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WESTERN CAPE DEPARTMENT OF AGRICULTURE'S APPROACH TOWARDS CARBON REDUCTION: CARBON FOOTPRINT PROJECT

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ABSTRACT

The agricultural sector is operating within a global environment and faces many uncertainties. Climate change in particular is expected to impact agricultural production and unfortunately, agriculture is also contributing to greenhouse gas emissions. Agriculture remains an important sector from a food security, economic and livelihoods perspective, which are some of the main reasons for integrated approaches for better stewardship of agricultural landscapes.

The Western Cape Department of Agriculture acknowledges the importance of mitigating and adapting to climate change and has implemented various initiatives to move towards climate smart agricultural practices. One initiative is the Carbon Footprinting Project, which was established to assist farmers in measuring their footprint, identifying hotspots, recommending ways to reduce these hotspots and manage their resources sustainably. The project further assists in putting a measurement tool in place before the Carbon Tax Act (Act 15 of 2019) directly affects the agricultural sector by also highlighting the gaps that still exist in the footprinting process.

1. Introduction

Combating the effect of climate change is a global challenge that requires cooperation, planning and policy instruments that promotes reduction strategies toward sustainable use of natural resources and the environment. It is well-know that the global agricultural sector is particularly exposed various risk associated weather conditions and the changing climate, but is also a major contributor to Green House Gas (GHG) emissions. Recent estimates suggest that agriculture's share in global GHG emissions to be around 19 – 29% (World Bank, 2020[1]). In South Africa, the ill effects of climate related disasters such as droughts, flooding, fires and storms have severely impacted the farming sector and the livelihoods it supports (Pienaar & Boonzaaier, 2018 [2]). Various efforts are currently underway to drive not only the agricultural economy, but also all sectors of the economy towards sustainable production, build on carbon reduction efforts. South Africa (SA) is one of the 195 signatory countries that have committed to the United Nations Framework Convention on Climate Change (UNFCCC) to combat climate change (UNFCCC, 2019 [3). This meant that SA needed to reduce its greenhouse gas (GHG) by 34% and 42% below its business-as-usual growth trajectory by 2020 and 2025 respectively (Ramaphosa, 2019 [4]; GreenCape, 2018 [5]). SA has also recently implemented the Carbon Tax Act (No. 15 of 2019), in an attempt to discourage greenhouse gas emissions and thereby drive the country towards a low-carbon economy (South African Government, 2019 [6]). Various policies and projects are being implemented to support SA's low carbon economy strategy, especially within the agricultural sector. Projects and initiatives implemented so far include the Smart Agri Plan (2016), which serves as a climate response framework and plan (SmartAgri, 2016 [7]). Conservation Agriculture (CA) is a farming system that promotes minimum soil disturbance (i.e. no tillage), maintenance of a permanent soil cover, and diversification of plant species. Fruitlook is another initiative and tool that makes use of satellite technology that provides weekly, semi-real time information on crop growth, evaporation deficits and crop nitrogen status for irrigation blocks in orchards and vineyards, therefore assisting deciduous fruit and grape farmers to be water efficient and climate smart (WCDOA, 2016 [8]). Confronting Climate Change carbon footprint tool is a carbon footprint calculator that can calculate the emissions for the wine and fruit industries. GreenCape is an agency supported by WCDOA that works closely with government and other private institutions to build a resilient green economy by supporting businesses and investors in the green economy to remove the barriers that is prohibiting growth. GreenCape focuses waste, water, renewable energy, energy efficiency, industrial symbiosis, sustainable agriculture, gas, green finance and the bioeconomy.

The Western Cape provincial government has acknowledged the risks and threats posed by climate change and resource inefficiency. In an attempt to address these threats and to decouple economic growth from environmental impact, the Green Economy Strategy Framework was developed in 2013 (Western Cape Government, 2013 [9]). This has led to various departments embarking on a range of proactive and reactive projects and programmes, collaborating with a wide range of different institutions. In one such initiative, the Western Cape Department of Agriculture (WCDoA) started a project in which it proactively measure and monitor their research farms' carbon footprints to assist and advise farmers in terms of reducing carbon emissions. The Carbon Footprint Project, established in 2011/12, measures the WCDoA's research farms' carbon footprint annually, identifying hotspots and suggesting strategies to reduce emissions. It serves both as an opportunity to lead by example and to gain knowledge to better serve the agricultural sector towards increased sustainability. The purpose of implementing this project was to:

- Assist in combating climate change;
- Assist in creating awareness of the impact of different farm activities;
- Help improve resource efficiency on each farm;
- Develop modules for other farms to replicate (demonstration models); and
- Enhance the reputation of the farms as supporters of sustainable farming practices through resource efficiency and waste minimization.

This report provides a brief overview of global and South African carbon emissions, followed by the methodology used to conduct a carbon footprint. The report offers results from the WCDOA project and concludes with a discussion on the gaps that still exist when conducting a footprint for the South African agricultural sector.

2. Global and South African Emissions

2.1. Global Emissions

The World Economic Forum's Global Risk Report (2020) identified the following top long-term risks by likelihood: 1) extreme weather, 2) climate action failure, 3) Natural disaster, 4) biodiversity loss, and 5) human-made environmental disaster (WEF, 2020 [10]). Clearly, the rising global carbon emissions presents a large threat to the planet, the economy and livelihoods which is why the Paris Agreement was established at COP 21 in Paris on 12 December 2015 and was signed in 2016 under the UNFCCC (Wood, 2019 [11]; UNFCCC, 2019 [3]). This agreement's aim is "to strengthen the global response to the threat of climate change by keeping a global temperature rise well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius" (UNFCCC, 2019 [3]). With the agreement in place, global emissions still grew by 2.0% in 2018 due to global energy consumption that grew by 2.3% (Gillan, 2019 [12]). To get a sense of how emissions have grown, the level of atmospheric CO_2 at the start of the Industrial Revolution (1700s) were approximately 280 parts per million (ppm) and in 2013 the level breached the 400ppm mark for the first time and by 3rd of June 2019, atmospheric CO2 levels stood at 414.40ppm (Fleming, 2019 [13]). Clearly, this unstainable rise in the burning of fossil fuels which started with the Industrial Revolution has intensified over the past decade to power global economic growth (Wood, 2019 [11]).

Table 1 ranks countries according to their CO_2 emissions based on 2017 and 2018 respectively. China was by some margin the largest, emitting around 10 065 metric tons of CO_2 into the atmosphere in 2018 which is 28% of the global total (Global Carbon Atlas, 2019 [14]). Next, the United States of America and India each emitted 5 416 and 2 654 tons of CO^2. These top three ranking countries together contributed to 48.6% of global emissions in 2017 and 49.5% in 2018. The rest of the top fifteen countries contributed 23.7% for both years to global emissions compared to the rest of the world's 27.7% and 26.8% respectively. Between 2017 and 2018, global emissions increased by 420 $MtCO_2$, largely driven by increases by the largest polluters.

Table 1: Global CO2 emissions per country for 2017 and 2018

Country	Rank 2017	Emissions in 2017 ($MtCO_2$)	% of Global Emissions 2017	Rank 2018	Emissions in 2018 ($MtCO_2$)	% of Global Emissions 2018
China	#1	9 839	27.2%	#1	10 065	27.5%
United States of America	#2	5 269	14.6%	# 2	5 416	14.8%
India	#3	2 467	6.8%	# 3	2 654	7.2%
Russia	#4	1 693	4.7%	# 4	1 711	4.7%
Japan	#5	1 205	3.3%	# 5	1 162	3.2%
Germany	#6	799	2.2%	# 6	759	2.1%
Iran	#7	672	1.9%	# 7	720	2.0%
Saudi Arabia	**#8**	**635**	**1.8%**	**# 9**	**621**	**1.7%**
South Korea	**#9**	**616**	**1.7%**	**# 8**	**659**	**1.8%**
Canada	**#10**	**573**	**1.6%**	**# 11**	**568**	**1.5%**
Mexico	**#11**	**490**	**1.4%**	**# 12**	**477**	**1.3%**
Indonesia	**#12**	**487**	**1.3%**	**# 10**	**615**	**1.7%**
Brazil	**#13**	**476**	**1.3%**	**# 14**	**457**	**1.2%**
South Africa	**#14**	**456**	**1.3%**	**# 13**	**468**	**1.3%**
Turkey	#15	448	1.2%	#15	428	1.2%
Top 15 countries		**26 125**	**72.3%**		**26 780**	**73.2%**
Rest of World		**10 028**	**27.7%**		**9 793**	**26.8%**

Source: Fleming, 2019 [13]; Global Carbon Atlas, 2019 [14]

Figure 1 gives a summary of the global greenhouse gas per sector. Focusing on the 2016 data, it shows that electricity and heat was the highest contributing sector, contributing 15,01 billion ton of CO2e, followed by transport (7,78 billion ton of CO2e), manufacturing & construction (6.11 billion ton of CO2e and the 4th highest contributor was the agricultural sector (5,80 billion ton of CO2e). The global agricultural sector is one of the larger sectoral emitters by contributing approximately 11% to the total global manmade GHG emissions (C2es.org, 2020[15]). This however a much smaller proportion compared to the energy sector who contributes to 72% of the world total. Within agriculture, livestock production is the largest contributor to agricultural GHG emission by means of enteric fermentation and manure management and since this form of farming is the world's largest user of land resources it is critical to negate any negative environmental impacts such as land degradation, water depletion and pollution (Jansen van Vuuren & Pineo, 2015). Furthermore, certain livestock systems such as natural grazing in grasslands also makes a positive impact in terms of carbon sequestration by using the natural carbon cycle to replenish carbon into the soil (Soussana et al., 2006 [18]).

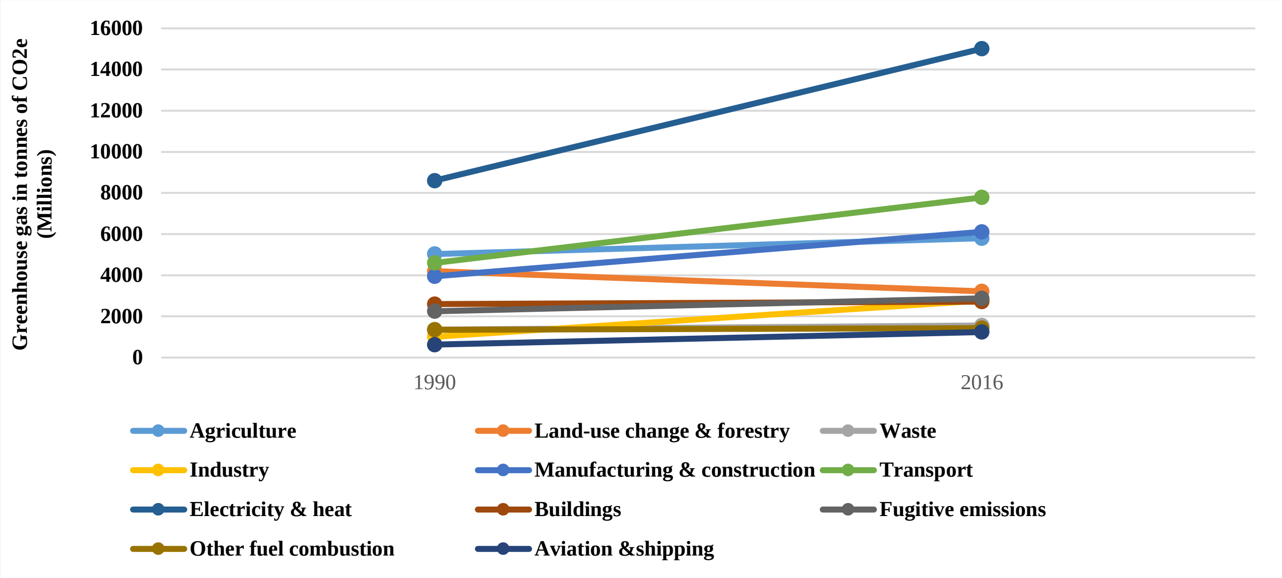


Figure 1: Global greenhouse gas emissions by sector

Source: Our World in Data, 2020 [17]

2.2. South African Emissions

SA is one of the highest contributors to GHG emissions and is ranked 13th on the global emissions list (Global Carbon Atlas, 2019 [14]). This tool is described as a cost-effective and affordable way to sustainably reduce emissions (SARS, 2020 [19]). It is deemed to be much simpler to implement than alternative carbon trading schemes. The carbon tax tools will also result in a "polluter-pays-principle" which will help to address the negative costs associated with climate change, as well as ensure that companies become more environmentally friendly when making future business decisions (SARS, 2020 [20]).The South African Revenue Service (SARS) and Department of Environment, Forestry and Fisheries (DEFF) are jointly responsible for administering the implementation and management of the Carbon Tax Act (SARS, 2020 [19]). SARS is responsible for collecting the tax revenue, while DEFF will be responsible for reporting on the methodology (SARS, 2020 [19]; Partridge, 2019 [20]). The Carbon Tax will be implemented in phases, with Phase 1 including most businesses, excluding agricultural and waste sectors (due to its complexity) (Rodseth, 2019 [21]). However, agriculture will be indirectly affected by the use of inputs such as electricity and fertilisers (Partridge, 2019 [20]). Phase 1 of the carbon tax came into effect on the 1st of June 2019 to end December 2022 (Rodseth, 2019 [21). The agricultural sector will only be directly affected in Phase 2. With the introduction of the carbon tax, more local studies are being conducted to determine emissions for sectors in SA, coupled with guidelines to assist with implementation. The agricultural sector is complex sector and a standardised emission source list is not readily available, especially for livestock.

The WCDOA's research farms serve as trials for the carbon footprint study and to help overcome this complexity of the agricultural sector. The Department has seven research farms across the Western Cape. These farms differ in size, location and farming activities, as can be seen in Table 2 below.

Table 2: WCDOA's research farms' profiles

Farm Name	Hectares	Farm activities
Nortier Lamberts Bay	***2 800 ha*** (whole 2 800 ha is actively used)	***Research:*** Veldt rehabilitation; Veldt restoration; Livestock which include beef cattle, sheep, ostriches and goats.
Langgewens Moorreesburg	***469 ha:*** 389 ha actively used 55 ha non-active land 25 ha virgin land	***Research:*** Small grain; Livestock (only focusing on sheep)
Worcester Veld Reserve Worcester	***110 ha:*** 25 ha actively used 85 ha virgin land	***Research:*** Veldt rehabilitation; Restoration of natural veldt
Oudtshoorn	***843 ha:*** 120 ha actively used 58 ha non-active land 665 ha virgin land	***Research:*** Ostrich; Lucerne production; Saltbush Pomology (figs and prickly pears)
Outeniqua George	***300 ha:*** 197 ha actively used 80 ha non-active land 23 ha virgin land	***Research:*** Dairy; Cattle; Grazing

Tygerhoek Riviersonderend	***2 760 ha:*** 660 ha actively used 2 100 ha virgin land	***Research:*** Livestock (Merino sheep); Pastures Small grain rotational crops (wheat, lupines, oats, barley, canola)
Elsenburg[1] Stellenbosch	***674 ha:*** 465 ha actively used 157 ha non-active land 53 ha virgin land	***Research:*** Pomology; Vegetable production; Livestock (dairy, non-dairy cattle and sheep); Vineyards; Cellar research; Small-scale research on aquaculture and horses

Source: Barends-Jones, 2020 [22]

The main aim of the research farms are to conduct studies that will add value to the farming communities in their areas and for this reason the idea of measuring the research farms' carbon footprints. The project started measuring the research farms' footprint for the 2011/12 financial year and has been running for 8 years.

3. Method

The reality of global warming and climate change is starting to affect both smallholder and commercial farmers. As a result, it is becoming imperative for farmers to measure and monitor their impact on the environment (Barends, 2016 [23]). The need for measurement tools has led to the development of various carbon calculators with numerous online calculators now available for individuals, households and businesses. Although a range of options are available, many of these systems are not without shortcomings. According to Ross et al. (2010) [24], online calculators have shown to be inconsistent and lacking transparency when it comes to how the calculations are done. Different calculators are suited for different purposes, which has a significant impact on the scope and methodology of each (Little & Smith, 2010 [25]). All the different calculators work on a basic principle that consists of two components:

- a database with standard emission source figures (emission factors) and,
- farm activity data. Emission factors are quantities that make it possible to convert activity data into GHG emissions.

The formula used to measure emissions is as follows:

GHG Emissions (tCO_2e) = Activity Data (mass/volume/kWh/km) x Emission Factor (CO_2e per unit) (Barends, 2016 [23]).

Farm activity data includes emission sources like fuel, electricity, waste, etc. as listed in Table 3. These emission sources can also be used as the boundaries of the study to indicate what is considered for measurement. These emission sources can be grouped into three scopes that influence the measures that can be put in place to reduce the farm's footprint. Scope 1 is direct emissions from owned or controlled sources and includes fuel, manure management, enteric fermentation and organic waste to compost. Scope 2 is indirect emissions from the generation of purchased energy. Scope 3, on the other hand, is also indirect emissions that are not included under Scope 2. Emissions are not from owned or controlled sources and occur in the value chain of the reporting industry/company and include both upstream and downstream emissions. Sources like business travels, procurement, the rest of the waste category and water fall under Scope 3 (EPA, 2020 [26]).

Table 3: Emission sources divided according to Scope 1, 2 & 3

Scope 1	Scope 2	Scope 3
Mobile fuel Stationary fuel Manure management Enteric fermentation Organic waste to compost Office and domestic waste recycled	Electricity	Office and domestic waste to landfill Organic waste to landfill Agro-chemicals

Source: Barends, 2016 [23]; EPA, 2020 [26]

A farm's carbon footprint tends to be multifaceted due to the following reasons:

- Farms in general are complex systems that tend to be cohesive.
- In most industries, the main greenhouse gas emitted is carbon dioxide (CO_2). However, in agriculture, methane (CH_4) and nitrous oxide (N_2O) are more important; especially methane from livestock, which contributes 27.4%

[1] Only activities under the direct control of the farm manager were included in the study. This included the sheep camps, farm offices and milking parlour.

to the national methane emissions. In total, livestock contributes 98% to agriculture's methane emissions but CO_2 emissions are only about 10% of total agricultural emissions (Little & Smith, 2010 [25]; du Toit, et al., 2013a [27]).

Despite the complexity of the process to calculate a farm's carbon footprint, it is still important to do so to help farmers measure, monitor and reduce their environmental footprints. The process leads to improvements in the efficiency and performance of their business and contributes to informing strategy and policy development. It can also be used as a marketing tool to inform environmentally conscious consumers and influence buying decisions (Little & Smith, 2010 [25]).

The internationally recognised measure of GHG is "tons of carbon dioxide equivalent" (tCO_2e) and is used when reporting on the carbon footprint. This measure is also used to compare the different GHGs to one unit of CO_2 (Barends, 2016 [23]). To calculate the tCO_2e, each greenhouse gas' emission is multiplied with its global warming potential (GWP)[2].

This paper will only focus on three of the GHGs: CO_2, CH_4 and N_2O. Table 3 gives a summary of the three GHGs and their GWPs.

Table 4: Greenhouse gases and their global warming potentials

Gas	Abbreviation	Global warming potential
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265

Source: GHG Protocol.org, 2016 [28]

Table 4 states that CH_4 is 28 times more effective in trapping the heat in the atmosphere than CO_2 over a 100-year period. N_2O is 265 times more effective than CO_2 in trapping the heat. CH_4 emissions remain in the atmosphere for approximately 9 to 15 years compared to N_2O that has an atmospheric lifespan of 150 years (du Toit et al., 2013b [29]).

Within the project, researchers have compiled detailed data on the different emission for the past eight years, by means of site visits, and informal interviews, followed with a "walk through" of the farm. The data is sorted and entered in a spreadsheet that has been prepared to calculate the emissions, so all the emission factors are already entered and the formulas.

4. Results

The research project to calculate WCDOA's research farms' footprints yielded interesting findings. Starting with the overall emissions for all of the selected farms combined, Figure 2 show the trend since the inception of the project in 2011. In the first four years of the project the total emissions continued to grow, albeit at a slower rate up until 2014, after which the emissions stabilised and somewhat declined. This suggests that, amongst other things, the carbon emissions awareness that resulted in measuring each farms footprint, coupled with the carbon reducing efforts made a significant impact on the overall footprint of the Department. Although each research farm has its own unique setting and differ in size, farming activities, enterprises, staff members and location.

[2] A list of all the GHGs and its GWP values is available on the GHG Protocol.org website

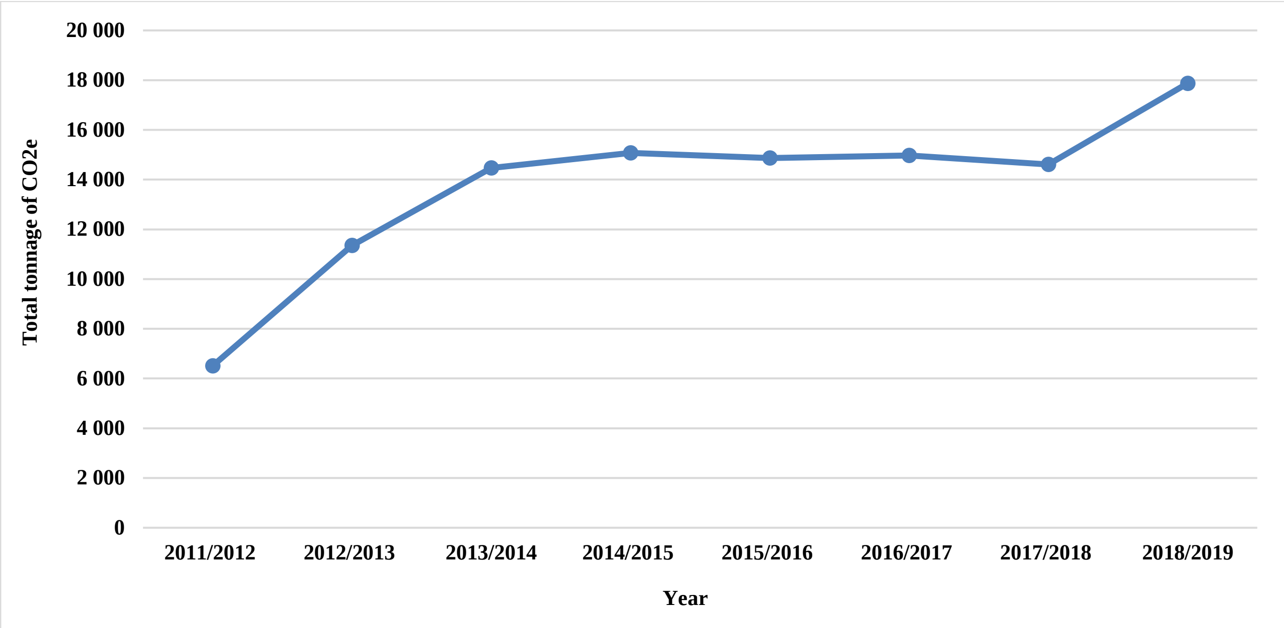
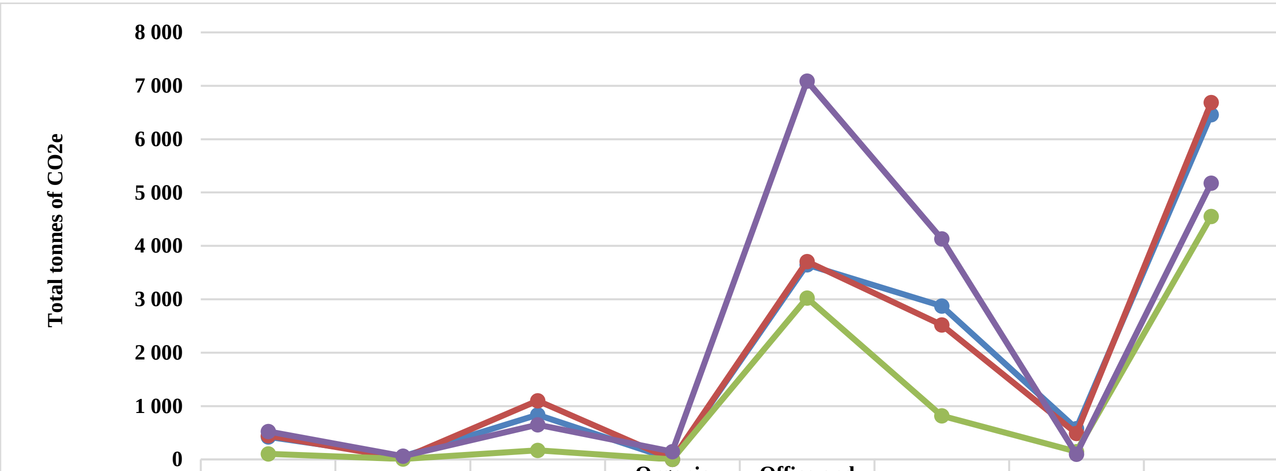


Figure 2: WCDoA research farms' total emissions, 2011-2018

Source: Barends-Jones, 2020 [22]

The reasons behind the sudden increase in emissions in 2018/19 is explained in Figure 3. For ease of interpretation, the past four years of the total emitted of CO2e is disaggregated into the main carbon emitting activities. Clearly, the office and domestic waste component's increase was the major driver behind the latest increase. This increase in the waste component was due to the recycling project that was discontinued in 2018. Farms were still given the option to continue but just without the support of the project coordinator and the incentives to motive the residence and employees. Elsenburg research farm is the main contributor to the high waste emissions due to the discontinuing of the recycle project. Furthermore, the increase emissions in 2018/19 was also due to higher enteric fermentation, largely driven by all the farms increasing its livestock components, These results shows that decisions on farms and how emissions are management makes a significant impact in actual reduction, of which the starting point should be to start measuring.



	Mobile fuel	Stationary fuel	Agro-chemicals	Organic waste to compost	Office and domestic waste	Enteric fermentation	Manure management	Electricity
2015/2016	421	59	834	1	3 649	2 874	575	6 460
2016/2017	445	19	1 101	0	3 710	2 523	488	6 687
2017/2018	103	9	171	0	3 025	819	148	4 551
2018/2019	522	61	649	144	7 090	4 131	97	5 178

Figure 3: Total emissions released per emission source for the 4 year period

Source: Barends-Jones, 2020 [22]

5. Gaps in the carbon footprinting process

Various carbon calculator tools are available but when it comes to measuring the agricultural sector's carbon emissions the tools available become limiting and emission source data used are not representative of the SA agricultural sector, especially for livestock. The calculators that focus on livestock can be used as a baseline as they are based on the Intergovernmental Panel on Climate Change (IPCC) principles and values, following a Tier 1[3] approach. The lack of tools that focus on non-ruminants is due to the global perspective that view these animals as minor sources of GHG emissions and therefore not having a major impact on total livestock emissions (du Toit et al., 2013a [27]). When calculating livestock emissions, methodology from Tier 1, Tier 2[4] or Tier 3[5] needs to be taken into account. Discrepancies can develop when the emission factors are not calculated and written in such a way that distinctions can be made between animal classes, production efficiencies and production systems. Livestock greenhouse emissions vary by animal type, growth stage and level of production owing to different diets, feed conversion mechanisms and manure management systems. Tier 2 methodology should be developed for all livestock.

Another gap that exists is the lack of a carbon tool that can assist in measuring a mixed farming enterprise (Barends, 2016 [23]). For example, a farmer, farming with various livestock, vegetables and fruit. For the farmer to be able to measure his farm's carbon footprint he has to conduct various footprints to get to the farms' total emissions. Once again discrepancies can exist due to different methodologies and emission factors that are used.

Lesson learned from starting a footprint project are to always keep record of farm activities on a monthly basis, know what you want to measure and what the boundaries of measure are – what can be controlled, always explain the bigger picture to everyone involved in such a project, especially when carbon reduction strategies will be implemented and get buy-in and cooperation are key for the success of the project.

6. Conclusion

Emission reduction plans and efforts are being developed and implemented across the world to help combat the effects of climate change. South Africa was one of the countries that committed to this framework and has implemented a Carbon Tax Act (No. 15 of 2019), that will serve as a tool to move to a low-carbon economy. With the carbon tax being implemented in phases, the WCDOA has already implemented projects to help with decreasing emissions, so as to be prepared for the implementation of Phase 2 of the carbon tax that will directly impact the agricultural sector. One of the implemented projects was to measure the research farms' carbon footprint. By measuring these footprints, the hotspots were identified and action can be put in place to try to decrease the emissions. The research farms served as trials to provide insight for the rest of the sector. This project has been running since 2011/12 and despite challenges along the way, with time the model is improving and becoming more accurate. The carbon footprint project also highlighted the gaps that exist in carbon emission data for the agricultural sector and due to its complexity will need more research and country-specific data to get SA's agricultural sector ready for the carbon tax.

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[3] Tier 1 methodology relies on the basic characteristics of livestock populations to estimate an approximate emission factor. These calculations include assumptions, for example animals consuming highly digestible diets such as temperate forages. These assumptions are not realistic for South African production systems since they mainly focus on ruminants, like dairy and beef cattle (du Toit, et al., 2013b [29]).

[4] Tier 2 uses enhanced characterisation of populations including information such as feed intake, weight gain, etc.

[5] Tier 3 incorporates an even higher level of detail relating to diet composition, seasonal variation, etc. (IPCC, 2006 [30]).

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