPCC methodology and are consistent with the draft 2010 national GHG Inventory (DEA, 2013) calculations as they were at the time this reference case projection was finalised in June 2013.[5]

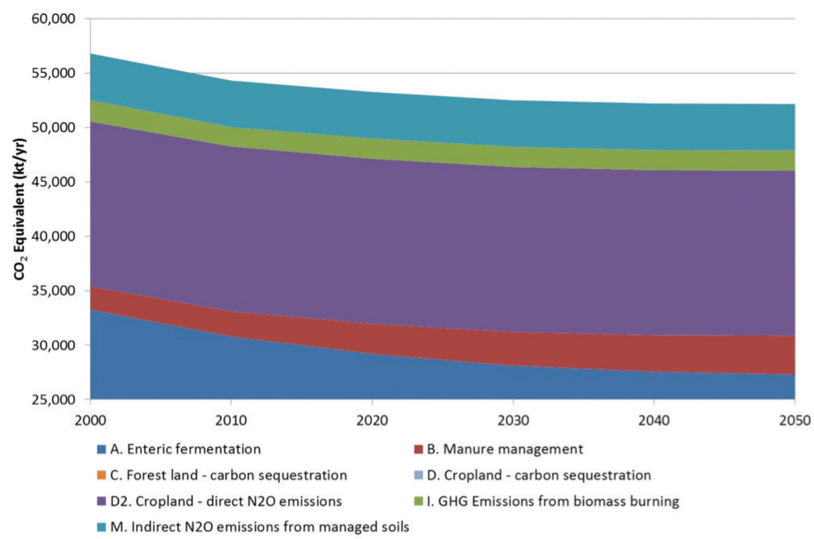

Figure 1: AFOLU reference case emissions projection

2. Note that this applies to plantation activity only and not to the 'downstream' activities associated with processing timber products. The latter are covered under the Pulp and Paper sector.
3. It is recognised that there is a shift in density as trees with low density are replaced with higher density species. However, it has not been possible to assess the extent of this change.
4. The primary reason for this is the change in land sensing methodology over the past decade.
5. A full set of calculations relating to the reference case is available on request.

Table 1: Reference case projection for AFOLU: Total of all GHG emissions

CO_2 equivalents (kt/yr)	2000	2010	2020	2030	2040	2050
A. Enteric fermentation	33,274	30,819	29,199	28,118	27,573	27,306
B. Manure management	2,135	2,297	2,784	3,107	3,363	3,578
C. Forest land – carbon sequestration*						
D. Cropland – carbon sequestration						
I. GHG emissions from biomass burning	1,969	1,772	1,861	1,858	1,856	1,853
D2. Cropland – direct N_2O emissions	15,150	15,150	15,150	15,150	15,150	15,150
M. Indirect N_2O emissions from managed soils	4,273	4,273	4,273	4,273	4,273	4,273
Total	**56,801**	**54 311**	**53,268**	**52,506**	**52,216**	**52,159**

* Forest land is taken here to include both natural and commercial forests. As stated above, there is not sufficient evidence to be able to predict a change in either case so no sequestration is provided for (positive or negative). Further research is needed in the future to better understand this.

It is evident from this analysis that there are gaps in the data primarily associated with the trends relating to carbon sources and sinks. This applies to forestry where, in the case of commercial forests, the situation is considered to be stable, as mentioned earlier in this document. In the case of cropland the data on carbon sequestration is too limited to make projections. Further research is needed and, to a large extent, will be covered by the DEA 'Sources and Sinks' study. Further research is also required to improve the understanding of trends for N_2O emissions which are assumed as constant in the analysis summarised above.

3. Identification of Mitigation Measures

The starting point for these measures was to put together a list of possible measures for consideration, with Table 2 below showing the full list of mitigation measures initially identified by the AFOLU Task Team. The applicability of these measures was then assessed by the project team and debated by the AFOLU Task Team. The table includes a summary of the assessment of each measure with a motivation for either including or excluding the options from the analysis.

It is notable that the reasons for not including some of the measures relates to a lack of data/research. This is particularly the case with conservation agriculture and veld fire management. Research into some of the measures which are included as mitigation measures is also needed to improve the data. Biochar addition to cropland and better data on South African experience with digestion of manure are cases in point.

Table 2: List of mitigation opportunities identified by the AFOLU Task Team

Subsector	Abatement measure/ mitigation opportunity	Motivation for inclusion or exclusion	Included?
3A1 Enteric fermentation	Livestock herd management (herd size, age, composition) and diet quality	Although herd size, age and composition is a practical and substantial intervention, it is not considered an 'additional measure' as it is taking place as part of existing measures not related to GHG mitigation initiatives.[7] Therefore this is not considered to be a mitigation option. Further, there is not enough evidence on the impact of dietary supplements to consider this as a mitigation measure.	No
3A2 Manure management	Reducing GHG emissions from manure management systems: livestock waste management (treatment through biogas digesters)	It is assumed this is an important mitigation option, particularly as use of feedlots increases. Considered a genuine mitigation option.	Yes
3B1 Forestry land remaining forestry land and land converted to forest land[8]	Tree planting: plantation forestry (expansion of plantations)	A practical intervention with potential for substantial mitigation. However, due to the fact that water availability limits forestry expansion, this mitigation option is analysed as a substitute for irrigated agriculture.	Yes
3B1b Land converted to forest land	Tree planting: urban tree planting	Practical intervention with growing interest from municipalities.	Yes
3B1b Land converted to forest land	Tree planting: carbon sink projects using trees (thicket restoration)	Practical intervention with experience in the country increasing.	Yes
3B1-6b Land converted into other land	Restoration of degraded lands (restoration of mesic grasslands)	Long range intervention but with important potential benefits.	Yes
3B2 Cropland remaining cropland and land converted into cropland	Biochar or other soil organic amendments (Assuming alien vegetation as a source of biochar)	Although insufficient evidence exists, biochar is gaining international acceptance as a feasible means of sequestering carbon. Therefore it is considered as a mitigation measure.	Yes

Subsector	Abatement measure/ mitigation opportunity	Motivation for inclusion or exclusion	Included?
3C4 Direct N_2O from managed soils	Fertiliser use: type, dose, placement, timing, adjuvants	While there is some contention over this the balance of research findings indicate that the reduction in emissions from fertilisers is small. Further, farming practice in SA is already relatively well developed with limited opportunity for substantial improvements in terms of emissions. In any event it is difficult to measure improvements and label them as mitigation measures.	No
3B2 Cropland remaining cropland and land converted into cropland	Conservation agriculture (conservation tillage and cropping systems)	Improved agricultural practice, specifically conservation agriculture has been assessed. Although conservation agriculture has many benefits, there is not enough evidence to confirm it as a mitigation option. There is no data and therefore experts agreed that this option could not be quantified in a meaningful way.	No
3B2 Cropland, remaining cropland and land converted into cropland	Biofuels: dedicated energy, crops	Energy related crops are included under cropland generally. The use of crops for energy (i.e. mitigating fossil fuel emissions) is not part of the AFOLU sector.	No
3B1b Land converted to forest land	Tree planting: agro-forestry (trees on farms)	Agroforestry is already well developed in South Africa and there is very limited opportunity for further gains in wood density.[9]	No
3C1 Biomass burning	Veld fire management	Veld fires are already fairly well managed in SA and there is thus limited change anticipated. There are also uncertainties relating to the aggregate benefits of fire management. Burning has recognised benefits but also recognised negative impacts. Before this can be considered as a mitigation measure further research is needed.	No
3C1 Biomass burning	Residue burning	This is more appropriately included in the energy sector.	No

Agreement was reached on the final mitigation opportunities after correspondence and collaboration with the AFOLU Task Team and other experts and specialists in the field. The final list includes:

- treatment of livestock waste
- expanding plantations
- urban tree planting
- rural tree planting (thickets)
- restoration of mesic grasslands
- biochar addition to cropland.

7. Changes in livestock numbers are considered as part of the reference case but not taken into consideration as a mitigation option (in other words such changes will take place for economic reasons not because of climate change mitigation objectives).

8. The definition of forest land is taken to include urban trees, thickets and other forests. The definition of forests needs to be clarified by the DEA for the future.

9. At the final AFOLU Task Team meeting, the inclusion of wind breaks for fruit orchards and vineyards was raised as a potential factor. However, the impact was considered to be too small to merit inclusion as a mitigation measure.

4. Costing and Mitigation Potential of Mitigation Measures

4.1 Basis for Costing

The assumptions used for making mitigation projections and costing the intervention in each case are given in Table 3 below:

Table 3: Costing and mitigation potential of mitigation measures for the AFOLU sector

Mitigation option	Basis for estimating quantum of emission mitigation	Key data elements	Key data sources
Treatment of livestock waste	All pigs are in piggeries; Cattle in feedlots during fattening stage increases at current rate to a maximum of 70%. Percentage of piggery and cattle feedlot waste treated with anaerobic digestion increases to 70%.	Manure projections per animal; capital and operating costs of digesters taken from literature.	Svoboda, 2003; Moser et al., 1998; Scholes pers. com., 2013; Stevens pers. comm., 2013
Expanding plantations	Current plans for 100,000 ha of new forests to be implemented. In addition, a further 100,000 ha to be developed with associated loss of water to the agriculture sector. Assumption that irrigated maize production will be reduced to allow equivalent water to be used for commercial forestry.	Since measure offsets forestry against agriculture to get water rights, assessment of impact on agriculture required. Irrigated maize assumed to be the counterfactual. Operating and capital cost of establishing new commercial forestry and irrigated maize taken from current catchment management studies.	Everard, SAPPI & Task Team member;
Urban tree planting	Assumption is one tree per household with backlog made up over 20 years and all new urban developments to have this number of trees.	Backlog estimates based on assumption that low income areas do not have trees; literature used for carbon content per tree; operating costs taken from recent experience.	Data from Basil Reid based on Cosmo City, pers. comm., 2013; Stoffberg, 2006
Rural tree planting (thickets)	Assumes thicket regeneration only possible in 800,000 ha of Eastern Cape. Assumes at current planting rate (based on STRP), 20% of this area will be planted over 40 years.	Area of thicket potential, planting rate, quantity captured per annum; cost per ha planted.	Mills, 2006 & 2013; Knipe, 2013; Powell, 2009; van der Vywer, 2011
Restoration of mesic grasslands	Restoration assumed to take place only on degraded mesic grasslands.	Area of mesic grassland suited for restoration; carbon sequestration rates, cost per hectare restored.	Blignaut et al., 2010; Carbutt et al., 2010
Biochar addition to cropland	Assumes that only alien invasive trees will be used as feedstock. 30% of wood to be used for biochar.	Carbon content per ha applied, carbon production from kilns assumed, assumes applied to soil at appropriate rate, capital and operating costs of biochar kilns taken from literature.	Shackley et al. 2010

4.2 Marginal Abatement Cost Curves

Marginal abatement cost curves (MACCs) provide insight into the marginal costs and associated mitigation potential at snapshots in time. In relation to the overall approach in assessing the relative impact of mitigation measures they only consider one criterion, cost.

In interpreting the results of the MACC in Figure 2 below, it is notable that the expanding plantations measure not only has the lowest marginal abatement cost (cost savings estimated to be -R91/tCO_2e), but that it also mitigates the most emissions (an estimated 2,400 ktCO_2e). The restoration of mesic grasslands has the highest marginal abatement cost (R480/tCO_2e), while the treatment of livestock waste mitigates the least emissions by 2020 (155 ktCO_2e). If all the options are implemented, a maximum of 5,315 ktCO_2e can potentially be mitigated in the year 2020.

In 2030 (Figure 3), expanding plantations, the treatment of livestock waste and biochar options all have negative marginal abatement costs and together mitigate an estimated 7,100 ktCO_2e. Restoration of mesic grasslands remains the option with the highest marginal abatement cost. In 2030, the total mitigation potential increases to 10,206 ktCO_2e. However, while these may be considered relatively easy measures to implement, other impacts need to be considered and are included as part of the multi-criteria analysis (MCA). This changes the relative priorities of these measures considerably, specifically commercial forestry which has high negative impacts under social and environmental criteria, for example.

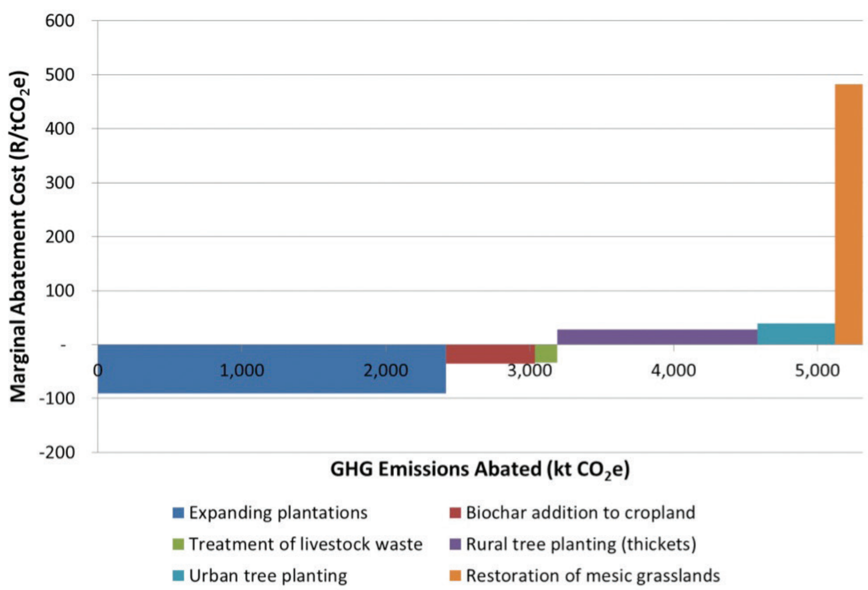

Figure 2: MACC for 2020 for the AFOLU sector

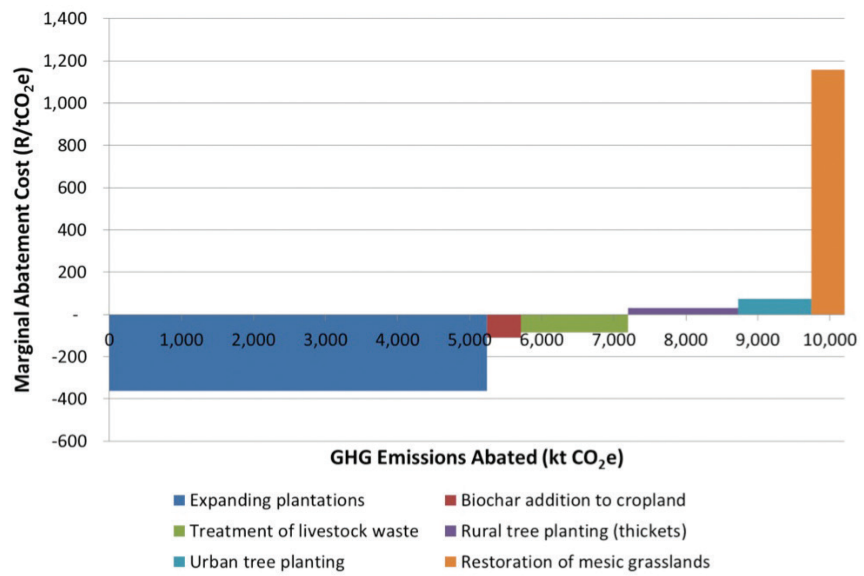

Figure 3: MACC for 2030 for the AFOLU sector

In 2050 (Figure 4), the expansion of plantations is no longer a mitigation option since the plantations can no longer expand and the total mitigation potential of the sector drops to 4,775 ktCO_2e. Rural tree planting and biochar addition to cropland contribute the most, while the mitigation potential from urban tree planting falls to 181 ktCO_2e as it is assumed that planting of existing areas is largely completed and the emphasis moves to newly developed areas. The expanding plantations, treatment of livestock waste and biochar options all have negative marginal abatement costs in 2050.

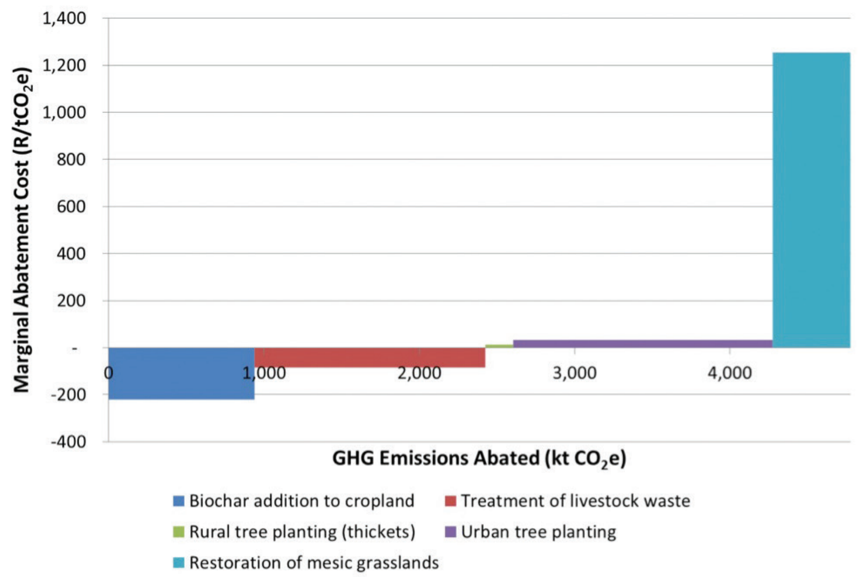

Figure 4: MACC for 2050 for the AFOLU sector

5. Projections 'With Additional Measures'

5.1 Technical Mitigation Potential

If all technically available mitigation potential in the AFOLU sector was implemented, then the current analysis shows that GHG emissions could be reduced by 5,315 ktCO_2e in 2020, 10,206 ktCO_2e by 2030 and 4,775 ktCO_2e by 2050. This represents a total potential reduction of 10%, 19% and 9% (respectively) of reference emissions under the WEM projection (Table 4).

Table 4: Technical mitigation potential for the AFOLU sector, assuming all measures are implemented (in ktCO_2e)

Measure	2020	2030	2050
Urban tree planting	539	1,016	1,671
Treatment of livestock waste	155	1,485	1,485
Biochar addition to cropland	619	473	939
Restoration of mesic grasslands	192	461	499
Rural tree planting (thickets)	1,392	1,532	181
Expanding plantations	2,418	5,240	0
TOTAL	5,315	10,206	4,775
TOTAL % Reduction (relative to WEM)	10.0%	19.4%	9.2%

5.2 The 'With Additional Measures' Projection

Applying all the measures identified above in the order in which they are ranked using the MCA, gives an emissions projection curve as shown in Figure 5.

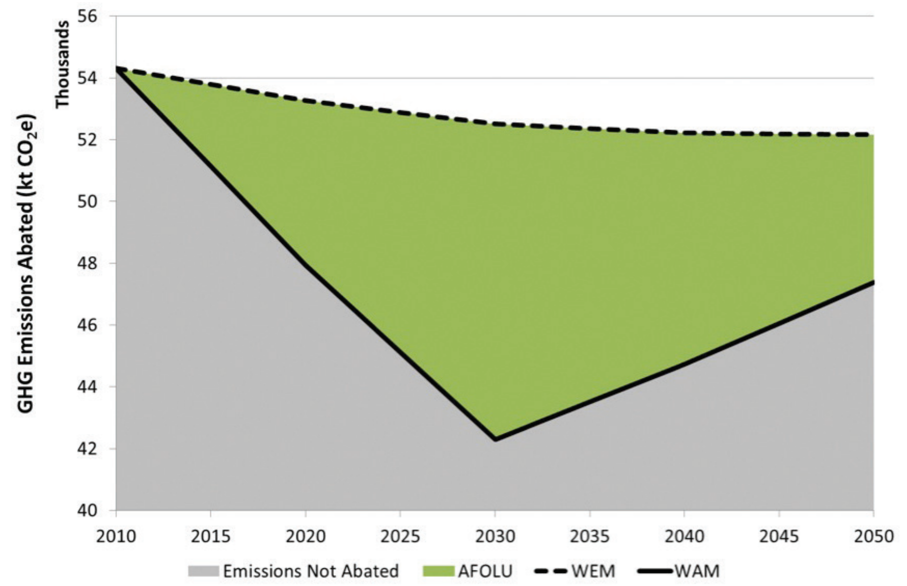

Figure 5: Emissions projections with all additional measures (WAM) for the AFOLU sector

6. Impact Assessment of Individual Mitigation Measures

The impact assessment is undertaken using the multi-criteria analysis (MCA) approach described in Section 12 of the Main Report and in Technical Appendix A: Methodology.

6.1 Scoring of Each Measure in Relation to Agreed Criteria

The criteria for assessing each measure are applied consistently across all sectors with the scoring and weighting options described in the Main Report. Two methods have been applied for scoring:

A quantitative assessment using the costs estimated for each measure and the economic models which provide figures for gross value added (GVA) (the economic criterion) and jobs (part of the social criterion).

A qualitative assessment based on scoring by the Sector Task Team.

In the case of the quantitative analysis which informs the cost, economic and social criteria, the data associated with each criterion is summarised in Table 5 below.

Table 5: Quantitative data informing the scoring of mitigation options for the AFOLU sector

	NPV* of costs per $ktCO_2e$ mitigated	GVA** impact per $ktCO_2e$ mitigated	Jobs created per $ktCO_2e$ mitigated	Ratio of unskilled to total jobs
	$R/ktCO_2e$	$R/ktCO_2e$	$Jobs/ktCO_2e$	
Expanding plantations	-1.84	3.09	0.02	0.34
Biochar addition to cropland	12.46	-0.29	0.00	1.37
Treatment of livestock waste	45.16	-2.11	1.12	0.71
Rural tree planting (thickets)	3.03	-0.33	0.24	0.73
Urban tree planting	11.56	-1.25	0.35	0.76
Restoration of mesic grasslands	293.22	-31.70	3.32	0.76

* *net present value*

** *gross value added*

Taking both quantitative and qualitative scores into consideration for each criterion, points are allocated to each measure with the results for the 'base scenario' shown in Table 6 below (zero is the worst result and 100 the best).

Table 6: Distribution of points assigned to each option for the AFOLU sector

Option descriptions	Cost	Economic impact	Social impact	Non-GHG environmental impact	Implementability
Expanding plantations	66.71	57.86	20.64	15.00	77.50
Biochar addition to cropland	63.48	52.23	36.94	95.00	50.00
Treatment of livestock waste	56.08	49.21	61.35	60.00	77.50
Rural tree planting (thickets)	65.61	52.17	56.72	95.00	85.00
Urban tree planting	63.68	50.63	83.46	75.00	100.00
Restoration of mesic grasslands	0.00	0.00	75.51	95.00	85.00

In comparing these results it is evident that, at the one extreme, expanding commercial forests has the lowest marginal abatement cost (forestry is a commercially viable business and hence also has a positive economic impact) and easy to implement (forestry is an established business in SA). However, forestry scores low on social impact (also in relation to agriculture it displaces) and low on environmental impact (uses large amounts of water, reduces biodiversity).

Almost all of the other measures score high for environmental impact but they are all costly. Biochar is a new measure which has yet to be applied in SA at scale. As conceived for this project, with the biomass feedstock coming from invasive aliens, it will be difficult to implement and costly.

Restoration of mesic grasslands is also a high-cost measure, with negative economic impact as a consequence. Nonetheless, the measure does create jobs, particularly low-skilled jobs. The measure also scores relatively highly for non-GHG environmental impacts and implementability.

6.2 Net Benefit Curve

The concept of net benefit is described in Section 12 of the Main Report. In the case of the 'balanced weighting' scenario the net benefit curve is shown in Figure 6 below:

The amount of CO_2e which can be mitigated for each measure, for the full period from 2010 to 2050, is shown on the horizontal axis. In order to maximise the net benefit (as determined by the MCA analysis), the measures should be implemented in order from left to right as they appear in Figure 6.

According to the graph, urban tree planting should be implemented first since it achieves the highest integrated net marginal benefit score of 75.8 and mitigates a total of 20 $MtCO_2e$ over the 40 year period. Rural tree planting (thicket restoration) has an overall weighted score of 71 and mitigates the second highest amount of emissions (57 $MtCO_2e$) over the period. Although the expansion of plantations mitigates the highest amount of emissions (81 $MtCO_2e$), it attains the lowest overall weighted score of 46 as shown on the graph below. Although the restoration of mesic grasslands has high social and environmental benefits, the option is associated with high costs and therefore only attains a weighted score of 53.

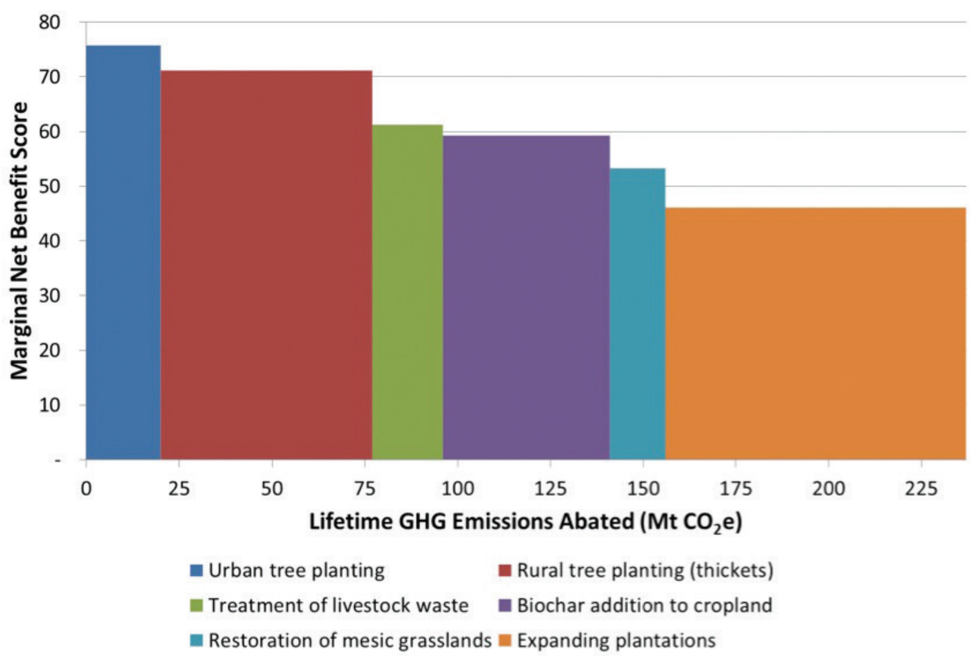

Figure 6: Net benefit curve for the balanced weighting scenario for the AFOLU sector

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