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Carbon Footprint Report: Departmental Research Farms 2019 - 2020

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March 2021

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1. Background

The global agricultural sector is one of the major contributors to Greenhouse Gas (GHG) emissions, with an estimated share of 19 – 29% (World Bank, 2020). Not only is the agricultural sector a contributor to emissions but is particularly exposed to various risks associated with weather conditions and the changing climate. In South Africa (SA), the ill effects of climate-related disasters such as droughts, flooding, fires, and storms that have been recorded are projecting the future narrative of the country - a severely impacted farming sector and the livelihoods it supports (poverty increasing), as well as food insecurity for rural and urban communities (Pienaar & Boonzaaier, 2018; DEFF, 2020).

South Africa's dependence on coal-based energy and its heavy emissions from the transport sector led to the country ranking 12th on the global carbon emission list for 2019 (Global Carbon Atlas, 2021), resulting in SA to be among the highest per capita emitters in the developing world (DEFF, 2020). Therefore there is a need for SA to invest in the transitioning of a low carbon economy, where the risk and impact of climate change will be reduced, poverty alleviated and livelihoods improved (DEFF, 2020). SA is also one of the 195 signatory countries that have committed to the United Nations Framework Convention on Climate Change (UNFCCC) and therefore it is of utmost importance for SA to stay committed to stabilising the GHG concentration in the atmosphere and halting the global average warming below 2°C above pre-industrial levels (DEFF, 2020; UNFCCC, 2020).

Various efforts are currently underway to drive all sectors of the economy towards sustainable production and build on carbon reduction efforts. SA has 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 (SARS, 2020; South African Government, 2019). Within the South African agricultural sector, numerous policies and projects are being implemented to support the low carbon economy strategy. Several projects and initiatives have been implemented as part of the Smart Agri Plan in 2016, which serves as a climate response framework and plan. This plan consists of a detailed background, which focuses on four strategic focus areas, six priority projects, regional and commodity briefs, case studies and proposed actions (SmartAgri, 2016). One of the six priority projects is the Conservation Agriculture Western Cape initiative and platform where producers, researchers, and industry can discuss conservation agriculture matters. Fruitlook and the Confronting Climate Change (CCC) carbon footprint tool are initiatives that will assist with the six priority projects. Fruitlook is an 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 more water efficient and climate-smart (WCDOA, 2016). The CCC carbon footprint tool is another Western Cape base tool made available to the agricultural sector and was developed for the wine and fruit industries (CCC, 2020). GreenCape is an agency in the Western Cape 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 prohibit growth. GreenCape focuses on waste, water, renewable energy, energy efficiency, industrial symbiosis, sustainable agriculture, gas, green finance, and the bioeconomy (GreenCape, 2020).

Different Provinces are implementing various policies and projects to support the low carbon economy strategy of the country. The Western Cape Department of Agriculture (WCDoA), for example, undertook the carbon footprinting project, whereby each departmental research farms' carbon footprint is calculated annually. This project was planned and registered in 2011 but only implemented in 2013. 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 copy (demonstration models); and
- Enhance the reputation of the farms as supporters of sustainable farming practices through resource efficiency and waste minimization.

This project is in alignment with the following policies:

Table 1: The project's strategic alignment

International	National	Provincial	Departmental
Millennium Development Goals • Goal 7, 12 and 13	**National Development Plan** (NDP) **2030** • Chapter 5	**Provincial Strategic Goal** (PSG) **1** (old) • Create opportunities for growth and jobs	**WCDOA's vision** • "A united, responsive and prosperous agricultural sector in balance with nature".
The Comprehensive Africa Agricultural Development Programme (CAADP)	**National Outcome (NO)** • NO 4, 7 & 10	**Vision – inspired priority** (VIP) **2** • Growth and Jobs	**Departmental Outcomes** • Increased agricultural production in a sustainable manner • Innovative and Resilient Rural Economies
	South African Constitution (1996), section 24	**Western Cape Green Economy Strategy**	**Ministerial Priorities** • Climate Change
		OneCape 2040	

Source: Own Compilation (2021)

This report will provide the findings of the carbon footprint assessment for all seven of the research farms for the period from April 2019 to March 2020. Previous data will be compared with the current footprint data to illustrate any changes overtime. Carbon reduction opportunities for the research farms will also be explored.

2. Global emissions

The World Economic Forum's Global Risk Report for 2020 identified the following top long-term risks by likelihood: 1) extreme weather, 2) climate action failure, 3) Natural disaster, 4) biodiversity loss and lastly, 5) human-made environmental disaster (WEF, 2020). The rising global carbon emissions present a threat to the planet, the economy, and livelihoods and therefore the establishment of the Paris Agreement at COP 21 in Paris on the 12th of December 2015 and was signed in 2016 under the UNFCCC (Wood, 2019; UNFCCC, 2020). 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 (˚C) above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5˚C" (UNFCCC, 2020). With the agreement in place, global emissions still grew by 2% in 2018 due to global energy consumption that grew by 2.3% (Gillian, 2019). To get a sense of how emissions have increased, the level of atmospheric CO_2 at the start of the Industrial Revolution (1700) was approximately 280 parts per million (ppm), in 2013 the level breached the 400 ppm mark for the first time, and by 3rd of June 2019, atmospheric CO_2 levels stood at 414.40 ppm (Fleming, 2019). The rise in the burning of fossil fuels started with the Industrial Revolution where it intensified over the past decade to power global economic growth (Wood, 2019).

Figure 1 summarises the top 14 countries contributing the most to the global megatons of CO_2 ($MtCO_2$) emissions for 2017, 2018, and 2019. China was the largest contributor, emitting around 10 175 $MtCO_2$ into the atmosphere in 2019, which is 28% of the global total (Global Carbon Atlas, 2021). Next, the United States of America (USA) and India emitted 5 285 and 2 616 metric tons of CO_2 respectively. These top three ranking countries contributed 50% of global emissions in 2018 and 2019 and 49% in 2017. Looking in-depth at the data, the USA and India show small decreases, whilst the rest of the top 14 countries contributed 22% to global emissions for the three-year under review period. Between 2017 and 2018, global emissions increased by 420 $MtCO_2$, driven largely by increases from the largest polluters. 2019 showed a small decrease of 132 $MtCO_2$, evident of the small emission decreases by USA and India. This is already a strong indication that if the top countries, especially the top three, start decreasing their emissions the global emissions will show a valued decrease.

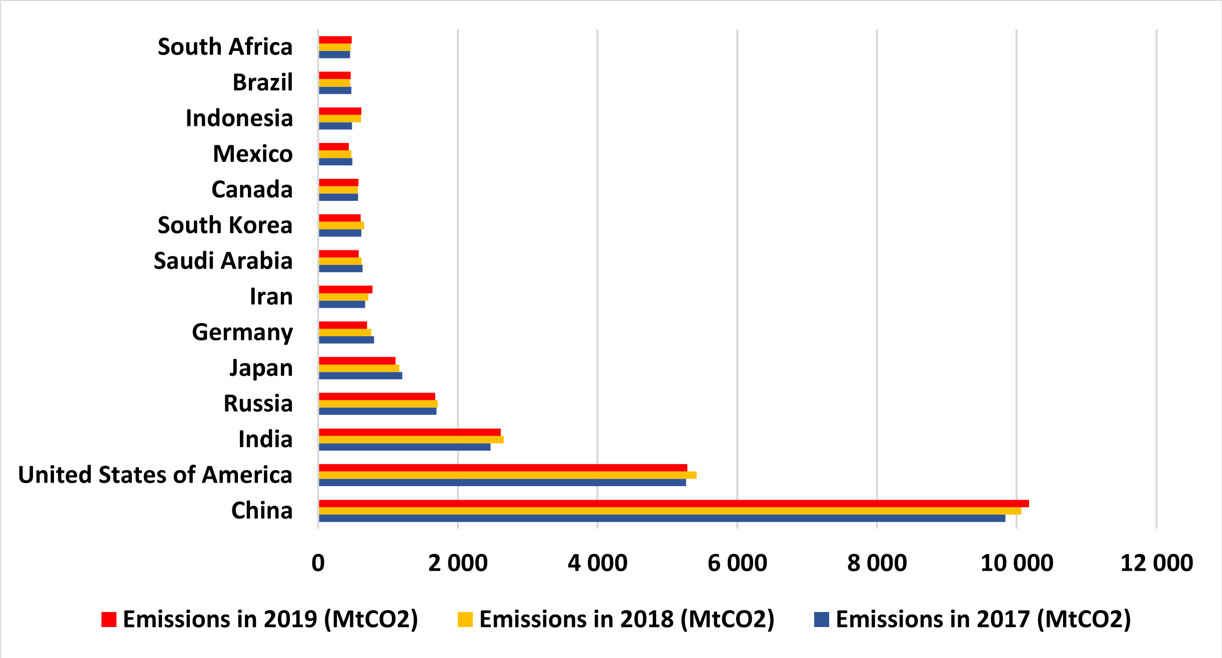

Figure 1: Global MTCO$_2$ emissions per country for 2017, 2018 and 2019

Source: Global Carbon Atlas (2021)

Figure 2 shows the spatial viewpoint of the data given in Figure 1 and indicates the location of the largest emitting countries i.e. the bigger the black dot, the more severe the emission impact is on the world.

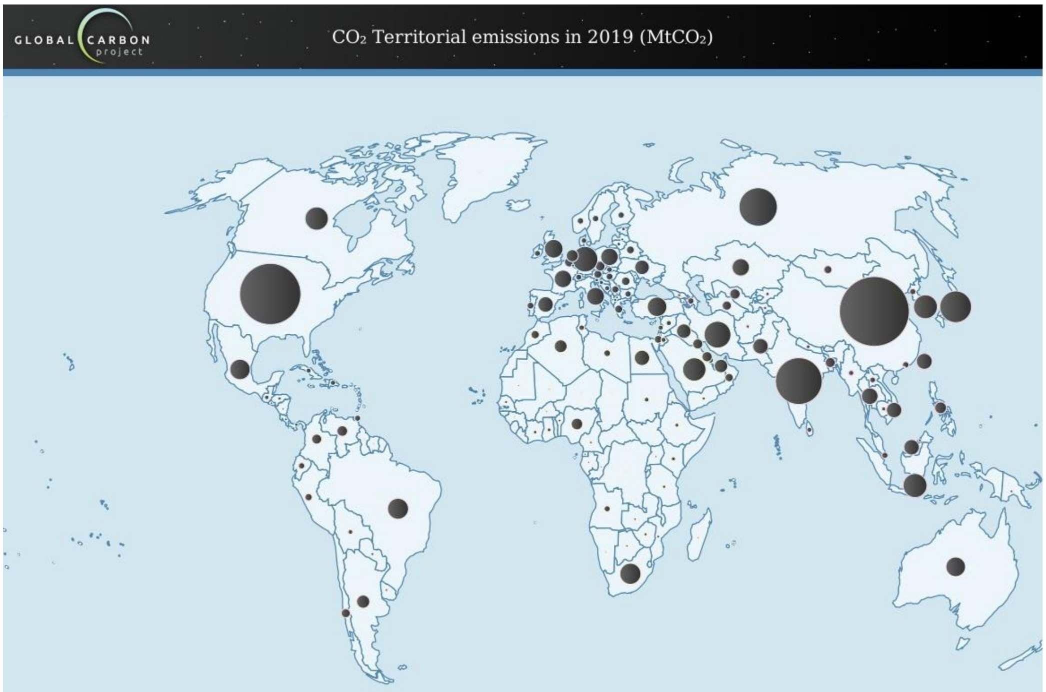

Figure 2: CO$_2$ Territorial emissions in 2019 (MTCO$_2$)

Source: Global Carbon Atlas (2021)

Figure 3 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 CO_2e, followed by transport (7.78 billion ton of CO_2e), manufacturing & construction (6.11 billion ton of CO_2e) and the 4th highest contributor was the agricultural sector (5.80 billion ton of CO_2e).

The global agricultural sector (including land-use change and forestry) is one of the larger sectoral emitters by contributing approximately 18% to the total global GHG emissions (Ritchie, 2020). This is a smaller percentage compared to the energy sector's (including electricity, heat, and transport) contribution of 73%, but this does not mean that carbon reduction efforts are not crucial in this sector.

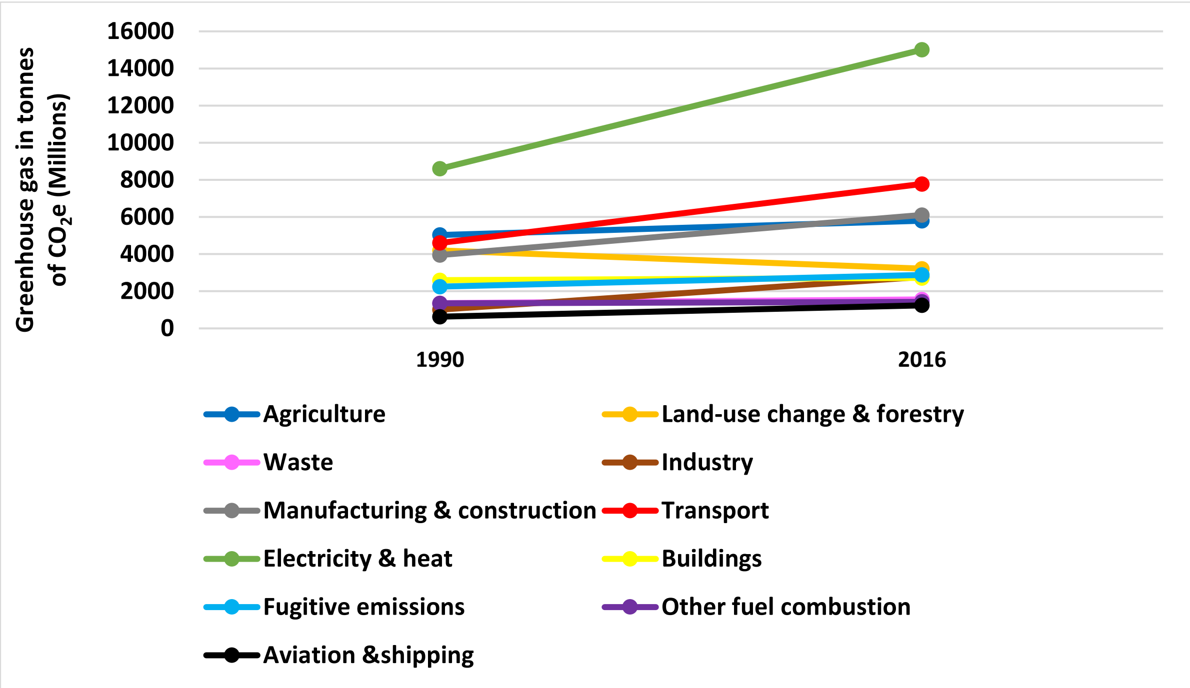

Figure 3: Global greenhouse gas emissions by sector

Source: Our World in Data (2021)

Within agriculture, livestock production is the largest contributor to agricultural GHG emissions through enteric fermentation and manure management. This form of farming is the world's largest user of land resources and it is critical to avoid any negative environmental impacts such as land degradation, water depletion and pollution (Jansen van Vuuren & Pineo, 2015; Ritchie, 2020). However, natural grazing on grasslands is one example of a livestock system that has a positive impact in terms of carbon sequestration by using the natural carbon cycle to replenish carbon into the soil (Soussana, et al., 2006).

3. South Africa's emissions

South Africa ranked 12th on the global carbon emission list for 2019 with an amount of 479 $MtCO_2$ and more recently has been fluctuating between spot 13th and 14th (Global Carbon Atlas, 2021; Our World in Data, 2021). Figure 4 shows South Africa's emissions totals since 1990, the highest emitting year was 2009. Since then there has been some declines but not consistent enough and increasing in the past five years (Our World in Data, 2021).

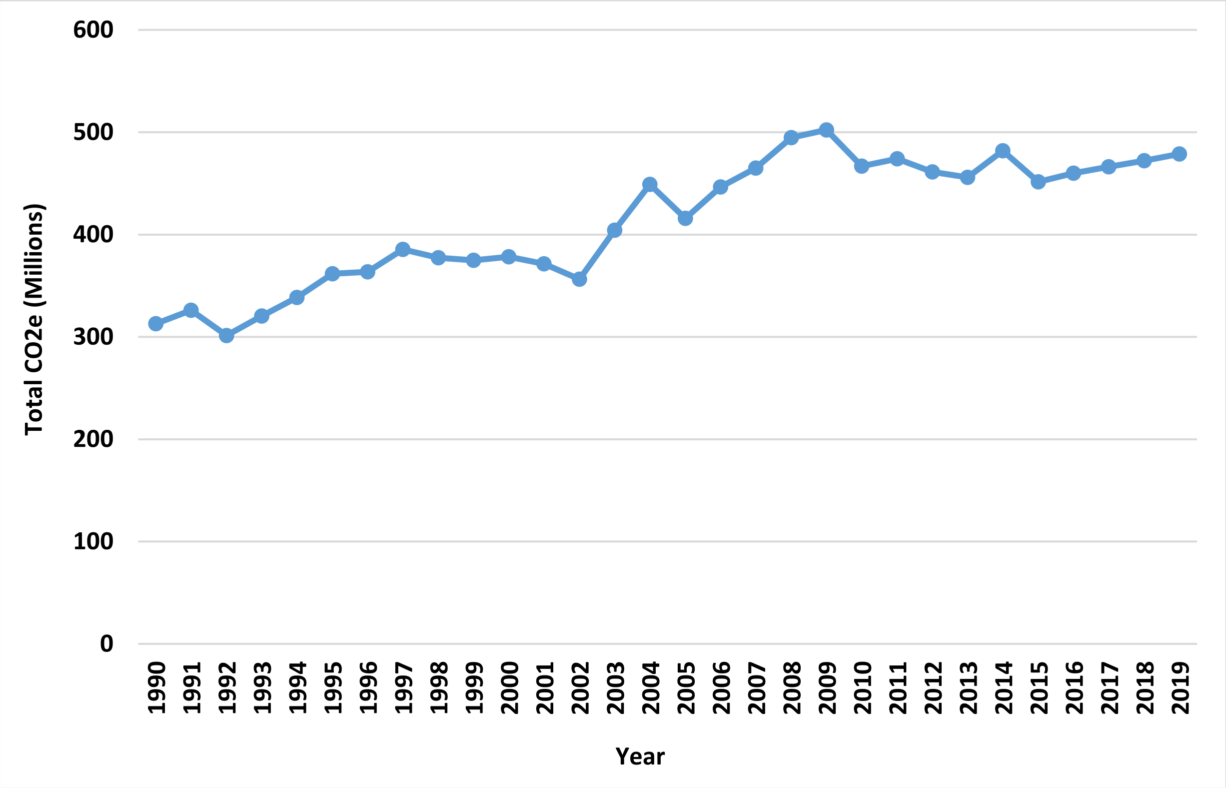

Figure 4: South Africa's carbon emissions

Source: Our World in Data (2021)

The high CO_2 emissions are due to the countries' dependence on coal as a source of energy (McSweeney & Timperley, 2018). South Africa has consented to the Paris Agreement and "*pledged to peak emissions between 2020 and 2025*", *and after that, it will let emissions plateau for roughly a decade before reducing emissions in the 2030s*" (McSweeney & Timperley, 2018). Figure 5 gives the pre- and post-COVID-19 scenarios for South Africa. The 2020 goal for South African emissions was set to be between 414 – 599 $MtCO_2e$, and looking at the pre- and post-COVID-19 projections shows that South Africa reached the goal for this period. One of the reasons why SA reached its goal was due to level 5 lockdown regulations, which caused many businesses to stall economic activities in an attempt to stop the spread of the virus.

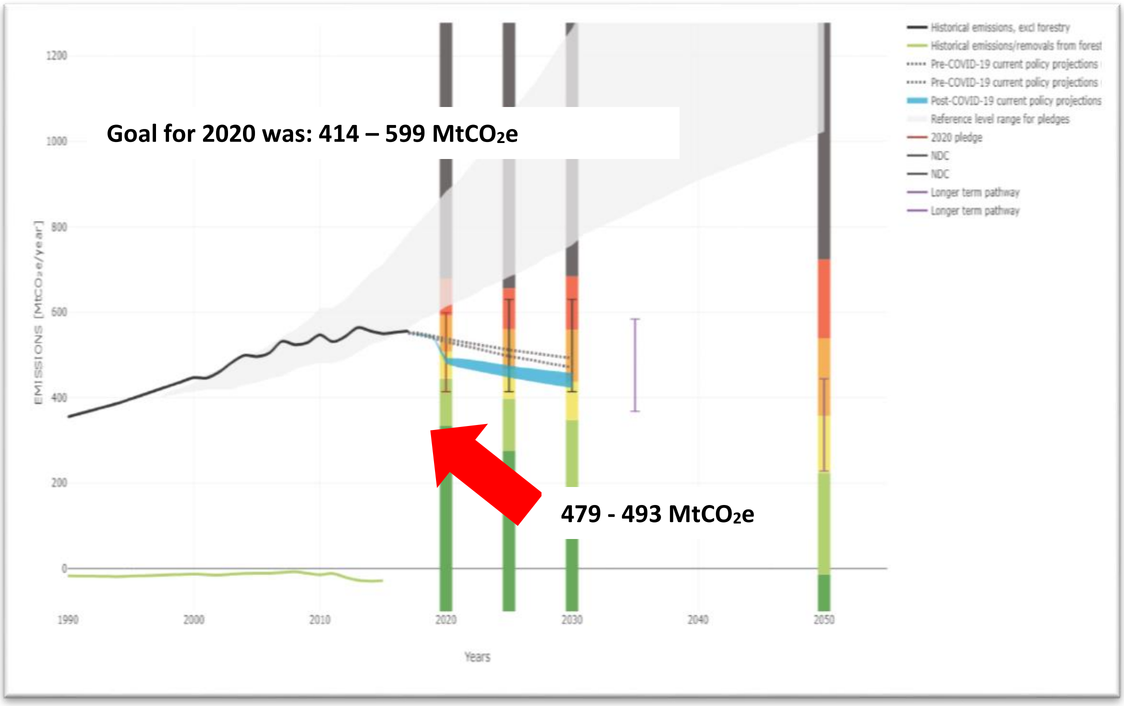

Figure 5: South Africa's emission trajectory

Source: Climate Action Tracker (2020)

As already noted, the country is committed to transitioning towards a low carbon economy and has also recently implemented the Carbon Tax Act (No. 15 of 2019), South Africa being the first African country to implement a tax of this nature (ESI Africa, 2020).

3.1 Carbon Tax

The South African Carbon Tax Act consists of two phases, phase 1, which includes most businesses, was implemented from 1st June 2019 and will run until December 2022 (Rodseth, 2019). The agricultural and waste sectors will only be directly affected at the beginning of 2023 due to the complexities of these two sectors (Rodseth, 2019). Although the agricultural sector will only be directly affected, later on, the indirect effects, for example, the use of inputs such as electricity and fertilisers, should be taken into account (Partridge, 2019). Figure 6 gives a summary of how the carbon tax is set up and being implemented.

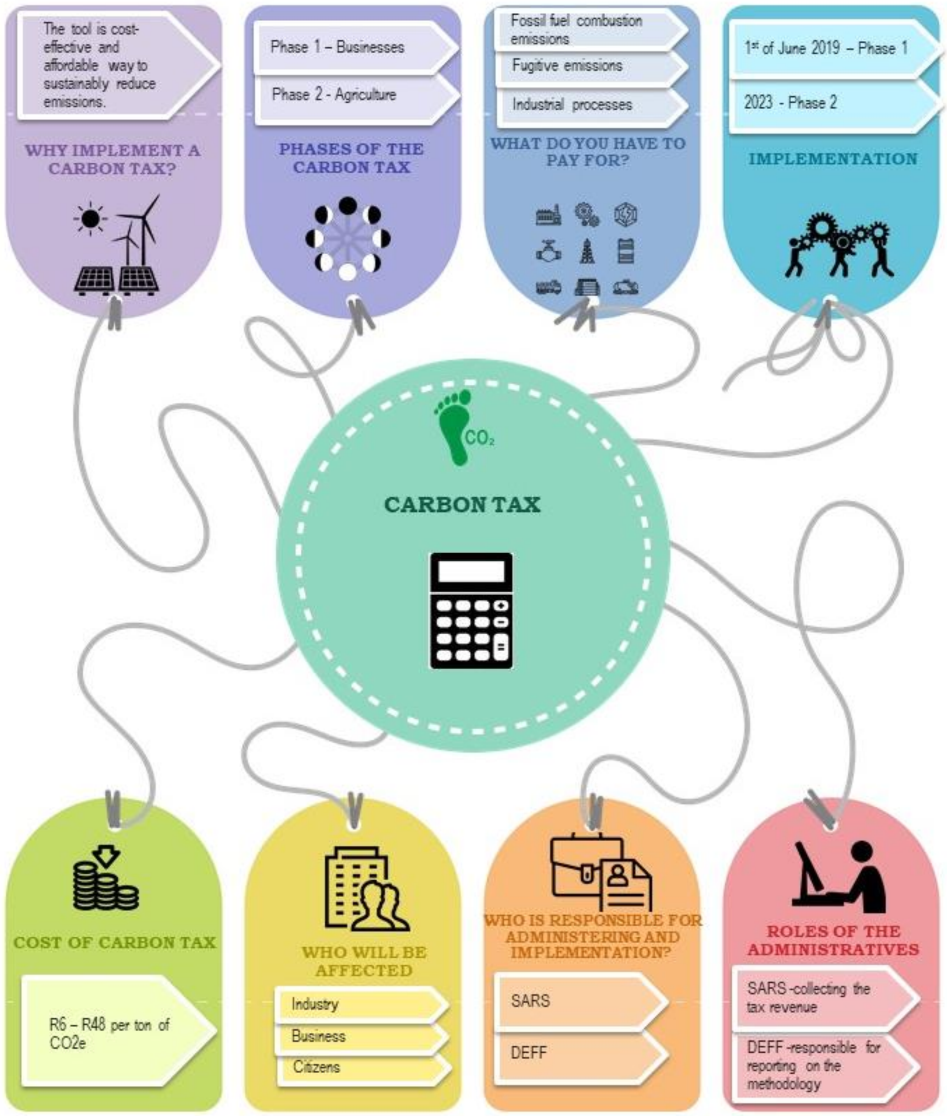

Figure 6: Carbon Tax summary

Source: National Treasury (2019); SARS (2020); Own Compilation (2020)

The cost of the carbon tax, is based on a basic carbon tax rate levy of R120/ton CO_2e on direct emissions (SARS, 2020). Tax-free allowances for the first phase of the carbon tax do exist and range from 60% to a claimable maximum of 95% for businesses (SARS, 2020; Rodseth, 2019), meaning a tax-free allowance ranging between R6 and R48/tonne CO2e. Carbon tax payments are due in July each year but due to the sudden onset of the global COVID-19 pandemic, the first carbon tax payments, 2019/20, were postponed to the end of October 2020 (SARS, 2020). Table 2 gives a summary of the tax-free allowable brackets:

Table 2: Allowable tax brackets

Allowance	Cost
Basic Allowances	60% - 70% (Fixed: 60% fuel combustion; 70% fugitive/process emissions)
Trade Exposure Allowance	10% (capped at 10%)
Performance Benchmark Allowance	5% (capped at 5%)
Carbon Offset Allowance	10% (capped at 10% for fuel combustion; capped at 5% for fugitive/process emissions)
Carbon Budget Allowance	5% (fixed)

Source: Burchell (2020); SARS (2020); Rodseth (2019); Partridge (2019); National Treasury (2019)

It is important to understand these allowance brackets, and based on this understanding and calculation to decide if it is worth (the value of amount the company can save) to claim from these different brackets or just to pay the amount owed to SARS (Burchell, 2020).

3.2 Calculating the carbon tax liability

When calculating the business's carbon tax liability it is important to understand and use the following formula:

Carbon Tax Liability (R) = Emissions[1] x Tax Rate[2] x (1- sum allowance)[3] (Burchell, 2020).

To illustrate how this formula is applied, an example from Ms. Zelda Burchell, a Carbon and Energy Manager at COVA Advisory, is used as shown below. Table 2 gives an example of Company A. This company emits 250 000 tCO_2e for a financial period and is therefore liable to pay a carbon tax to SARS of R30 000 000. This means that that the company is multiplying the total emissions of the company with the tax rate of R120/tCO_2e (250 000 x R120). Luckily, for Company A, tax-free allowance brackets do

[1] Emissions are the total emissions the business has emitted for the financial year.
[2] Tax Rate is the R120/tonne CO_2e
[3] The sum allowance ids the percentage value of the allowances that the business can claim. So for example the business can claim 35%, so it is 1 – 35% = 0.65

exist and the company can make use of these to pay a lesser amount to SARS. In the Table 2 example, Company A gets a total sum allowance of 90% off the total tax liability and therefore only owes SARS R3 000 000 instead of the R30 000 000. The company will have a saving of R27 000 000.

Table 3: Example of how to calculate a business's carbon tax liability

	Emissions (tons CO_2e)	Tax Liability
Total Emissions	250 000	R30 000 000
Value of Allowances		
Basic Allowance (***60%***)	150 000	R18 000 000
Trade Exposure (***10%)***	25 000	R3 000 000
Performance Benchmark (***5%)***	12 500	R1 500 000
Carbon Offset (***10%)***	25 000	R3 000 000
Carbon Budget (***5%)***	12 500	R1 500 000
Net Liability	**25 000**	**R3 000 000**

Source: Burchell (2020)

4. Farm profiles

Under the WCDOA umbrella, seven research farms situated throughout the Western Cape Province. These farms are; Nortier (Lamberts Bay), Tygerhoek (Riviersonderend), Worcester, Elsenburg (Stellenbosch), Oudtshoorn, Outeniqua (George), and Langgewens (Moorreesburg). The WCDOA's head office is located on the Elsenburg Research Farm. Table 4 gives a summarized profile of each of the seven research farms. Each farm profile gives detail about the farm size and what the farms' key research focus areas are. These profiles highlight the differences in farm activities, which assist in calculating the carbon footprint for each farm but are also showcasing the diverse nature of agricultural production across the Province.

Table 4: Farm 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[4] 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: Aucamp (2020); Swart, (2020); Engelbrecht, (2020); Gerber (2020); Jordaan (2020); Laubscher (2020); Rheeder (2020)

It is noted that these seven farms are dependent on Eskom electricity and municipal water for their daily needs. Elsenburg has installed solar PV at the main building recently in order to get a sense of the possible savings generated by this renewable energy source. This will be discussed in more detail under the results section. Most of the housing communities on these research farms have switched to solar geysers as well, which is another green initiative. Six of the seven farms are dependent on municipal water, except Nortier, which only makes use of borehole water. The other

[4] 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

six farms use a mix of municipal and borehole water but due to the poor quality of the borehole water and with the drought experiences in recent years, they tend to rely more on municipal water.

5. Carbon footprint results

5.1 The calculating process

Activity data are collected from the different farm managers of each research farm through a questionnaire. The questionnaire asks farm-specific questions, and these questions are based on activities that fall under the control of the farm manager. That "control" is called the operational boundaries. In the case of Elsenburg research farm, the college and offices are excluded as it does not fall under the farm managers' control. Electricity and water accounts are sourced from the departments' Operational Support Services (OSS) team. The calculations are based on the global formula that is used to calculate emissions. This formula consists of two components – emission factors and activity data:

GHG Emissions (tCO_2e) = Activity data (mass/volume/kWh/km) x Emission factor (CO_2e per unit) (Barends, 2016).

GHG's are measured in tonnes of carbon dioxide equivalents (tCO_2e) globally for reporting purposes, making it easier to compare gases (Barends, 2016). Table 5 focuses on the top 3 GHGs which are more dominant in agriculture and shows their global warming potential (GWP). The GWP is used to calculate the tCO2e by multiplying each GHG with its GWP.

Table 5: The top Greenhouse gases and their global warming potentials (GWP)

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

Source: GHG Protocol.org (2016)

Table 5 is highlighting that methane (CH_4) is 28 times more effective in trapping the heat in the atmosphere than CO_2 over 100 years (du Toit, van Niekerk, & Meissner, 2013).

Table 6 below gives a summary of the activity data for the study and groups it according to three different scopes. These three scopes 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, including both upstream and downstream emissions. Sources like business travels, procurement, rest of the waste category and water fall under scope 3 (EPA, 2020).

Table 6: 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); EPA (2020)

5.2 Results – 2019/20

Figure 7 gives a summary of the 2019/20 emissions for each farm. Elsenburg (4 761 tCO_2e), followed by Outeniqua (3 120 tCO_2e) are the two research farms that emit the most emissions. Looking that these two farms only, it is clear that emissions are coming from electricity usage (pink portion of column), animal activity (enteric fermentation – green block), and agro-chemicals (red portion of column). Reasons for these activities being comparatively high are the farming set-up (people living and working on the farm – the electricity bills cannot be split as it only gives a meter number), the amount of livestock kept on the farms and farms doing different feed trials.

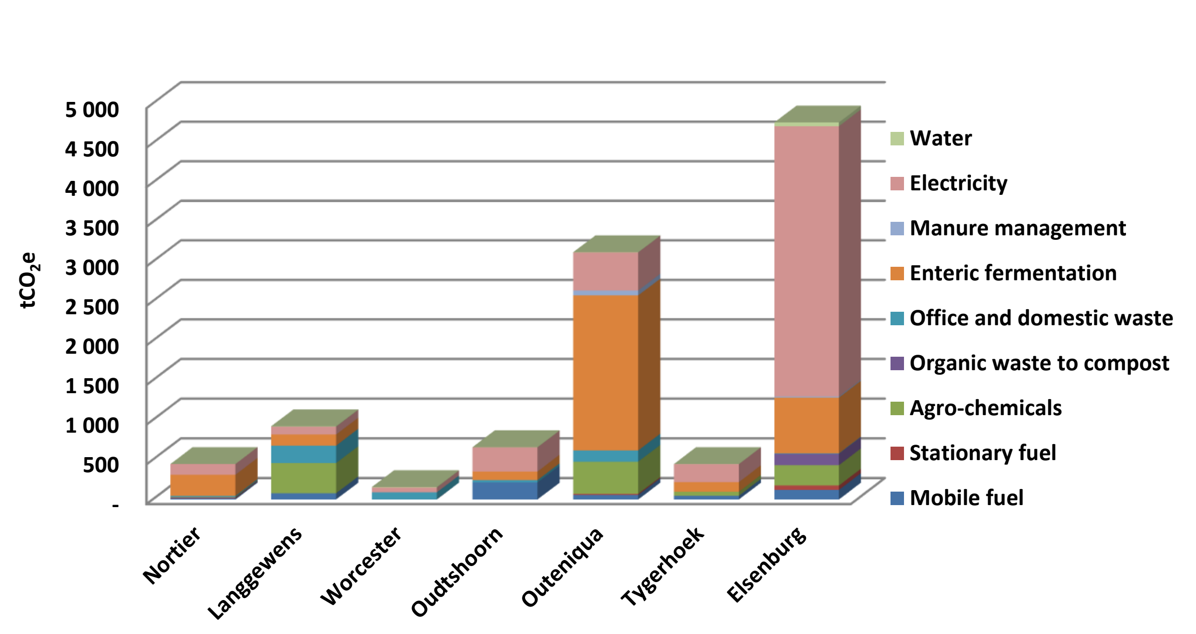

Figure 7: Research farms' measured carbon emission activities - 2019/20

Source: Own compilation, 2021

Worcester research farm shows a smaller emissions number (156 tCO_2e) and this is due to the size of the farm and the type of research being conducted. For Worcester research farm, 56% of emissions are from office and domestic waste and 39% from electricity usage. Figure 8 gives the percentage breakdown of the emission activities for the 2019/20 period. The overall conclusion that can be drawn is that electricity is the highest emission source for all the research farms, followed by enteric fermentation and agro-chemicals.

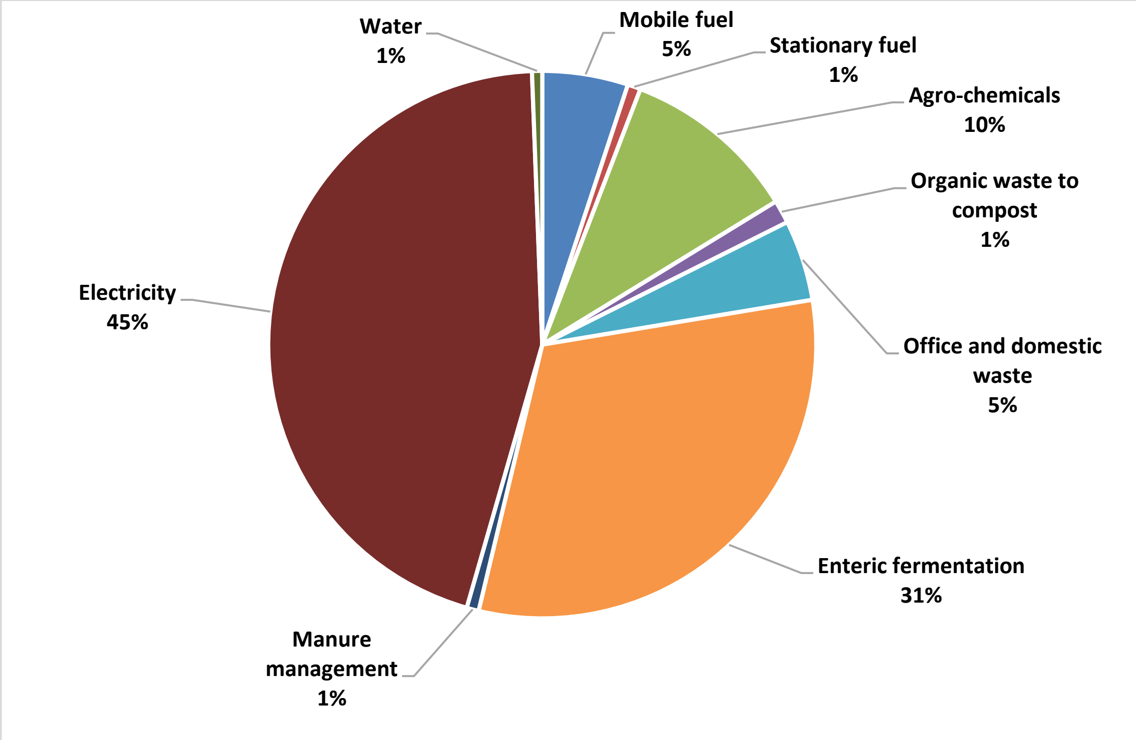

Figure 8: Aggregated carbon emission activities for all research farms for 2019/20
Source: Own compilation, 2021

Emissions can also be grouped according to the different scopes to help with decision making regarding reduction strategies. Figure 9 groups the emissions of each farm according to the scopes.

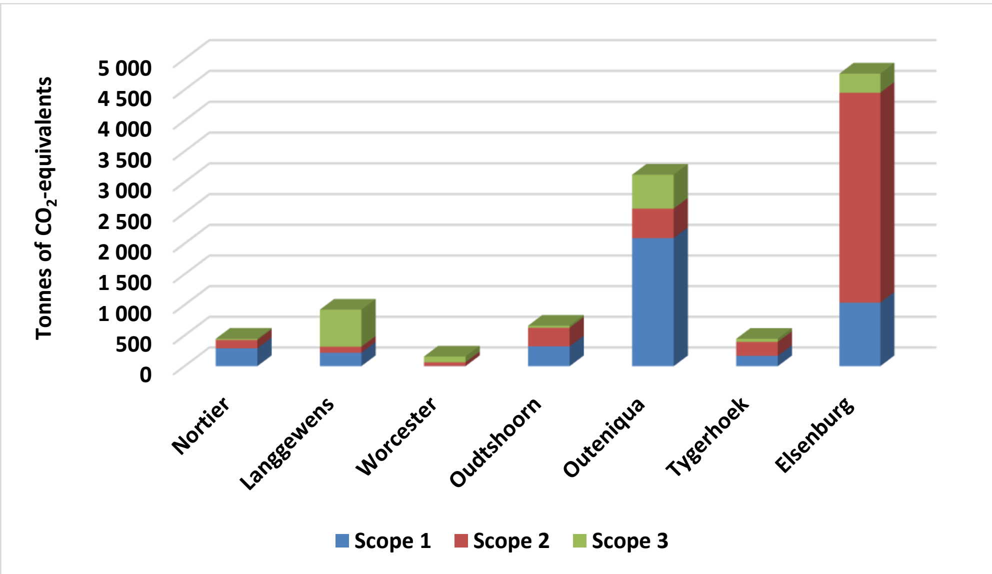

Figure 9: Emissions grouped according to scope for each farm - 2019/20
Source: Own compilation, 2021

Scope 2 emissions are more dominant, followed by scope 1 emissions for most of the farms, except Worcester research farm. Scope 3 emissions are also illustrated.

5.3 Comparing results from 2015/16 until 2019/20

One of the main reasons for implementing this carbon footprint project was to measure and monitor each farms' progress over time. To see if strategies that are being put in place are assisting in combating climate change and are having a positive effect on each farms' footprint. Figure 10 gives the aggregated emissions for all seven research farms over a five year period. For the first three years, it shows almost a plateau shape with a sudden spiked increase for the 2018/19 period. The reason for this increase (can also be seen in Figure 11) was the increase in the waste component and the livestock numbers (enteric fermentation) increase. The Figure shows for the last year of measure a decreasing trend.

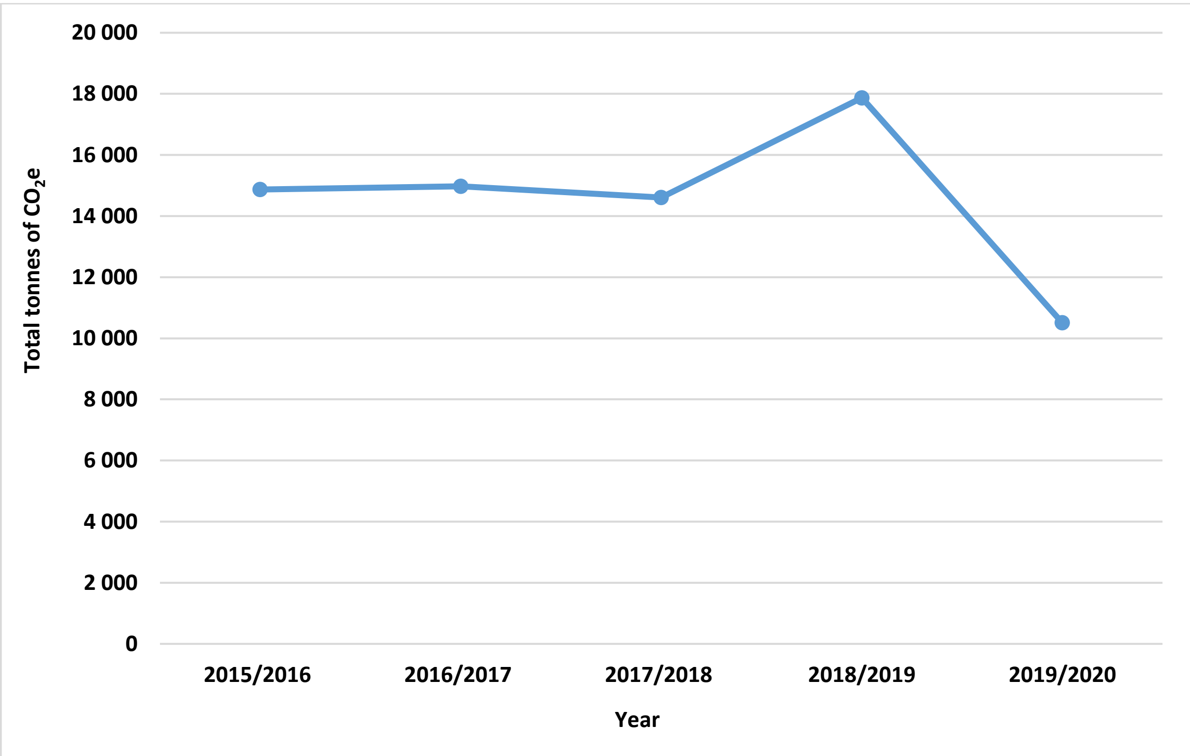

Figure 10: Aggregated emission contribution over a 5-year period

Source: Own compilation, 2021

Figure 11 gives an in-depth look at the aggregated emissions for the research farms and shows what emission activities increased or decreased for the periods under review. Office and domestic waste, followed by electricity and enteric fermentation are the three emission activity categories that are identified as hotspots for all the periods under review. Office and domestic waste was a major hotspot for the 2018/19 period, the reason being that the recycle systems on-farm was discontinued due to operational reasons. Electricity was another hotspot, showing an overall decrease as farms are becoming more aware of their impact on the environment and because this emission activity is something that they can immediately change without having a major impact on their farming operation they are putting various initiatives in place e.g. energy-efficient lightbulbs, using energy-efficient machinery and looking at solar PV option.

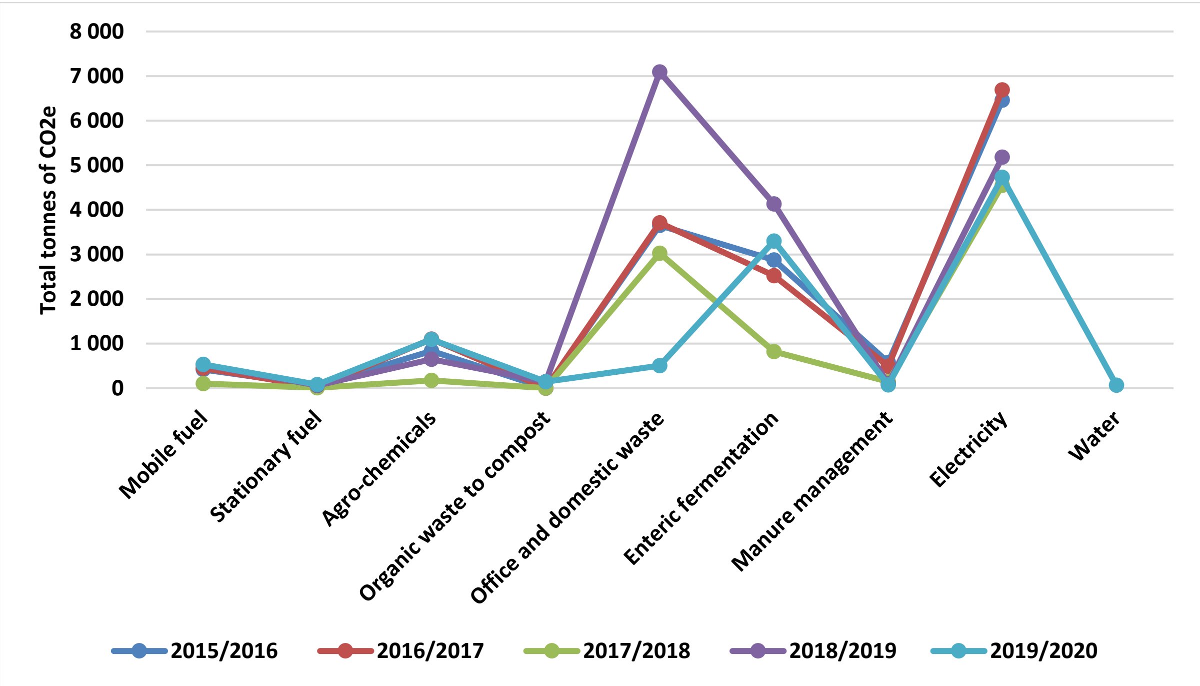

Figure 11: Emissions divided according to farm activity data for the 5 year period

Source: Own compilation, 2021

For the 2018/19 period, the waste component contributes 40% to overall emissions, followed by electricity with a 29% contribution and enteric fermentation contributing 23%. The 2019/20 period looks slightly different with electricity being the highest contributor with a 45% contribution, followed by enteric fermentation contributing 31%

and waste only contributing 5%. Figure 11 shows that for the 2019/20 period that agro-chemical emissions surpassed the waste category and are ranking as the 3rd hotspot with a 10% contribution to total emissions.

Figure 12 gives an overall emissions contribution percentage per research farm, which indicates that over the last 5 years Elsenburg (61%) and Outeniqua (21%) made the biggest contribution towards the Departments' footprint. Nortier and Worcester had the smallest contributions (2%) towards the Departments' footprint.

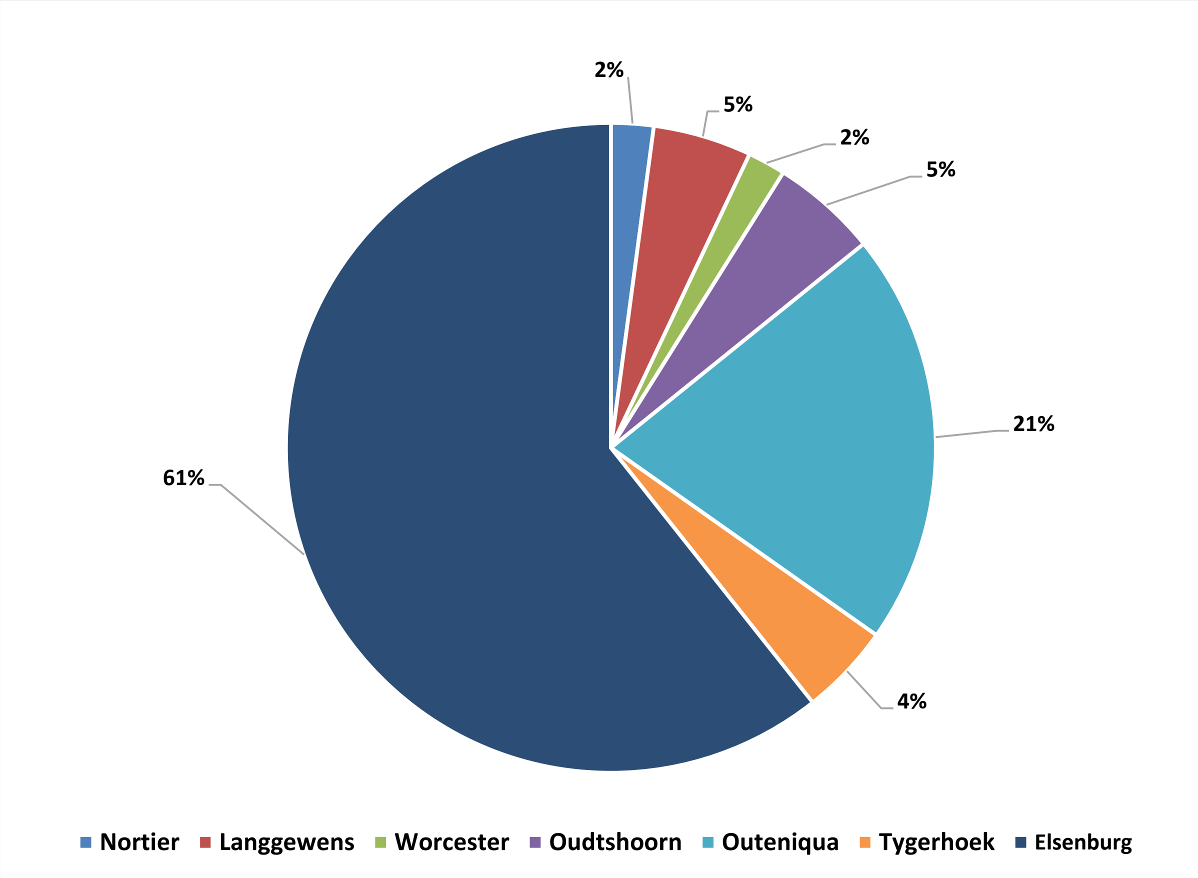

Figure 12: Emission contribution per farm over a 5 year period

Source: Own compilation, 2021

To see if the reduction measures that were put in place have affected each farm's emissions, comparisons of the individual years are needed. Figure 13, 14 and 15 below, gives a summary of the seven research farms' carbon emission activities for the respective years under assessment: 2015/16, 2016/17, 2017/18, 2018/19 and 2019/20. Figures are arranged from the lowest to highest emitters. Figure 13 sums up the lowest emitters, Worcester and Nortier for the period under review. Farms' ranking is based on the total carbon contribution to the department's emissions for the five years. Worcester showed a constant trend until 2017/18 where a slight drop of 77 tCO_2e for office and domestic waste occurred, as well as a drop in electricity (29 tCO_2e). For the 2018/19 period even further drops in tCO_2e for office and domestic waste, and electricity occurred, 93 tCO_2e and 38 tCO_2e, respectively. The 2019/20 period showed a slight decrease (39 tCO_2e) in office and domestic waste but a 37 tCO_2e increase in electricity usage. Nortier, on the other hand, showed an increase after the 2016/17 period for enteric fermentation and mobile fuels. Electricity shows a slight decrease but increased with 35 tCO2e for the 2019/20 period. Office and domestic waste shows an overall decline in emissions.

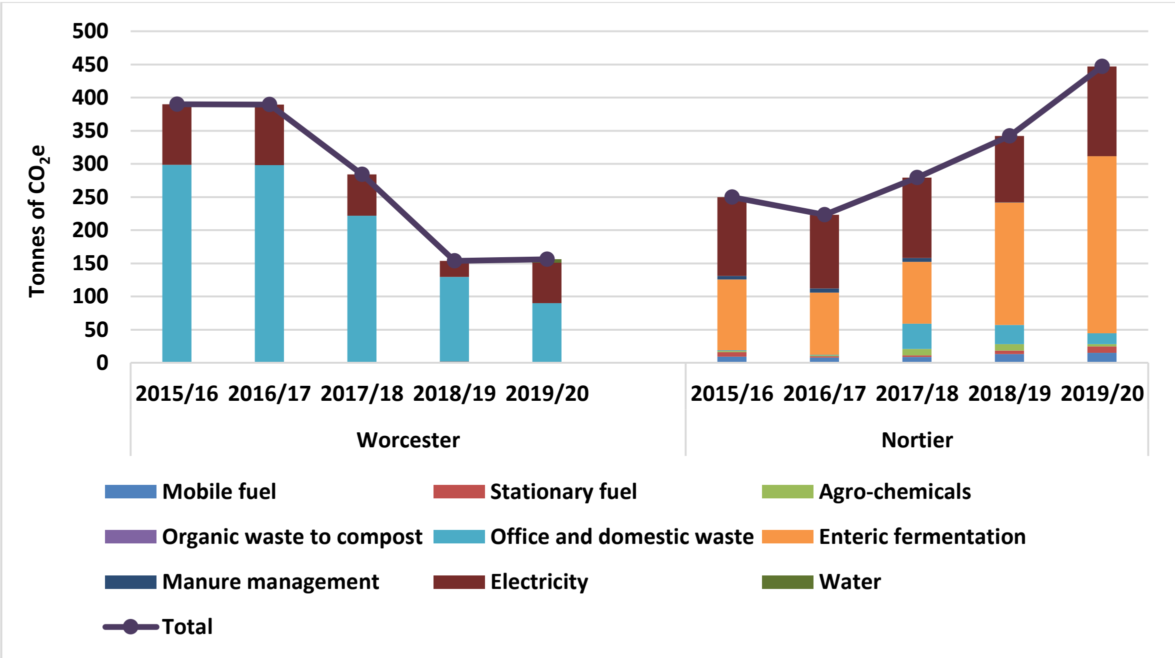

Figure 13: Research farms' measured carbon emission activities for Worcester and Nortier - 2015/16 to 2019/20

Source: Own compilation, 2021

Moving to the middle emission group of farms, Langgewens, Tygerhoek, and Oudtshoorn, Figure 14 shows that Langgewens has an almost constant pattern. A slight increase occurred after the 2016/17 period. The activities where an increase in emissions occurred are mobile fuels and enteric fermentation. The 2019/20 period had an increase in emissions of 231 tCO_2e. The activity categories where emissions increased, were office and domestic waste followed by electricity and mobile fuel. Langgewens has an overall emission contribution of 5% to the total emissions of the department. Tygerhoek again shows a major increase in emissions (220 tCO_2e) for the 2016/17 period but since then have managed to lower its emissions towards its lowest total since the project started. The activity category where emissions were decreased were office and domestic waste. Tygerhoek contributes 4% to overall departmental emissions. Oudtshoorn's emissions performance has been mixed, with a large spike in 2017/18 period due to an increase in office and domestic waste. After the major increase in 2017/18, Oudtshoorn's emissions have been declining and this is due to minimizing electricity emissions. Oudtshoorn's contribution to the department's total emissions is 5%.

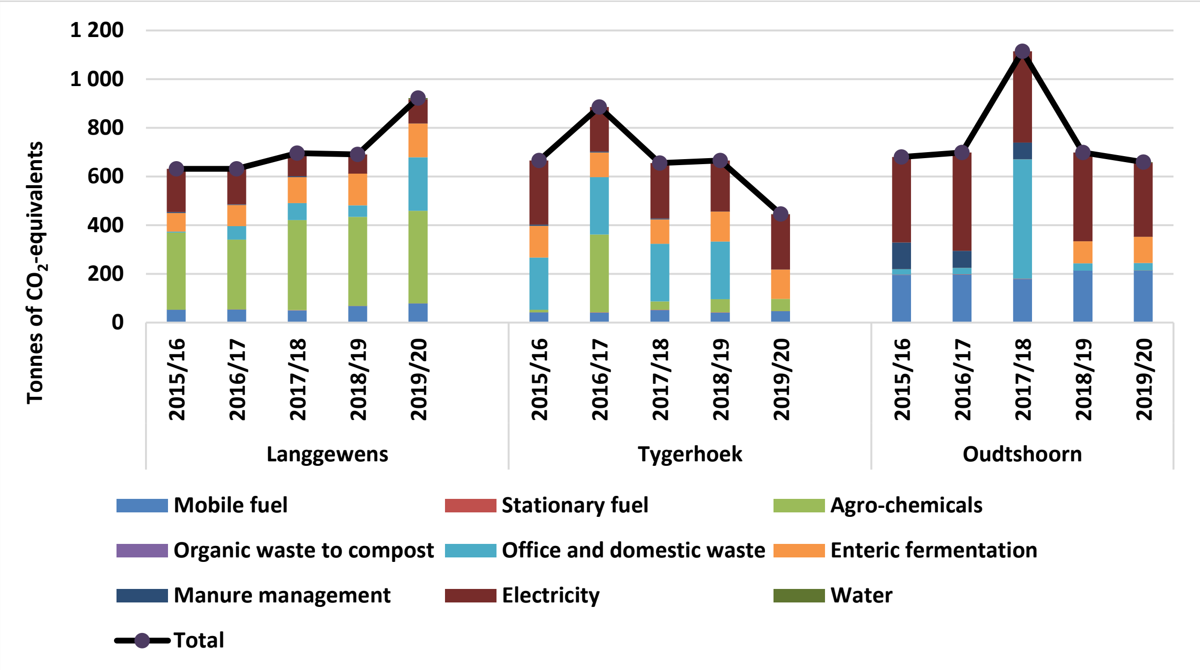

Figure 14: Research farms' measured carbon emission activities for Langgewens, Tygerhoek and Oudtshoorn - 2015/16 to 2019/20

Source: Own compilation, 2021

Figure 15 looks at the highest emitters, Outeniqua and Elsenburg. Outeniqua contributes 21% to the department's carbon emissions and Elsenburg 61%. Traditionally these two farms have been seen as the two farms that emit the most emissions. Although they are not as big as Nortier and Tygerhoek in terms of farm size, the research and activities of these farms are more complex, intensive and they tend to have a stronger livestock focus and therefore the spikes in emissions are somewhat expected (see Table 4 for each farms' profile). Outeniqua shows a slight constant pattern, with slight increases in mobile fuel and stationary fuel. Enteric fermentation increased significantly for the 2018/19 period with 888 tCO_2e but slightly decreased again with 270 tCO2e for the 2019/20 period. Electricity decreased by 155 tCO_2e for 2018/19 and decreased by a further 165 tCO_2e for the 2019/20 period.

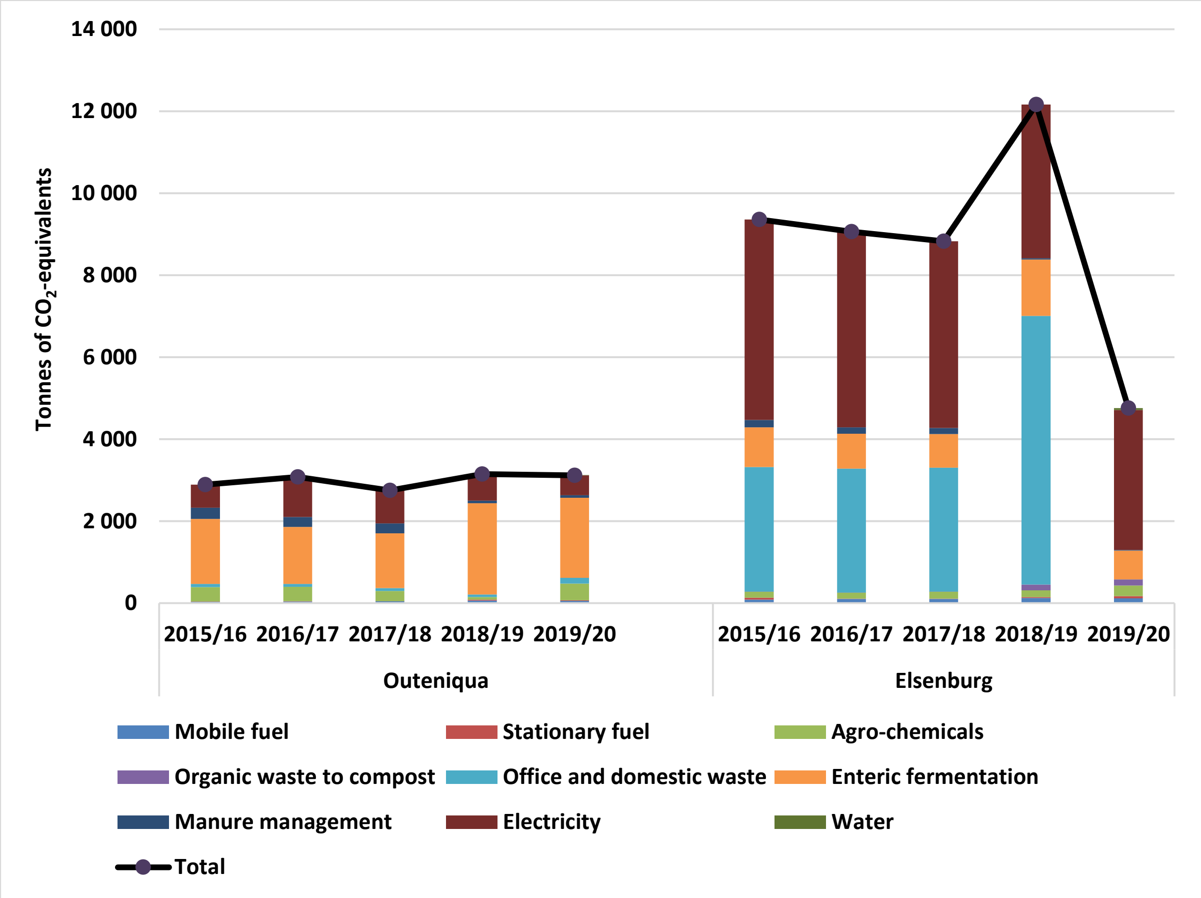

Figure 15: Research farms' measured carbon emission activities foe Elsenburg and Outeniqua - 2015/16 to 2019/20

Source: Own compilation, 2021

Elsenburg showed a decreasing trend from 2015/16 until 2017/18, but a major increase of 3 343 tCO_2e for 2018/19 was noted, caused by increases in activities such as mobile and stationary fuel, the waste component and enteric fermentation. When looking in-depth, the main reasons for the increase is due to the increase in livestock numbers, which means the enteric fermentation category emissions are increasing, as well as the recycling system that was phased out led to more waste being diverted to the landfills. The 2019/20 period shows a massive overall drop in emissions, with office and domestic waste being the highest decreasing category for emissions, followed by enteric fermentation and electricity. Elsenburg installed solar PV at the main building in September 2018. This has led to cost savings, as well as the a decrease in consumption of Eskom electricity,

6. Carbon Reduction Opportunities

The carbon footprint results for the 2019/20 period showed that electricity (45%), enteric fermentation (31%), and agro-chemicals (10%) are the emission hotspot sources but looking at the overall footprint for the five years, office and domestic waste also seems to be an area of concern. Opportunities do exist to decrease these hotspot areas by implementing various reduction activities. To see the effectiveness of reduction activities, farms need to monitor and manage their emissions continuously and accurate record-keeping is of utmost importance. Reduction activities include:

- **Energy**

Most of the farms are already having a declining electricity pattern that was seen in the various figures illustrating the emissions. This is due to farms switching to energy-efficient equipment and lights, as well as making use of solar PV. These reductions are commendable and relatively easy to implement.

Additionally, farms should investigate options to substitute existing coal powered electricity and invest in 50% to 100% solar PV (depending on the area) or implementing other renewable energy sources or do a renewable energy mix, which might include wind energy and biogas. Other options can also include looking at the greening of the buildings to be more energy-efficient. The high electricity emissions for Elsenburg can be attributed to the combined electricity bill for the college and the main building, thereby not reflecting the actual farming system. The department should look into splitting the electricity bill for the various divisions so that a true reflection can be obtained for the farming section.

- **Methane**

Current "green" research projects being conducted by the department and that will have an impact on the overall footprint are: the study on improved feed conversion for dairy cattle; conservation practice trials; study on different grazing pastures that will result in higher outputs (for example higher milk production leading to lower methane release), etc. Implementing a proper manure management system, where the manure gets used as fertiliser or if possible, as an input source to generate energy should be explored. Using a biogas digester will also significantly decrease the enteric fermentation category.

- **Agro-chemicals**

The department is the forerunner when it comes to conservation agriculture practices and principles. Various trials are being conducted. This research should be made public on all platforms (printed, online, etc.) and should be implemented on all the research farms on a bigger scale.

- **Waste**

The reinstatement of a fully operating recycling system will have a major impact on emissions. Implementing a compulsory recycling and composting system will reduce waste and pollution, as well as cut down the cost of waste disposal. This system will help instil a "buy only what we need" approach if implemented correctly and having an incentive method in place. Re-use feedbags and use recycled materials for packaging.

- **Employee engagement**

Creating awareness amongst employees will help with the implementation of carbon reduction strategies, as well as explain the bigger picture and including them in the environmental vision for the farm. Awareness can be created by having workshops, where everyone is informed and has an opportunity to share ideas for reduction.

7. Conclusion

South Africa has committed to becoming a low-carbon economy and this is evident in the various policies and strategies that have been developed. One such policy is the carbon tax act that has been implemented and is affecting the agricultural sector indirectly. The WCDoA supports the low-carbon economy strategy and is proactive in terms of measuring and monitoring its research farms' carbon footprint to assist and advise farmers in terms of carbon emissions. The department also implemented this project to assist the sector for when the second phase of the carbon tax will be implemented.

The research farms served as guinea pigs, and the idea is to copy the model for the rest of the sector. This project is running since 2011/12 and mistakes were made along the way, but with time the model is improving and becoming more accurate. As the carbon tax becomes the new norm, more local studies are being conducted to determine emissions for sectors in South Africa, coupled with guidelines to assist with implementation. The agricultural sector is complex, and a standardised emission source list is not readily available, especially for livestock. When a livestock footprint was conducted in the past, assumptions and comparisons were made and emissions factors were based on IPCC[5], DEFRA[6], and other country-specific data. With time, researchers realised the importance of emission data that is more country-specific and this has been reflected in the last four years of measurement.

The 2019/120 calculations show that total CO_2e emissions for the research farms have declined by 7 360 tCO_2e. This decline was due to declines in the waste category, the enteric fermentation category and the electricity category. The decline in the waste category is not a true reflection of what is currently happening on each farm because on three of the seven farms, no records are being kept of the waste being generated and numbers were based on the "feeling" of the farm manager. Electricity usage is decreasing slowly but that is due to the department switching and testing which renewable energy sources can work for the farms, without having implications on operations.

[5] IPCC - Intergovernmental Panel on Climate Change

[6] DEFRA – Department for Environment Food & Rural Affairs

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