IMPLICATIONS

of a carbon tax and offset system for Agriculture in South Africa

A presentation by Agri SA's Commodity Chamber to the Department of Environmental Affairs, the Department of Agriculture, Forestry and Fisheries and National Treasury

AGRI SA

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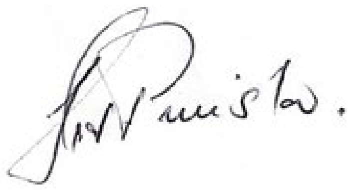
Preface

South Africa and the sub-continent are predicted to be on the forefront of unusual challenges as the negatives associated with climate change take effect. Agriculture is inextricably linked and bearing the brunt as it represents the primary responsibility to feed the nation amidst progressively adverse conditions. Since it shares the blame for anthropogenic greenhouse gas emissions, Agriculture has the obligation to limit its emissions and it accepts the responsibility to do so. In that context Agriculture is unique, because its mitigation contribution can be twofold, limiting emissions and increasing carbon storage and sequestration. However, whereas the means to limit emissions are modest, the possibilities to excel in sequestration and storage are vast and should be exploited vigorously. To do so will require dedication by all role players and stakeholders, including committing resources.

Government has opted for a carbon tax system to enhance mitigation in all sectors. Whereas, there may be positives associated with a tax system, this presentation argues for the option to implement a carbon incentive/offset scheme to support large scale implementation of carbon sequestration and storage programmes in Agriculture. In doing so, several environmental and socio-economic co-benefits should result.

"The Commodity Chamber of Agri SA wishes to express its sincere thanks to Heinz Meissner, Hendrik Smith (Grain SA), Hugh Campbell (Hortgro), Johan Pienaar and Nic Opperman who assisted greatly in the preparation of this presentation".



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Chairman: Agri SA Commodity Chamber

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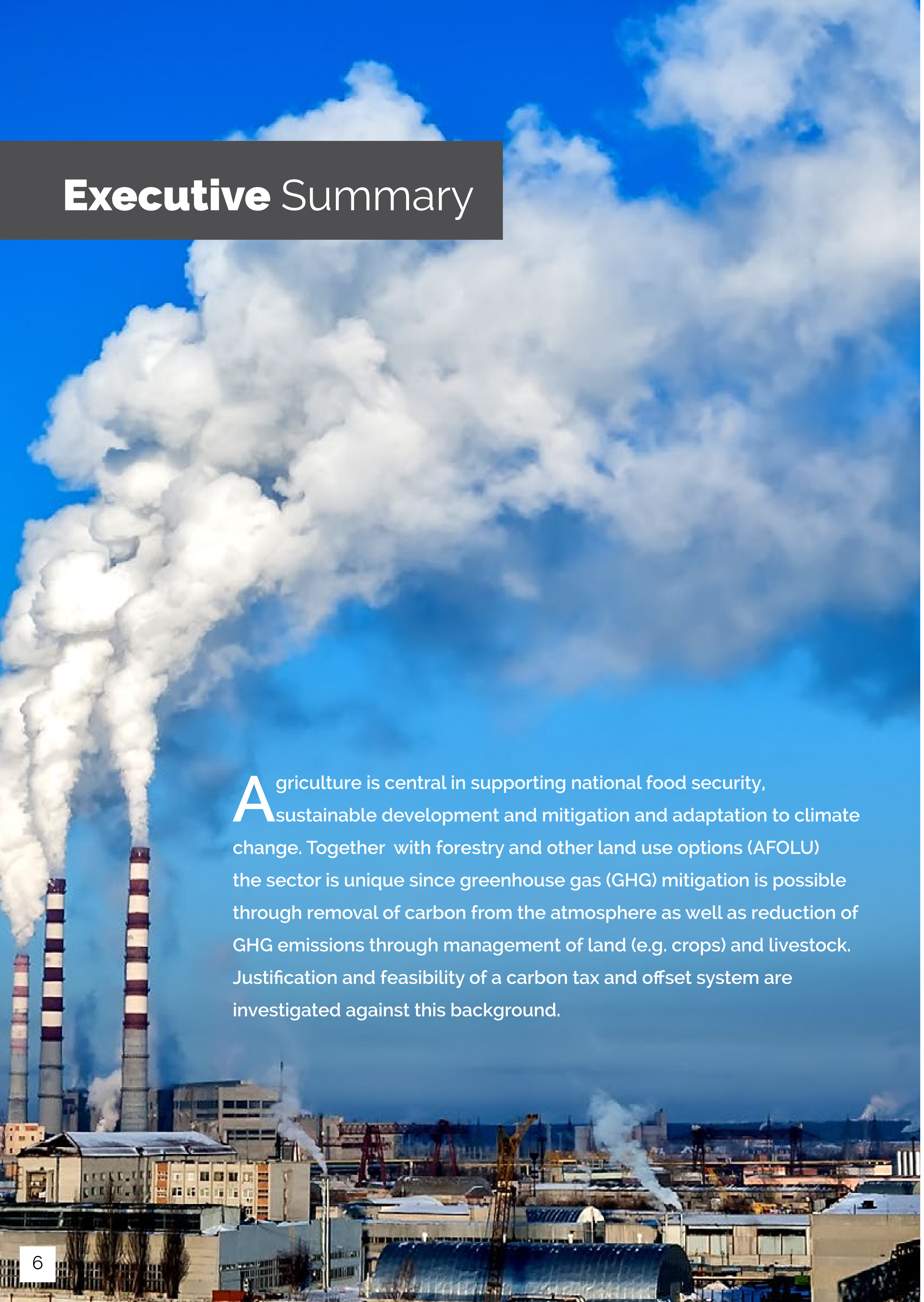

Executive Summary

Agriculture is central in supporting national food security, sustainable development and mitigation and adaptation to climate change. Together with forestry and other land use options (AFOLU) the sector is unique since greenhouse gas (GHG) mitigation is possible through removal of carbon from the atmosphere as well as reduction of GHG emissions through management of land (e.g. crops) and livestock. Justification and feasibility of a carbon tax and offset system are investigated against this background.

Agriculture contributes only 2.3% to South Africa's gross domestic product (GDP), but its importance in the South African economy is recognized if all backward and forward linkages are included in its influencing sphere. When this is done its contribution increases 5-fold. Gross farm income was R225 760 million in 2015. Of the 70 000 commercial farmers in South Africa less than 10% can be regarded as mega-farmers with a gross income in excess of R3 million per year, whereas about 75% have a gross income of R500 000 or less. Employment in agriculture amounts to 897 000, illustrating agriculture's significant role in job creation. Commercial agriculture is divided into three major groups: grain crops, horticulture and livestock. Their contribution to the agricultural economy, and GHG emissions and potential mitigation is discussed separately in the text.

The risks associated with climate change will affect agricultural sustainability and resilience. This depends on maintenance of water, soil and vegetation integrity, biodiversity and ecosystem conservation. Agriculture can provide both adaptation-mitigation services to climate change and socio-economic and environmental co-benefits.

This was recognised by the Department of Agriculture, Forestry and Fisheries (DAFF) when they developed the Climate Smart Agriculture (CSA) programme, in concert with global initiatives.

In support of their responsibility to enhance mitigation the Department of Environmental Affairs (DEA) developed a Mitigation, Reporting and Verification (MRV) strategy and baselines towards 2050 for AFOLU to provide guidance for GHG reduction for the sector. The guidelines will also assist National Treasury in development of the proposed carbon tax and offset schemes. The Agri SA Commodity Chamber supports the MRV and baselines initiatives of DEA, but is of the opinion that future updates may be improved if organised agriculture can assist officially.

A vital issue is inaccurate agricultural statistics which is acknowledged by DEA in the baseline document, and which should be addressed by

General recommendations:
Farmers should be encouraged to take-up sustainable land management practices to sequester carbon. This will require a comprehensive dedicated approach based on scientific practice, a sound legal framework, facilitating mechanisms to educate and promote land-use change and a range of financial and market-based economic incentives to initiate and then reward actions that realise or have the potential to realise improvements.

Recommendations specific to CA:
The education and empowerment approach for mainstreaming CA and other sustainable, regenerative agricultural practices to farming communities and other key stakeholders is pivotal and should receive priority. Appropriate incentive and market-based mechanisms (such as PES) should be investigated, developed and introduced to facilitate CA on a broader scale across the country. Such mechanisms should be tailored for smallholder, communal and commercial farmers. These mechanisms should also consider various carbon offset models with agricultural input supply partners.

DAFF if the baselines and MRV are to be credible.

Agriculture, forestry and other land uses in South Africa contribute 6 to 9% of the country's GHG emissions, which is much lower than the global average for agriculture which is 13.5%. Benchmarks for grain crops, horticulture and livestock indicate that emissions per unit product produced compare favourably with global estimates, but there is scope for improvement through improvements in efficiency and application of conservation agriculture (CA) practices. The potential for carbon storage and sequestration in agriculture, however, are several orders bigger than agricultural emissions and therefore should be the primary focus in reducing atmospheric carbon by the AFOLU sector.

Agriculture has shown commitment to GHG emission reduction and carbon sequestration. Several on-farm applications and research projects are discussed in the text where grain crops, horticulture and livestock have advanced in CA practices. Measurements showed significant improvements in soil carbon storage and rangeland vegetation cover and, in addition, improvements in soil health. However, vast opportunities still exist in commercial, smallholder and communal systems which should be pursued with commitment by all stakeholders.

Apart from already being indirectly taxed by means of energy-based emissions and the fuel levy as other sectors, the AFOLU sector is exempted from direct emissions taxation until 2020. The expected threshold for direct emissions taxation for the AFOLU sector could be 100 000 ton CO_2 eq/annum, which implies that very few agricultural enterprises will be taxed through the direct GHG emissions route. Because of the comparatively high threshold, the Agri SA Commodity Chamber can associate with the number of 100 000 ton CO_2 eq/annum. However, the Agri SA Commodity Chamber is of the opinion that, as a principle, carbon taxing of agriculture is not justifiable, because it is responsible for food security, as a small role player its contribution to the country's GHG emission reduction target is almost insignificant, the large error of estimate of its contribution will induce unnecessary legal actions and a further tax on a sector with small profit margins will render agriculture vulnerable. The Agri SA Commodity Chamber does, however, support incentive/carbon offset schemes to facilitate the adoption of CA with all its environmental and socio-economic benefits. The Chamber is also of the opinion that agricultural enterprises which exceed the emissions threshold should be allowed to offset their emissions by submitting carbon storage/ sequestration inventories.

On-farm carbon offset projects are small and with high project registration and management costs to companies, the realized benefits may not justify the investment. Since legal incentives (e.g. carbon tax) and voluntary participation are unlikely to lead to the required level of adoption of best management practices, direct payment or other indirect support to farmers for larger initiatives and large incentive/offset schemes such as payment for ecosystem services (PES) should be considered. Ecosystem services are public goods that provide benefits to a large number of citizens. Rather than subsidies and emergency aids, recommended management practices (e.g. improved management of rangelands, large scale application of CA) can be advanced through agricultural policies that promote PES. Specifically in terms of carbon offset projects, examples include those for sequestering carbon in soil, improving water availability and quality, strengthening nutrient cycling, controlling floods, increasing biodiversity and improving habitat for plants and animals. All examples provide benefits to society at large as well as do the recommended programmes below, qualifying them as true PES projects.

Recommendations specific to rangeland management:
Government, through DAFF, should employ extension officers well trained in rangeland management in every district and retrain the many extension officers serving communal systems. Extension officers should evaluate grazing capacity on individual farms, communal systems and commonages to determine more precise stocking rates and monitor rangeland condition and species composition at regular intervals. They should also assist with restoration of bare patches and eroded areas by advice and administering funds made available for this purpose. Furthermore, the extension officers should be trained to determine carbon storage and sequestration in order to over time and at regular intervals monitor progress. In liaison with the extension services, large carbon offset investment programmes for companies will also become viable because districts, commonages and communal systems can be included into the benefit of carbon storage and socio-economic support.

Agriculture, plus Forestry and Other Land Use (AFOLU as depicted by the DEA) is central in supporting national food security, sustainable development, and mitigation and adaptation to climate change. Plants when growing use carbon dioxide (CO_2) from the atmosphere and nitrogen (N) from the soil and re-distribute it among different pools, including both above and below-ground living biomass, dead residues and soil organic matter (stocks). The CO_2 and other greenhouse gases (GHG), such as methane (CH_4) and nitrous oxide (N_2O), are in turn released into the atmosphere by plant respiration, by decomposition of dead plant biomass and soil organic matter and by combustion. Thus, there is a continuous flux in and out of pools. Anthropogenic activities (e.g. cultivation of croplands, deforestation, poor rangeland management and destroying wetlands/ecosystems) and changes in land use or cover (e.g. conversion of forest lands and grasslands to cropland and pasture, and reforestation) can cause additional changes to these natural stocks and fluxes. AFOLU activities lead to both emission of CO_2 (e.g. deforestation and peat land drainage) and sinks of CO_2 (e.g. reforestation and management for soil carbon sequestration and storage), and to non-CO_2 emissions primarily from agriculture (e.g. CH_4 from enteric fermentation in livestock and N_2O from manure storage, agricultural soils and biomass burning).

Rationale of **Investigation**

The AFOLU sector is unique compared to all the other GHG emitting sectors (e.g. waste, transport, energy and industry), since mitigation is possible by removal of GHG as well as reduction of emissions through land management (e.g. crop fields) and livestock. The sector is furthermore unique due to its central role in development and food security as mentioned above.

The implications of a carbon tax and offset system are investigated in the context of the uniqueness, estimation methodologies, and practical implementation and monitoring. It is therefore relevant to give some background of the impact and importance of agriculture in the socio-economy of the country.

1 Overview of the role of Agriculture in South Africa

The gross value of agricultural production in 2015 was R225 232 million[1]. Although agriculture contributes only 2.3% to GDP, if all backward and forward (e.g. the food industry) linkages are included in its influencing sphere, the contribution may increase five-fold. Gross farm income in the same year was R225 760 million but declined sharply because of the severe drought of 2016. The value of capital assets on farms was R393 168 million in 2015, agricultural imports R102 660 million and exports R108 902 million, which implies a small net export. Indices of producer prices in 2015 compared to 2010 were 184, 140 and 147 for respectively field crops, horticulture and livestock, whereas the combined index of all input requisites was 149 and the consumer price index 130, suggesting a moderate favourable period for commercial agriculture between 2010 and 2015.

Commercial farmers are about 70 000[2] (down by 50% since the late eighties) and market-oriented smallholder farmers 210 000 to 270 000[3]. Of the 70 000 commercial farmers 7.5% have a gross income of more than R3 million per year, whereas about 75% have a gross income of R500 000 or less. Employment in agriculture, hunting, forestry and fishery as defined by the Abstract of Agricultural Statistics 2016[1] amounts to 897 000. Bearing in mind that some 2.5 million[3] to 4 million[4] subsistence farmers (communal systems) provide household sustenance, it is a remarkable achievement that the small number of farmers supplying the market and their associated workforce can provide food and other sustenance to a population of 55 million plus a few million non-registered immigrants.

Commercial agriculture comprises three sectors: grain crops, horticulture and livestock which are briefly highlighted.

1.1 Grain crops

This sector accounts for about 30% of total gross agricultural production. In the five year period 2010/11 to 2014/15 the area of farmland planted with maize was 3 076 million hectares, followed by sunflower (555 million), wheat (531 million) and soybeans (519 million)[1], with ground nuts, grain sorghum, oats, barley, canola and dry beans accounting for less than 100 000 hectares each. The area planted during the 2015/16 season was 4 229 million hectares, which because of the drought of 2015/2016 was 759 000 hectares less than the previous year.

Maize is the most important grain crop. It is both the primary carbohydrate of most South Africans and the main concentrate source of the livestock feed industry. The maize industry contributes 0.4% to the national GDP and is interlinked with many industries in the manufacturing sector, hence providing income to value chain agents from producers, processors, exporters, transporters etc. Demand is largely met by domestic supply. Some 84% of production is utilised locally and the per capita consumption is about 81kg/annum[1]. In most years, the country is a net exporter of maize. Nonetheless, at times of drought, South Africa may import maize from the Ukraine, Botswana, Zambia, Argentina, the USA and Brazil[5]. Although fluctuating with annual rainfall, maize's contribution to foreign earnings in general has been growing over time, from R630 million in 2001 to R4 865 million in 2014.

Wheat's contribution to agricultural GDP has declined since the 1980's, which is of concern since the wheat industry has many forward and backward linkages and multiplier effects, resulting in job losses and the associated negative welfare effects. Employment since 2006 has declined by 40% from 19 167 to 11 480 in 2015/16, which is largely attributed to the unprofitability of the wheat sector[6].

Annual production of wheat is approximately 1.8 million tons whereas consumption is 3.0 million tons. From 2005/2006 to 2015/16, local consumption increased by 12%, being currently at about 49 kg/capita/annum[1], whereas production of wheat decreased by 26%. Thus, wheat shortfalls need to be met by imports. South Africa is therefore a net importer of wheat and was able to supply only between 48% and 65% of the domestic demand for commercial consumption in the last couple of years[7].

1.2 Horticulture

The total farm land under horticulture is about 330 000 hectares, with wine and table grapes accounting for the largest portion (98 000), followed by deciduous fruit (81 000), citrus (68 000) and potatoes (54 000)[8]. The industry employs about 312 000 direct on-farm employees. Total horticultural production exceeds 10 million tons with a gross value of R47 600 million. Exports contribute significantly to foreign earnings since more than a third of total produce is exported. Notable are earnings by the wine and grape industry which is largely export based: earnings increased from R6 900 million in 2010/11 to R10 470 million in 2014/15[1]. A further third of total produce is domestically utilised in fresh format, whereas about 20% is processed. The average per capita consumption (kg/annum) of major products since 2010 was[1]: potatoes 36, other vegetables 45, deciduous and subtropical fruit 24.5, citrus 15.5 and wine 16[8].

1.3 Livestock

Since 70% of agricultural land in South Africa can only be farmed with livestock and game, species are found in all provinces. A comprehensive analysis in 2010[9] indicated 13.6 million beef cattle, 1.37 million dairy cattle, 24.6 million sheep, 6.33 million goats, 2.99 million game species (private ownership), 1.13 million pigs, 113 million broilers, 31.8 million layers and 1.6 million ostriches. The gross value of livestock products in 2015 was R109 913 million[1] which is about 49% of all agricultural production. Animal foods on a weight basis contribute 27%[9]. The per capita consumption in 2015 of fresh milk, eggs, red and white meat was respectively 38.6, 8.76, 27.2 and 39.6 kg/annum[1].

The livestock sector is modest in terms of international trade. Major exports are wool and mohair (52 200 tons) and sheep skins (19 258 tons). Major imports are meat, respectively 19 000 tons beef and veal, 10 200 tons mutton, lamb and goat, and about 385 000 tons of white meat. Trade with Africa is increasing, particularly in the SACU region, indicating that the livestock industry plays an important role in stabilizing the economies of SADC countries. On the other hand, some imports from the EU, Australasia and Brazil are highly competitive and contribute to the country being a net importer of livestock products.

Employment has declined markedly since 2000 because of increased minimum wages, less commercial farmers and increased property size. Calculations in 2012[9] indicated that some 245 000 employees are employed on 38 500 commercial farms and intensive units; the number of dependants being 1.45 million. Because of the vast area of the country utilised by livestock farming, it forms the backbone of the socio-economy and sustenance of most non-metropolitan towns and rural communities.

2 The Carbon challenge facing Agriculture

2.1 The risk

Climate change is one of the world´s greatest challenges in the 21st century. Warmer global temperatures are already causing profound changes in many of the earth´s natural and food production systems. Increased flooding, droughts, early frosts and frequency and intensity of severe weather events, are being experienced across the globe, also in South Africa. Approximately 20-30%[10] of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5 C, which is the ceiling target by 2050. It is significant that in The Global Risk Report[11], success of climate change mitigation and adaptation, biodiversity loss and ecosystem collapse, water crises and extreme weather events are considered at the same scale of threat to the global economy as energy price shocks, fiscal crises, terrorist attacks, large scale involuntary immigration, cyber attacks and un- and underemployment.

For agriculture the risk affects sustainability and resilience which depend on maintenance of water, soil and vegetation integrity, biodiversity and ecosystem conservation.

2.2 Government directives

Agriculture can provide both adaptation-mitigation synergies to climate change as well as socio-economic and environmental co-benefits. This was recognised by DAFF[12] when they put together a Climate Change Sector Plan for Agriculture, Forestry and Fisheries (CCSPAFF) in line with the National Disaster Management Framework of 2005. Thereby a climate change related plan of action was established which would increase climate intelligence through awareness and knowledge of anthropogenic activities and to plan appropriate actions. From the initiative followed the Climate Smart Agriculture (CSA) programme which is also a global initiative[10]. It entails the integration of land suitability, land use planning, agriculture and forestry to ensure that programmes are properly captured and that they will enhance resilience, adaptive capacity and mitigation potential. The CSA has been implemented in the provinces, with the Western Cape in particular highly active[13].

In government, the DEA has the obligation to report the GHG emissions of the country to the dedicated international climate change bodies at pre-determined regular intervals, in particular to the United Nations Framework Convention on Climate Change (UNFCCC)[14]. The commitment is according to the National Development Plan (NDP)[15] which states that GHG emissions must be reduced by 34% by 2020 and 42% by 2025. It is accepted that every sector, where practically possible, has the obligation and should strive to meet the targets. Draft Regulations associated with the obligation are set out in Notice 336 of 2016 of the National Environment Management: Air Quality Act (Act No 39 of 2004)[16]. For the AFOLU sector, the Strategic Plan 2016 - 2020[17] of the DEA indicates the proposed approach and actions required to develop a Measurement, Reporting and Verification (MRV) system. The MRV is intended to monitor, quantify and report both the GHG emissions and non-GHG impacts of emission reduction responses over a long-term period. This hopefully will enable reliable analysis, evaluation and combination of data and inputs towards the desired outputs (e.g. emissions profiles, management scenarios, international reports etc).

In order to support progress towards GHG emission reduction targets, National Treasury in consultation with DEA has developed a carbon tax policy[17], which is scheduled to come into effect in 2017. The Carbon Tax forms an integral part of the mitigation system for implementing government policy on climate change as outlined in the National Climate Change Response Paper (NCCRP)[18] and the NDP.

2.3 GHG emissions and benchmarks

Emissions by agriculture are presented with and without the Forestry and Other Land Use (FOLU) sector, the reason being that forestry records a considerable amount of carbon sequestration and uncertainties are associated with other land use options. The total GHG emissions estimated in 2010 for South Africa are 544 314 Gg CO_2 equivalent (eq) (excluding FOLU) and 518 239 Gg CO_2 eq (including FOLU)[14]. The corresponding figures for agriculture and AFOLU are 50 568 Gg CO_2 eq and 30 949 Gg CO_2 eq respectively[19]. The agriculture and the AFOLU sector emissions therefore respectively represent 9.3% of total emissions if FOLU is excluded and 6% if FOLU is included, which is much lower than the global average of agricultural anthropogenic GHG emissions of 13.5%[10].

In addition, using BFAP[20] and other models, baselines were projected towards 2050, which take into account growth in the sector and food needs of an increasing population. Baselines can be seen as the future GHG emission levels in the absence of present and future mitigation actions, which can also be defined as the 'business-as-usual' scenario[19]. A well-developed baseline, more specifically a projected baseline, has the advantage of enabling Desired Emissions

The ultimate intention is to develop a carbon system that can account for emissions and removals or sequestration.

Reductions Outcomes (DEROs) and Carbon Budgets to be determined for agriculture or the AFOLU sector. The projection indicates increases for agriculture alone to 69 621 Gg CO_2 eq/annum and for AFOLU to 38 938 Gg CO_2 eq/annum. For livestock the emissions calculated for 2010 are 29 708 Gg CO_2 eq, consisting of 28 140 Gg CO_2 eq for enteric fermentation and 1 568 Gg CO_2 eq for manure management. Emissions of livestock according to the baseline are projected to increase to 41 178 Gg CO_2 eq/annum by 2050, which is a 38% increase. The emissions of Grain Crops and Horticulture per se were not calculated in the report but can be derived from estimates for cultivated soils, which include liming, urea application, and direct and indirect N_2O emissions. For 2010 the estimate is 20 374 Gg CO_2 eq and for 2050 27 360 Gg CO_2 eq, an increase of 34%. From a calculation by Blue North[21] for citrus, pome and stone fruit, and wine and table grapes a number of 327 Gg CO_2 eq/annum is derived, which suggests that the emissions of horticulture are insignificant and in line with expectation since the total area utilised is a mere 330 000 hectares compared to 3 076 million for other crops.

Benchmarks for GHG emissions set targets and scope of improvement and mitigation. For that purpose emissions should be expressed per unit product produced to account for differences in environment and production systems. In that way it also associates with the emission baselines which take into account the increase in output to meet the needs of an increasing population. De Wit et al[23] calculated the variation in CO_2 emissions per hectare with conventional tilling. Emissions varied between 1.087 ton CO_2 eq/ha/annum in the North West province to 1.235 ton CO_2 eq/ha/annum in the Western Free State. With conservation agriculture emissions can be reduced from 35kg carbon/ha/season to 30 kg carbon/ha/season[23], which although not expressed per unit product provides a benchmark in cultivation management. A benchmark for pome fruit production at farm gate was set at 0.20 kg CO_2 eq/kg fruit[24]. The variation measured at farm and district level (0.09 to 0.59 kg CO_2 eq/kg fruit) shows that there is considerable scope for mitigation in this industry. Corresponding benchmark farm gate estimates for hard citrus, soft citrus, stone fruit, table grapes (all per kg fruit), red wine grapes and white wine grapes (per litre wine) were respectively 0.15, 0.22, 0.27, 0.35, 0.25 and 0.35 kg CO_2 eq/kg fruit or L wine[25]. In this instance annual variation was more than 20%, illustrating the effect of environmental fluctuation over production years. For commercial beef and milk production, GHG emissions varied between 25 and 35 kg CO_2 eq/kg beef, and 1.3 and 1.5 kg CO_2 eq/kg milk which compare satisfactorily with numbers reported in Australia, Europe, the UK and the US[9]. From low to high it nevertheless illustrates the vast potential in mitigation, which in this case largely reflects the amount of beef or milk produced per unit input, i.e. efficiency.

2.4 Carbon sequestration and storage

The most significant contribution to solving the problem of global warming and climate change is to transfer atmospheric CO_2 into soil and other biotic pools (carbon sequestration). Increasing carbon levels in the soil beyond a threshold level of about 1.2% in the surface layer[26] is essential to improve soil quality, increase agronomic productivity and protect the quality of stored waters. Carbon sequestration in soils and biota is cost effective, safe and has many co-benefits compared to leaving carbon in the atmosphere or sequestering it in geologic and oceanic strata. Biotic (plant-based) sequestration is based on a chemical transition whereby CO_2 is photosynthesized into organic substances and stored in plant products and soil organic matter. The rate of photosynthesis in the global biosphere is about 120 billion ton carbon per annum[26]. Fossil fuel combustion emits about 8 billion ton carbon annually and deforestation and land-use conversion another 1.6 - 2 billion ton carbon per annum. This is a total of 9.6 to 10.8 billion ton carbon emissions per annum. Thus, if roughly 8% of the carbon being photosynthesized by the biosphere is retained within the soil and biotic pools, the global carbon budget should be balanced. Soil carbon sequestration is a win–win strategy. It mitigates climate change by offsetting anthropogenic emissions, improves the environment - especially the quality of natural waters, enhances soil quality, improves agronomic productivity and advances food security.

Worldwide adaptation to climate change and the mitigation potential of agriculture is acknowledged at all levels of socio-economic development in both developed and developing countries, specifically also by farmers[10]. Agriculture industries, therefore, are regarded as priority for adaptation and mitigation[27].

Mitigation in agricultural land management which generates soil carbon sequestration has substantial potential. For example, one estimate[28] put the technical potential of soil organic carbon sequestration by world cropland soils through adoption of good management practices at 0.4 to 1.2 billion ton carbon per annum and if soils and vegetation are considered together, the equivalent could be a decrease of about 50 ppm atmospheric CO_2 by 2100 to 2150. In different terms this implies that about 89% of agricultural carbon mitigation potential can be achieved by soil carbon sequestration through improved grazing land management, improved cropland management, restoration of organic soils and degraded lands, bio-energy and water management[26,28]. In another estimate, the WFO[10] projected that the mitigation potential of agriculture could reach 5.5-6 Gt CO_2 eq/annum by 2031. Eighty-nine% of this potential can be accounted for by soil carbon sequestration and 70% of the total mitigation potential can be realized in developing countries. A South African estimate[29] of carbon storage in the most important rangeland biomes utilised for livestock grazing showed numbers for Savanna (358 473 km^2) of about 2000 Tg (2 billion ton) carbon, Grassland (224 377 km^2) 2300 Tg (2.3 billion ton) carbon and Nama and Succulent Karoo (334 812 km^2) 580 Tg (580 million ton) carbon. These biomes collectively are about 90% of all biomes and therefore contribute significantly to estimates which suggest that the annual flux in and out of all rangeland and ecosystems, which is about 1 100 Tg (1.1 billion ton) CO_2 or 297 million ton carbon/annum, is over twice the emissions from the country from all anthropogenic sources.

There are of course also several other forms of mitigation – aside from soil and vegetation carbon sequestration – that agriculture can provide, including reductions in CH_4 emissions from livestock through improved management, feed alterations and breeding, and reductions in N_2O emissions from fertilizer use through the practice of integrated nutrient management. Although necessary to implement, the potential in comparison to soil and vegetation carbon sequestration is modest. For example, CH_4 emissions in the beef cattle industry in South Africa can be reduced by not more than 25% if maximum efficiency from birth to slaughter is achieved[30], whereas the potential of feed changes is less than 10%. Put in perspective, if the total agricultural emissions (2010 figure) are 50 568 Gg CO_2 eq/annum[19], a reduction in agricultural GHG emissions in one year if a 25% reduction in beef cattle GHG can be achieved, will be 4476 Gg CO_2 eq, i.e. only 9%. Of course, the reduction in one year is not possible as an efficiency improvement of 25% may take 15-20 years.

2.5. Sector commitment to GHG mitigation and carbon storage:

Since crop and grazing land systems are managed in various ways, different degrees of GHG emissions or sinks result. The amount of carbon stored in and emitted or removed from permanent cropland depends on crop type, management practices e.g. conventional cropping (CV) or conservation agriculture (CA), as well as soil and climate variables. Application of manure either as synthetic fertilizer or organic manure, tillage methods and crop residue management will influence GHG emissions. Conservation agriculture is increasingly adopted globally; CA reduces energy use and mostly increases carbon storage in soils[31].

Table 1 shows GHG emissions between CV and CA cropping systems in the four major grain crop regions of South Africa.

Table 1. CO_2 eq emissions of CV to CA-friendly systems[23].

Region	CV total CO_2e emissions	Total CO_2eq emissions saved and CO_2eq sequestrated through adopting CA*
	ton/ha/year	ton/ha/year
North West	1.087	10.705
Western Free State	1.235	1.326
Eastern Free State	1.204	13.613
KwaZulu-Natal	1.126	11.532

* Total net CO_2e emissions saved through adopting CA = CV CO_2e emissions - CA CO_2e emissions +CO_2 sequestrated. It is an averaged value over the modelling period (20 years) due to the fact that the CA emission values are time varying (i.e. CA emission values gradually reduce as a CV farmer transition to CA-friendly systems owing to gradual reduction in fertiliser, diesel, herbicide and pesticide use).

The authors of this study stated that the transition from CV to CA systems has the potential of not only reducing costs, increasing yields, increasing net farm income, but it also has ecological benefits. This is through lower GHG emissions, lower input use and carbon sequestration.

Smith et al.[32] mentioned a range of major CA initiatives implemented in South Africa:

- Many successful CA activities are based on innovative and successful local CA farmer groups. Several of these initiatives have sprung up among farmers in the past few decades, of which the No-Till Club in KwaZulu-Natal has been the oldest and best example, whereas the CA Western Cape and the Ottosdal No-Till Club in the North West Province are two of the most prominent later structures created to serve the information needs of farmers in the corresponding regions. Forty percent of commercial farmers across all grain producing areas of South Africa have adopted all CA principles[33] and it is expected that adoption trends will increase sharply over the next decade. The highest adoption figures are in the Western Cape (80%) and KwaZulu-Natal (70%), whereas the Free State, North West and Mpumalanga Provinces have a 20% and lower adoption, suggesting still much scope for adoption. Nevertheless, calculations suggest that the success of adoption already exceeds the DEA[19] predicted potential which CA has in mitigation. They estimated a 7.7% (1.27 million ton CO_2 eq) mitigation potential contribution for the total AFOLU sector of South Africa.

- For the past decade the Maize Trust has invested in CA research projects financially, through the Agricultural Research Council (ARC) and other stakeholders.

- From 2013, the Maize Trust in cooperation with Grain SA, supported the development of the CA Farmer Innovation Programme (FIP); the main aim of the CA-FIP is to mainstream CA to and through grain farmers.

- Most CA activities among smallholders are done through projects funded by government and other implementing agents, such as LandCare, ARC and Grain SA. Others include:

- The Department of Rural Development and Land Reform (DRDLR) has been supportive with conservation agriculture technology (CATs) projects for a number of years already, primarily in KZN and EC;

- The ARC has been supporting CA research initiatives since the 1980s (initially working mostly with commercial farmers, such as in KwaZulu-Natal and from 1997 mostly with smallholders in LandCare related projects. Around 20 LandCare-related CA projects have been implemented by the ARC in the last 20 years involving hundreds of farmers and reaching thousands more through awareness activities.

The Confronting Climate Change (CCC) Project[24] is a strategic initiative of the Fruit and Wine Industry aimed at supporting the sectors' efforts to effectively realize and respond to the opportunities and challenges posed by climate change. A key theme of the project is the provision of a freely available on-line carbon emissions calculator together with the technical training supporting its adoption and use. The aim is to enable farms, pack houses, wineries and other stakeholders across the supply-chain to undertake accurate measurement of the energy-use and carbon-emissions intensity of their respective business activities. Such measurement is generally accepted as a prerequisite for effective management towards improved resource-use efficiency, reduced emissions and long-term sustainability of business activities and operations. A major milestone of the project is the development of robust and representative industry level benchmarks of the carbon emissions intensity of each of the major commodities. Against these benchmarks individual businesses can evaluate their own results, and the collective profile of the industries can be developed and their performance tracked over time. The process of benchmarking supports credible industry-level reporting as well as supporting the identification of opportunities for improvement and best-practice at the business-level. Benchmarks were given in item 2.3.

The livestock sector has shown commitment to rangeland/ecosystem conservation9 through conservative stocking rates, with several studies[34,35,36] and observations reporting improvement in rangeland condition and vegetation species composition since the nineties. Livestock farmers through their own Codes of Best Practice[37, 38] have also committed to adhere to the associating regulations and guidelines for stocking rate, which may now bear fruit, including financially. Conservative stocking rate and improvement in rangeland condition go hand-in-hand with carbon storage.

On the south-eastern seaboard milk production is primarily from cultivated pastures. Before 1990 monoculture pastures were conventionally established with deep tillage, resulting in deterioration of soil quality and loss of organic carbon. Since the late-nineties minimum tillage practices were introduced, including the successful pasture management system of kikuyu over-sown with ryegrass. This has improved soil quality and carbon was drastically sequestered. In an experiment on soil analysis from Swellendam to Humansdorp[39], soils from the kikuyu-ryegrass management system, shallow tilled and deep tilled (conventional) recorded carbon contents of 50.3kg carbon/m^3, 54.3kg carbon/m^3 and 34.6kg carbon/m^3 respectively. This represents an improvement of 50% in soil carbon stocks. Pastures established with minimum tillage including the kikuyu-ryegrass management system now comprise 70 - 80% of commercial dairy farms between Swellendam and Humansdorp; the area being about 60 000 ha and carrying 240 000 dairy cattle. The improvement in soil carbon stocks on the 60 000 ha amounts to 10.4 million ton carbon (38.1 million ton CO_2 eq), whereas the methane emission of the 240 000 dairy cattle amounts to a mere 25 000 ton CO_2 eq/year. Minimum tillage practices have also been adopted in crop rotation systems integrated with livestock in the Mediterranean region of South Africa, which has been associated with increasing soil carbon stocks[40].

Carbon sequestration aside, improving efficiency in production has the highest potential of all measures to mitigate GHG emissions in the livestock sector. If efficiency is optimal, land use and resources are optimized and the carbon and water footprint reduced. In order to improve efficiency all input variables (natural resources, financial arrangements, human resources, inputs, skills and other factors such as social concerns) need to be harnessed in support of biological measures in such a way as to ensure that the end product is the result of efficiency at all levels. The increase in efficiency is well illustrated by the example of milk and beef production by the commercial sector: Since 1990, the number of dairy farms has declined by 92% and the number of cows by 24%, yet total milk production has increased by 56%[41]. This, obviously, implies that not only GHG emissions but also waste and water use have declined to the benefit of sustainability. In the beef sector feedlot production has increased dramatically to the current production of about 80% of all beef produced. As the production cycle to slaughter compared to fattening on rangeland is shortened with 100 - 160 days, the GHG emission from cow to calf to slaughter animal is reduced by more than 15%[9].

Following testing of methane measurement technologies using among others laser equipment, beef bulls in the National Performance Testing Scheme are now routinely tested for methane emissions from enteric fermentation. Lower methane emission has thus become one of the selection criteria.

Research projects in the livestock sector. The list is not comprehensive, but gives examples:

- Methane production of dairy cows on the kikuyu-ryegrass pasture management system: Since this is a highly successful system in the south-eastern seaboard as discussed above, the methane emissions of cows are measured and compared with the International Panel for Climate Change (IPCC) guidelines, using different levels of concentrate supplementation on pasture. Preliminary results suggest methane emissions to be 7% lower than IPCC guidelines[42]. As this area harbours about 240 000 heifers, dry cows and cows in milk, the resulting reduction is substantial.

- Modelling rangeland production using MODIS LAI: Relationships are established between biomass, water metabolism and carbon uptake in different biomes.

- Innovative management of beef cattle for improved productivity: Amongst traditional efficiency and reproduction parameters, heat stress, methane emissions and water use efficiency are also recorded in an experiment running over years.

- Carbon and water footprint of beef cattle: This is measured on an ARC experimental farm in the savanna ecosystem.

- Methane and nitrous oxide emission factors from cattle manure: This is done to support more accurate estimations for the DEA's AFOLU inventory.

Quantification of methane emissions from C_4 grasses: IPCC methodology to estimate methane from forage sources is based primarily on C_3 (temperate) grasses, whereas sub-tropical regions such as South Africa rely on C_4 grasses. The intention is to adapt IPCC methodologies for sub-tropical regions.

2.6. Suggested management and practices for mitigation and sequestration

Carbon is protected or increased in significant quantities with no or minimum tillage practices (CA) as discussed. What should be acknowledged is that cultivated soils in South Africa have lost between 45% and 65% of their carbon due to conventional tillage (CV) practices over the last 50 to 100 years[43,44], which implies that their current reserves of soil organic carbon are much lower than their potential capacity. This suggests a huge carbon sequestration potential for cultivated lands in the country. However, the rate of carbon sequestration will depend on CA adoption and the specific combinations of soil types and climate, which points to a responsibility of extension and farmer support bodies. The rates need to be sustained for 20 to 50 years or until the soil sink capacity is filled.

Management options to reduce or eliminate negative impacts of many current agricultural practices have been outlined by Teague et al[45].

These include:

- changing tillage to no-till cropping and using precision agriculture to moderate the rate and timing of application of agrochemicals and water;

- diversifying annual cropping systems to include legumes, perennial crops and forages in rotations;

- using cover crops in conjunction with row crops;

- re-integrating grazing animals into cropping systems;

- using organic soil amendments, such as cover crops, manure and bio-fertilizers;

- reducing nitrogen fertilizer use, changing the type of fertilizer used (e.g. legumes, controlled-release and nano-enhanced fertilizers) and using nitrification inhibitors;

- applying biotic fertilizer formulations that feed the soil microbial systems and improve mycorrhizal function, reducing nitrogen and phosphorus runoff and ground water losses; and

- improving grazing management, converting marginal and degraded cropland to permanent pasture and forests, and restoring wetlands.

In short, the proposal is for regenerative management practices. **In both cropping and grazing systems, soil management is the key to optimizing ecological function and reversing degradation caused by previous management.** These are practices that are implemented to a limited extent, but which provide valuable directives for future production systems.

Other practices include planting of trees and shrubs, improved efficiency, changes in feeding practices, solar and wind power, biogas and bio-digesters, energy-saving bulbs and other energy-saving equipment, saving on fuel and various other known measures. These are obvious measures which farmers should do. Vienings[21] provides a list of measures in this context where the effect on GHG emissions in horticulture was either measured or should support reductions:

- Renewable energy: Generating renewable electricity on the farm and thus reducing the consumption of 'dirty' Eskom electricity. However, Eskom energy mix is slowly improving as more renewable energy producers feed into the grid[46] and more efficient coal power plants come online.
- Renewable energy: Using solar hot water geysers for on farm housing.
- Efficient energy consumption: Improving irrigation system designs, e.g. fitting Variable Speed Drives (VSD) to irrigation and borehole pumps.
- Reduced water consumption: reduced pumping, precision farming with moisture probes and cover crops/mulching.
- Reduced diesel consumption: precision farming with inputs and latest technology farm machinery.

3 DEA's MRV and Baseline Estimates for AFOLU

The Strategic Plan 2016-2020[17] proposes the approach and actions required to develop a Measurement, Reporting and Verification (MRV) system. The MRV is intended to monitor, quantify and report both the GHG emissions and non-GHG impacts of emission reductions over a long-term period. This should support analyses of data, the compilation of emission profiles, management directives and the establishment of international reports, e.g. the biennial report to the IPCC, etc. The aim of the project to develop baselines[19] was to develop a robust, transparent and as accurate as possible GHG emissions baseline for the AFOLU sector. This should enable South Africa to project its emissions into the future and demonstrate its contribution towards the global goal of reducing emissions in the AFOLU sector.

The Agri SA Commodity Chamber supports the intention of both initiatives since it is believed that the MRV system and the baselines create an important and credible platform for South African agriculture to communicate its contribution to reduce global GHG emissions. The Chamber nevertheless wants to offer some comments since Organised Agriculture was not officially involved in development of the two documents and is of the opinion that it is important for agriculture to be represented and be involved in the development of future updates:

- The MRV is apparently not a policy instrument, but it is accepted that both documents will inform future endeavours such as the proposed carbon tax and offset system of National Treasury. Therefore, the data sets and models should be sound and convincing.
- The MRV does not provide guidance on activities within managed lands. The relevant contents in this presentation may be considered.
- The datasets used are very high level (national). Therefore the baselines do not address specific agricultural sectors or commodities which is a limitation. For example, there is no specific feedback on horticulture as such in the document.
- In the baseline project the land cover map of 1990–2014 was used. The lack of data on land change makes it difficult to validate changes. As acknowledged by the authors, this is an issue which needs further research as it has a significant impact on future projections and baselines. The report recommends that land change be monitored more frequently (every 5 years) using a standardized method which is supported.

- The agriculture baseline is limited in terms of the cropland detail, particularly land use changes within the cropland division. This is a major limitation of the model which needs to be addressed in the next update.

- The baseline report recommends reduced tillage for grain crops to increase soil carbon stocks. Again no specific recommendations are made for horticulture.

- The baseline report acknowledges that ongoing research is required to improve the availability, consistency, scope, scale, resolution etc. of models and data. Several recommendations have been made on how to improve the baselines in future. It is anticipated that with the participation of organized agriculture more detailed data for future versions should be available.

- Specific challenges with major effects on the MRV and baselines:

- Fluctuating and unreliable statistics: It will be difficult to monitor GHG reduction at the rate the DEA is expected to report to the UNFCCC because of unreliable statistics of livestock and game numbers referred to in the AFOLU Base Line Report (acknowledged by the authors)[19], seasonal and longer term variability in numbers and production because of drought and other reasons. Whereas the challenge will be immense in the commercial sector, the challenge will be exacerbated in the small holder and subsistence sectors. Also, the error associated with the numbers is more than the GHG reduction that can be achieved. **It is recommended that the DAFF develop and finance a project to systematically count all livestock and game using air and surface methodologies, where after new prediction models can be developed and implemented.** Unreliable numbers are not only a limitation in this context but for all major planning projects of the sector.

- Different land use options and objectives: Whereas to some extent livestock numbers in the commercial sector may stabilize due to more efficient production practices and by aligning with signals and pressure of markets, GHG mitigation and longer term animal-based food requirements, the numbers in the subsistence sector and game ranching enterprises are expected to maintain increasing trends because of different goals and objectives. For subsistence farming livestock is kept for socio-economic reasons[9] which reflect the constraints that subsistence farmers face (e.g. finances, access to information and services, tenure). They do not exploit the open market significantly, but the animals are kept for a variety of reasons such as to produce food for home consumption, to generate income, to provide manure as fertilizer, for traction and transport, to serve as financial aid and to enhance social status. The entrepreneurial pressure therefore is increasing numbers not efficiency or market directives. Game farmers are driven by hunt yields, tourism and favourable investment opportunities in rare animals. Again increasing numbers are the drive, not increased efficiency.

- Future needs: Agriculture is central to long term food and national security. Expected population growth will demand more food which will put pressure on GHG reduction targets. Based on supply and demand, taking into consideration population growth, economic projections and increased demand for animal-based foods, BFAP[20] modelled needs until 2024. In the AFOLU baseline project[19] these projections were taken into account and further extrapolated to 2050 to factor in food needs that should result in an increase in GHG emissions because of the inevitable increased population. As discussed in item 2.3 the estimate shows an increase in livestock emissions from 29 708 Gg CO_2 eq/annum in 2010 to 41 178 Gg CO_2 eq in 2050, i.e. an increase of 38%. The increase appears to assume that ruminants on rangeland and pasture will have to increase to meet the needs since the GHG emissions from pigs and poultry are small. While it is acknowledged that there is some scope with feedlot and intensive dairying, significant increasing numbers on rangeland and pastures are highly unlikely as these resources have largely reached their limit. Ruminant production in the commercial sector has to increase efficiency (producing more from the same base), or the subsistence sector should be drawn into the markets which in the current dispensation appears unlikely, pig and poultry production will have to increase which also has limitations, and imports will have to increase. These are major challenges but from the projected baseline point of view, barring short term fluctuations, ruminant GHG emissions will probably remain below the projected increase.

4 Feasibility of carbon tax and incentive/ offset schemes

4.1. Proposed carbon tax

National Treasury has finalised the Carbon Tax Policy scheduled to come into effect in 2017 or soon thereafter[17]. The carbon tax scheme is in support of mitigation planning proposed in government policy on climate change as discussed in item 2.2. The design will depend partially on the administrative feasibility and practicality to cover most GHG emissions. Below is a summary of the design as envisaged in the Draft Carbon Tax Bill[47]:

- A basic 60% tax-free threshold during the first phase of the carbon tax, from 2017 to 2020.
- An additional 10% tax-free allowance for process emissions.
- Additional tax-free allowance for trade exposed sectors of up to 10%.
- Recognition for early actions and/or efforts to reduce emissions that beat the industry average in the form of a tax-free allowance of up to 5%.
- A carbon offsets tax-free allowance of 5 to 10%.
- To recognise the role of carbon budgets, an additional 5% tax-free allowance for companies participating in phase 1 (2016 - 2020) of the carbon budgeting system.
- The combined effect of all of the above tax-free thresholds will be capped at 95%.
- An initial marginal carbon tax rate of R120 per ton CO_2 eq will apply. However, taking into account all of the above tax-free thresholds, the effective carbon tax rate will vary between R6 and R48 per ton CO^2 eq.

The carbon tax system will apply to all the sectors and activities. Apart from the forestry sector where plantations and natural forests exceed 100 ha, the AFOLU and waste sectors will be exempt during phase 1 (2016 to 2020) from direct GHG emissions taxation due to methodological difficulties, but will be indirectly taxed for energy and fuel use. Although there are uncertainties because it is a future endeavour for agriculture, post 2020 direct GHG emission taxation will probably only apply to farms and enterprises which exceed the threshold of 100 000 tons CO^2 eq per year[47]. Agriculture, therefore, has been provided with more time to improve methodologies and develop mitigation and adaptation strategies.

Indirect GHG emissions which will impact the agriculture sector (Sharlin Hemraj, National Treasury, pers. comm.) include:

Combustion related emissions will be covered under the carbon tax. The threshold refers to a combined boiler capacity equal to or above 10 MW(th)[48] net heat input. For example, the combined boiler design capacity for six (6) 2 MW(th) equal 12 MW(th) which is above the reporting threshold of 10 MW(th). Therefore, the tax inventory provider will have to report GHG associated with so-called stationary combustion in this case.

- **Transport related non-stationary emissions** arising from liquid fuels will be covered but will be implemented as an add-on to the existing fuel levy. Assuming a 60% basic tax free threshold, meaning that 40% of fuel related emissions will be taxed at R120 per ton CO_2eq, this translates into an estimated carbon tax of 11c/l for petrol and 13c/l for diesel.

Principles and implications of the carbon tax scheme on Agriculture:

Food security: It seems strange and questionable that a sector which is responsible for food provision to the nation is taxed in the act of doing so. It is inevitable that as production increases because of population growth, GHG emissions will increase. The carbon tax is not similar to taxes associated with income; it is positively correlated with food security and socio-economic development and therefore GHG emissions should be considered differently for agriculture than for other sectors. Suggestions and recommendations follow below.

Burden on farmers: The PMR modelling study[49] on the impact of a carbon tax on the South African economy suggests that the tax will reduce GHG emissions but otherwise have little effect on agriculture. However, modelling simulates trends over a defined period, whereas tax and income have major short term influences (e.g. the drought of 2016), often with major implications to survival of farmers. The drastic reduction in numbers of commercial farmers since the eighties and nineties bears testimony to that. As discussed under item 2, about 75% of commercial farmers earn less than R500 000 per year[2] and market-oriented smallholder farmers even less. Due to the nature of their business (e.g. tractors, irrigation equipment, transport of produce etc.) many will qualify to pay the indirect carbon tax. A further tax could be devastating. Estimates above suggest that the carbon tax could be between R6 to R48 per ton CO_2 eq[47], the variation due to a number of factors. If R20 is accepted as an example, the tax per year for a 3000 dairy cows in-milk operation (45% of total number) emitting 20 000 ton CO_2 eq[49] per annum could be R400 000, a beef feedlot fattening 250 000 cattle per year, whilst emitting 447 600 ton CO_2 eq[50], could be R8 952 000 and a 1000 ha CV prepared maize crop emitting 1.235 ton CO_2 eq emissions per ha per annum[32] could be R24 700 [For these calculations energy and fuel carbon taxes were not included as they are accounted for in the Energy and Transport sectors]. Horticultural farms are too small to warrant examples. However, the calculations suggest that it is only the mega-enterprises emitting more than the suggested threshold of 100 000 tons direct CO_2 eq/annum[47] which will be taxed.

The Agri Commodity Chamber can therefore associate with the threshold of 100 000 tons CO_2 eq emissions, even though it has a principle objection to the introduction of a carbon tax system for agriculture. The Chamber, however, suggests that enterprises exceeding the threshold should be allowed to provide carbon storage/sequestration inventories to offset their GHG emissions burden.

Negligible impact on national GHG emissions: Reduction targets set in the National Development Plan (NDP) are 34% by 2020 and 42% by 2025[15] as mentioned in item 2.2. The errors associated with GHG emissions are of concern, and this has been acknowledged in the baseline report19.The Livestock industry serves as example. The contribution of the livestock industry to the national GHG inventory is about 5.4% (see item 2.2). If a reduction of 35% is achieved the impact on the national inventory is 5.4 x 0.35 = 1.9%, which is less than the error associated with the calculations in the inventory.

- Fluctuating production environment: Production in rangeland and pasture-based systems is influenced by weather and seasonal fluctuations. The 2016 drought is an extreme example but nevertheless illustrates the principle. A pilot study showed that 15-20 % beef cattle were taken out of the national herd. This has a dramatic reduction effect on GHG emissions, but the recovery period may require up to four years. During recovery when herds have to be built up again, reduction in GHG is almost impossible to achieve.

These challenges make it difficult to calculate a justifiable tax that will not be questioned in court and therefore legal costs could become a major issue.

4.2. Incentive/offset schemes

Many activities on farms supporting sustainability, such as GHG emission mitigation, active carbon sequestration, bio-gas and -energy, maintaining biodiversity, protecting ecosystems and wetlands, good management of rangeland, conservation agriculture, tree planting and supporting socio-economic development of the workforce, can potentially be used as carbon offsets projects. For AFOLU, National Treasury sanctioned the following as being eligible[51]:

- Restoration of sub-tropical thicket, forests and woodland;
- Restoration and management of grassland;
- Small scale reforestation;
- Biomass energy;
- Anaerobic biogas digesters; and
- Reduced tillage.

Projects in these categories can be offered to companies (e.g. agricultural input suppliers) to offset 5 to 10%[51] of their tax liability or as a means of directly sequestering their emissions which are then deducted from the company's total combustion emissions. If the proposed MRV system[17] is effective and the offsets can be quantified, then the offset programme should be valuable to reduce tax liability of agriculture-associated companies or invest in GHG emission reduction projects. This will provide an opportunity for agriculture as a whole and farmers and companies in particular to utilise such generated funds for promotion of sustainable and regenerative agricultural practices which can support carbon sequestration or otherwise can be utilised in socio-economic development.

The PMR study[49] shows that the introduction of a carbon tax, in general, will not affect the country's economy detrimentally and therefore suggests legal enforcement. It does, however, acknowledge that implementation of legal incentives (e.g. carbon tax) per se may be ineffective for regulating different sources of environmental damage and is unlikely to lead to the required level of adoption of best management practices. Secondly, programmes that rely on altruism bestow few direct financial benefits on farmers and, therefore, are unlikely to be widely adopted. Thirdly, information distribution and training programmes are likely to be most effective where implementation requires minimal capital investment and results in short term financial benefits. Where the private benefits are difficult to quantify, or realise only in the long term and involve considerable financial investment, widespread change and adoption are unlikely. The limitations of legal and voluntary incentives emphasize the need for financial incentives (e.g. carbon offsets, tax reduction, direct payment) to provide encouragement for implementation of sustainable management practices that will contribute to environmental improvement.

Carbon offset initiatives already registered or proposed include Credible Carbon, CDM, VCS, Gold Standard and CCBS[52]. Credible Carbon targets socio-economic development, i.e. poor communities benefit from carbon storage or other ecosystem protection services. An example of tax reduction is the Biodiversity Stewardship Fiscal Benefits project of Birdlife SA[53], with ecosystem restoration co-benefits on farms. A limitation of on-farm carbon offset projects is the insignificant benefit to the investor[54]. On-farm projects are small and with project registration costs, it may not be justifiable. Thus, direct payment or other indirect support to farmers for larger initiatives may enhance the time frame towards reaching the desired outcomes or goal. Payment in the context of so-called ecosystem services should be considered.

Ecosystem services are public goods that provide benefits to a large number of citizens[28]. Rather than subsidies and emergency aids, recommended management practices (e.g. improved management or restoration of rangelands) can be advanced through agricultural policies that promote payment for ecosystem services (PES). Examples of payments include those for sequestering carbon in soil, improving water availability and quality, strengthening nutrient cycling, controlling floods, increasing biodiversity and improving habitat for plants and animals. Societal benefits of ecosystem services may be local (e.g. water supply) or global (e.g. carbon sequestration in soil[28]).

The FAO (2010)[55] goes even further by stating that PES should include all financial and non-financial rewards (or compensation mechanisms) between buyers and sellers for the provision of an environmental service. A concrete way to move towards sustainable development is to guarantee the good functioning and delivery to society of all types of ecosystem services, including: supporting services (e.g. biodiversity, photosynthesis, nutrient cycling and soil formation); provisioning services (e.g. food, water, wood, fibre and fuel); regulating services (e.g. climate regulation, flood regulation, drought control, water purification, disease regulation, predation and pollination); and cultural services (e.g. recreation, aesthetic experience, cognitive development, relaxation, and spiritual reflection). Of course, the real contribution and efficacy of PES to the development of a green economy mainly depends on the capacity to design and implement sustainable PES programmes. This may require extensive research.

Biodiversity conservation, closely related to soil and vegetative carbon sequestration, is relevant to PES. Contracts for soil carbon sequestration and PES that contribute to household income are important strategies to provide farmers with incentives, especially resource-poor small holders and communal systems, to adopt management practices that increase and diversify ecosystem services from agricultural lands[28].

In order to effectively implement a PES strategy, information is required for the following[28]: (a) Gross versus net sequestration; (b) Measurement of soil carbon sequestration over a landscape, farm, or watershed scale; (c) Permanence (need the same land-use and management practices to be followed for many years or decades); (d) Technical versus economic potential and the marginal abatement cost, and (e) carbon trading (it is important to determine the carbon price according to transparent, just and fair criteria).

South Africa's rangeland biomes and pastures qualify for PES. Carbon storage estimates for the grazing areas within the biomes of Savanna, Grasslands and Nama and Succulent Karoo have been estimated[29]. The carbon storage potential is substantial and it can be increased by improving vegetation cover (biomass) and composition. For example, for the Nama and Succulent Karoo the storage is estimated as 580 Tg (580 million ton) carbon for the total area and for the Grassland biome 2300 Tg (2.3 billion ton) carbon. With good management practices grass species will variably increase in the Nama and Succulent Karoo, depending on site and other factors, which should be beneficial to carbon storage. With overutilization of rangeland, bare patches and erosion may result to the detriment of both grazing capacity and carbon storage. If restored, the results can be dramatic, but to advance the process of gaining maximum benefits from carbon sequestration and storage a PES strategy and implementation plan will be required.

5 Recommendations

Farmers should be encouraged to take-up sustainable land management practices to sequester carbon as this is the thrust of overcoming inevitable emissions as discussed. This requires a well-designed approach based on scientific practices and research, a comprehensive legal framework, facilitative mechanisms to educate and promote land-use change and a range of financial and market-based economic incentives to kick-start and then reward actions that realise or have the potential to realise improvements.

Specific to conservation agriculture (CA): Education and empowerment to mainstream CA and other sustainable, regenerative agricultural practices are pivotal and should receive priority. The following could be used as guidance in any such endeavor, both through private (e.g. commodity bodies) and government initiatives[32]:

- Facilitate the formation and operation of farmer innovation platforms or -systems, for sharing, learning, implementation and scaling out of CA practices.
- Facilitate research where different stakeholders (i.e. scientists/researchers, extension officers, farmers, agri-business) share responsibilities. In this context, launch R&D projects for the development of robust monitoring and assessment frameworks (spatial and temporal) in support of the DEA's MRV system for GHG emissions, carbon footprint and sequestration under various land

use systems (e.g. grain crops and horticultural activities). Pilot projects should also prioritise the collection of benchmark data for different industries and regions.

- Educate and involve extension officers to learn, participate in and facilitate innovation platforms and research.

- Improve the general awareness and understanding, through among others social media, publications, conferences and farmers' days, of the impact (carbon footprint) and the sustainability of the various farming systems.

- Identify and/or strengthen the various rural institutional arrangements, especially under smallholder farmers and communal systems, as platforms to improve local crop production systems through CA.

Investigate, develop and introduce appropriate incentive and market-based mechanisms (such as PES) to facilitate CA on a broader scale across the country. Such mechanisms should be tailored for smallholder (from subsistence to semi-commercial) and commercial farmers. These mechanisms should also consider various carbon offset models with agricultural input supplier partners.

Specific to rangeland management: Some of the above initiatives also apply here. Rangeland management is guided by grazing capacity and stocking rate relative to a defined standard, the Large Stock Unit (LSU). All districts have DAFF approved grazing capacities described in ha/LSU. However, individual farms per district may differ in grazing capacity from the approved because of differences in local plant cover, species composition and rangeland condition. To maximise carbon storage and sustainability, rangeland condition should be optimum with regard to plant cover, species composition and restoration of bare patches and eroded areas. However, this has cost implications which should be supported by government by financial incentives (e.g. PES).

Government, through DAFF, should employ extension officers well trained in rangeland management in every district and retrain the many extension officers serving communal systems. Extension officers should evaluate grazing capacity on individual farms, communal systems and commonages to determine more precise stocking rates and monitor rangeland condition and species composition at regular intervals. They should also assist with restoration of bare patches and eroded areas by advice and administering funds made available for this purpose. Furthermore, the extension officers should be trained to determine carbon storage and sequestration in order to over time and at regular intervals monitor progress. In liaison with the extension services, large carbon offset investment programmes for companies will also become viable because districts, commonages and communal systems can be included in toto to the benefit of carbon storage and socio-economic support.

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Contact Details:
Inkwazi Building, Block A,1249
Embankment Road, Zwartkop X7

Private Bag X180, Centurion,
0046, South Africa

Website: www.agrisa.co.za

AGRI SA