Carbon emissions of grain farming in the Western Cape

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Introduction

Grain SA initiated the Carbon Footprint project, with Phase 1 aiming to calculate and compare the greenhouse gas (GHG) emissions of different farming systems in the winter grain region in the Western Cape. An increase of GHGs in the atmosphere traps the sun's radiation or energy directly leading to an increase in the earth's temperature or so-called global warming (IPCC, 2007). The most common GHGs in the atmosphere are water vapour, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone. Human activities have led to a significant increase in the concentration of specifically CO_2 in the atmosphere from the burning of fossil fuels (coal, oil and natural gas), deforestation, land use change and soil erosion (Earth System Research Laboratory, n.d.). GHG emissions are measured in carbon dioxide equivalents (CO_2e) and will be further referred to as carbon emissions. Phase 1 was the start of a longer term process of using the carbon footprint methodology and results within the grain industry as an adaptive management tool (Figure 1).

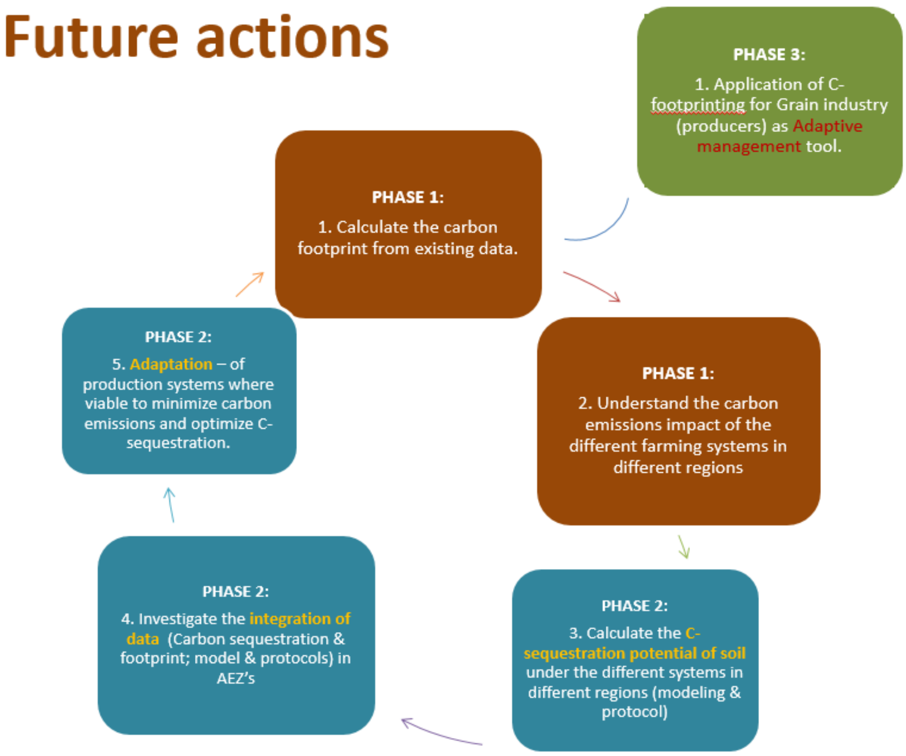

Figure 1: Carbon footprint project phases envisaged by Grain SA.

Project scope and methodology

The study only included activities and inputs at the farm stage of the grain value chain. The methodology used to calculate the carbon emissions per ton grain was the PAS 2050: 2011 protocol developed by the British Standards Institute (BSI). Carbon emissions is only one of a range of impacts that need to be taken into account to obtain a holistic view of the environmental impacts of a farming system.

The winter grain sub-regions included in this study are presented in Figure 2. Existing data (inputs and yields) was collected from representative production practices in each region to model the current scenario of carbon emissions. The current scenario consists of a combination of conventional (CT) and conservation agriculture farming systems (Current CA) currently practiced in these regions. For the future scenario, an ideal but realistic CA system (Future CA) predicted to be adopted by most grain producers twenty years into the future was calculated with corresponding inputs and yields. **In the Western Cape there is currently no big difference between CT and CA**; the CT wheat farming system does not practise crop rotation and therefore wheat is planted every year. In the Current CA and Future CA systems crop rotation is practised and the commodities included in the models per region were wheat, barley, canola, medics and lupins. All inputs were specified on a per hectare basis. The carbon emissions (kg CO_2e/ton) per farming system was calculated from the data provided.

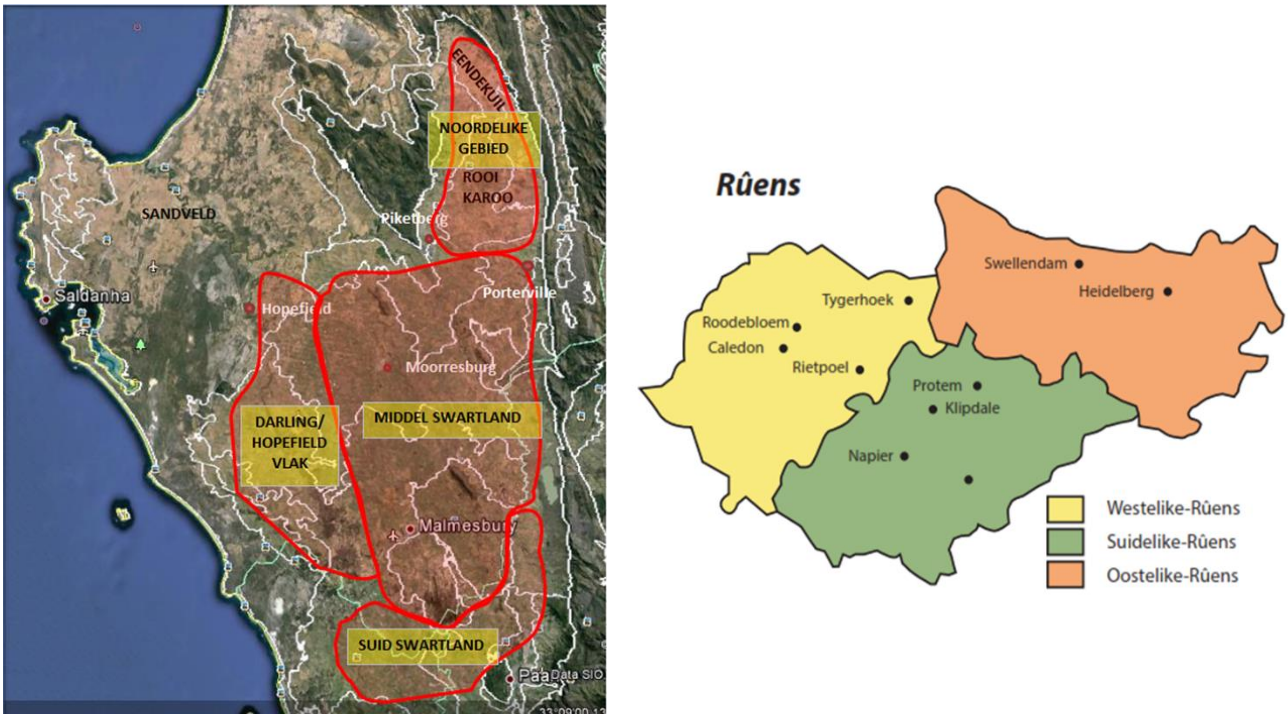

Figure 2: Winter grain sub-regions in Swartland and Southern Cape (Rûens) regions, Western Cape

In order to calculate a regionalised carbon emission profile, the results per commodity were weighted according to the yield per farming system. Information from the Crop Estimates Committee (CEC) was used in order to calculate the current regional carbon emissions for each region. Thereafter these figures were extrapolated to provide a snapshot winter grain region carbon emission profile for the current and future scenarios. In addition to the regionalised carbon emissions for the current and future farming scenarios, farming input hotspots were identified. **Hotspots are defined as activities which contribute the most to the overall carbon emissions and are therefore categorised as 'carbon intensive'.**

The snapshot carbon emissions per ton product for the winter grain region currently and for the future was determined through a pro-rata allocation of the result to the total yield per commodity. According to best available estimates, approximately 90% of total grain yield (tonnes) in the Western Cape are currently under CA while the remaining yield is under CT. With the calculation of the future scenario it is predicted that 80% of the total yield will be under Future CA.

Data and Inventory

Grain SA sourced existing production practice data from the different agribusinesses in the Western Cape. The main participants who collaborated with production cost information for the different systems were Kaap Agri (Swartland), Overberg Agri (Southern Cape) and SSK (Southern Cape).

Error! Reference source not found. illustrates the data collection process with all the different production inputs collected to calculate the carbon emissions per ton grain.

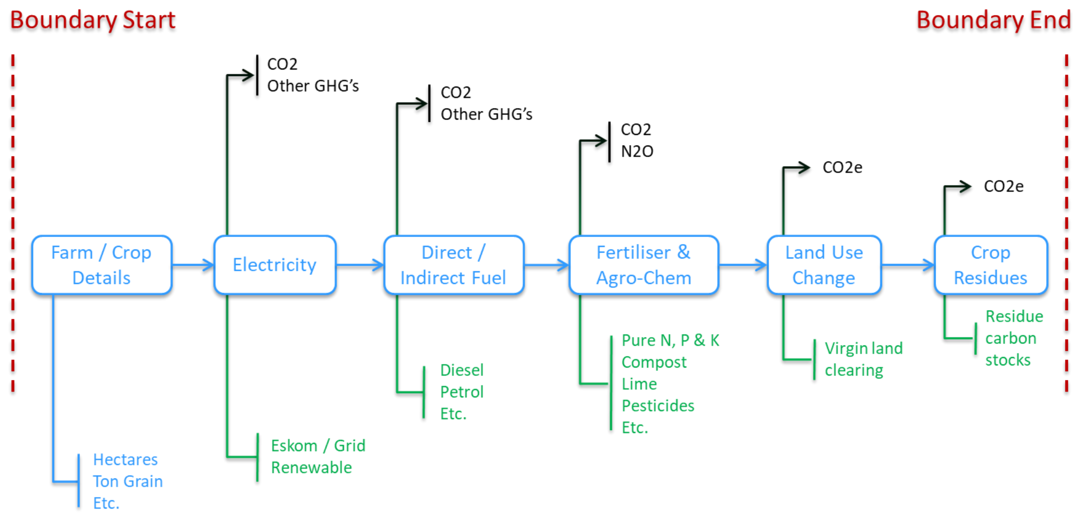

Figure 3: Data collection process map to calculate carbon emissions per ton grain in winter grain regions.

In addition to the existing data, Grain SA had discussions with CA researchers from the Western Cape (Johan Strauss, personal communication) for making realistic assumptions regarding production inputs under an ideal Future CA scenario (see **Error! Reference source not found.**).

Table 1: Assumptions for inputs for Future CA system.

Inputs	Assumptions
Yield	Increase with 10%
Fuel	Decrease with 50%
Fertiliser	Decrease with 50%
Lime	No change
Fungicides	Decrease with 50%
Herbicides	Decrease with 50%
Insecticides	Decrease with 60%
Burning of crop residues	No burning
% of the above ground residue removed	30% removed

Error! Reference source not found. illustrates the three different grain farming systems with their crop rotations in the region. In the CT system only wheat is cultivated each year while different crops are planted in rotation with each other in the Current CA and Future CA systems. The transition from the CA to the Future CA system sees a change in the commodities cultivated in the Swartland regions but no change in the Ruens regions.

Table 2: Winter grain sub-regions with corresponding crop rotations and farming systems.

Region	Farming system		
	Conventional	**CA**	**Future CA**
Darling/Hopefield	Wheat	Wheat	Wheat
		Medics	Medics
		Lupins	Canola
Northern Swartland	Wheat	Wheat	Wheat
		Medics	Medics
Middle Swartland	Wheat	Wheat	Wheat
		Medics	Barley
			Canola
Southern Swartland	Wheat	Wheat	Wheat
		Medics	Medics
		Canola	Canola
Western Ruens	Wheat	Wheat	Wheat
		Barley	Barley
		Canola	Canola
Southern Ruens	Wheat	Wheat	Wheat
		Barley	Barley
		Canola	Canola
Eastern Ruens	Wheat	Wheat	Wheat
		Barley	Barley
		Canola	Canola

Results

The results are presented per farming system (CT, Current CA and Future CA). In addition to the carbon emissions per ton grain results the hotspots for the current and future scenarios on farms are presented.

Carbon emissions profile per farming system

The carbon emissions per ton wheat are presented in **Error! Reference source not found.**. Wheat is the only grain grown under all three systems (Table 2) and therefore this comparison could be performed.

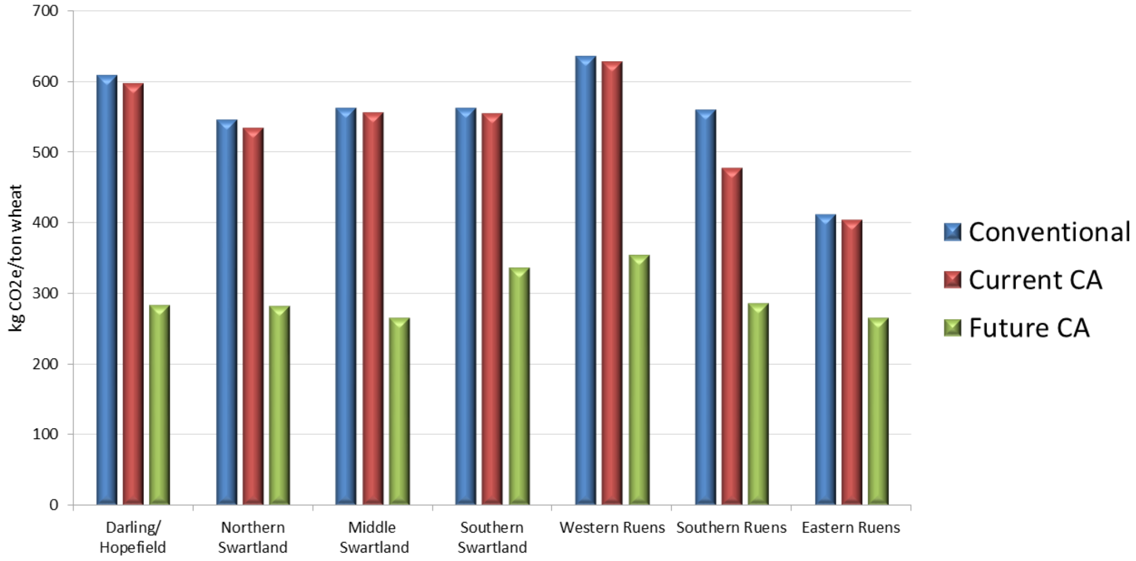

Figure 4: Carbon emissions per ton wheat per farming system per sub-region.

The results indicated that there was a 46% decline in carbon emissions per ton grain with the transition from CT to Future CA and a 44% decline from Current CA to Future CA. There is only a small difference in carbon emissions between CT and Current CA (3.5%) due to very similar input amounts and yields.

Carbon emissions profile for current scenario (CT and Current CA)

The weighted average carbon emissions based on the total yields (tonnes) under CT and Current CA per sub region are presented in

Table *3*.

Table 3: Carbon emissions per ton grain for current scenario per sub region and overall

Region	Total tonnage	Carbon emissions for region [kg CO2e/ton grain]
Darling/Hopefield	54 507	597.23
Northern Swartland	146 217	534.76
Middle Swartland	276 399	555.90
Southern Swartland	21 896	609.73
Western Ruens	182 449	637.92
Southern Ruens	209 245	485.85
Eastern Ruens	325 585	396.22
Weighted average		**513.70**

The overall carbon emissions under the current scenario is 513.70 kg CO_2e/ton grain. The carbon emission hotspot profile per hectare for the current scenario is presented in Figure 5. **It is evident that the farming input with the largest contribution to overall carbon emissions is fertiliser use**, but **more specifically synthetic Nitrogen**, which makes up 90% of the total fertiliser carbon emissions at 757 kg CO_2e/hectare out of a total of 1 182 kg CO2e/hectare.

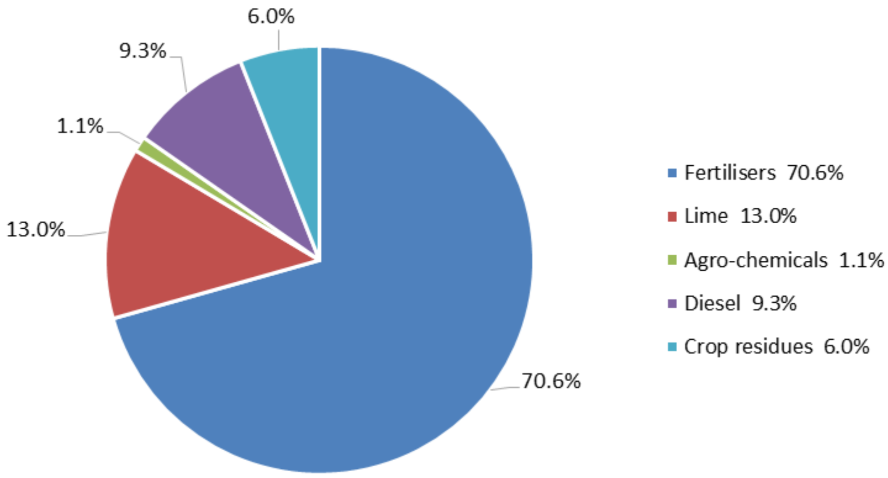

Figure 5: Carbon emission contributions per input per hectare for current scenario

Carbon emissions profile for future scenario (Current CA and Future CA)

Using the total predicted tonnages for grains under the Current CA and Future CA systems, the future weighted average snapshot carbon emissions per ton grain for the winter grain region is predicted to be 328 kg CO_2e/ton grain. The results per sub region is presented in Table 4.

Table 4: Carbon emissions for future scenario per sub-region

Region	Total tonnage	Carbon emissions for region [kg CO2e/ton grain]
Darling/Hopefield	58 993	339.93
Northern Swartland	157 914	327.68
Middle Swartland	307 043	314.72
Southern Swartland	22 283	400.70
Western Ruens	182 575	418.47
Southern Ruens	207 598	334.52
Eastern Ruens	315 426	276 38
Weighted average		**327.83**

The carbon emission hotspot profile per hectare for the future scenario is shown in Figure 6. **Fertiliser use is the largest contributor or hotspot to total carbon emissions per hectare followed by lime and crop residues.** This profile is the same as for the current scenario but total GHG emission per hectare are significantly lower at 811 kg CO_2e/hectare.

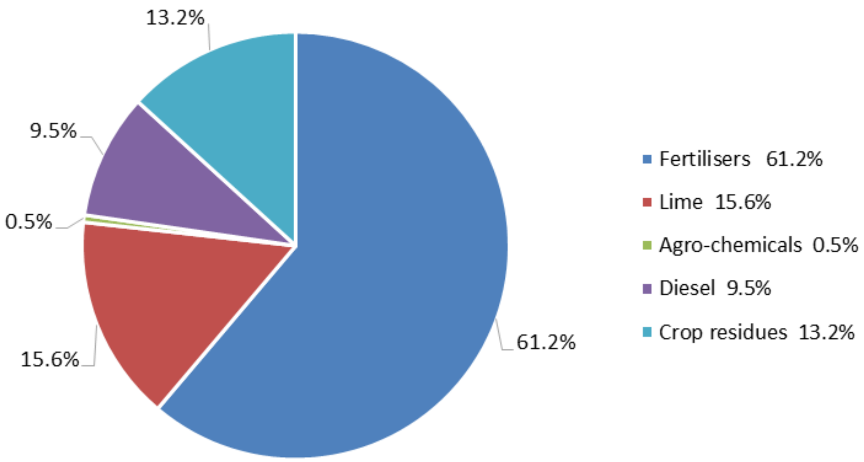

Figure 6: Carbon emission contributions per input per hectare for future scenario

Conclusion

It is evident that there will be a significant decrease in carbon emissions in the winter grains industry with the transition to the Future CA systems as well as other environmental, economic and social benefits including the protection of biodiversity, increase in net yields and farm income and improving human nutrition (Putter, Smith & Lange, 2014).

From the perspective of the climate change impact, the transition to a higher level and quality of CA (defined here as Future CA) is highly beneficial for the winter grain region in the Western Cape. The synergies between the Future CA farming system and the environmental, economic and social benefits will ensure the sustainability of future grain cultivation in the region.

References

Earth System Research Laboratory. n.d. *Trends in atmospheric carbon dioxide*. Available: https://www.esrl.noaa.gov/gmd/ccgg/trends/global.html.

IPCC. 2007. *IPCC Annex I: AR4 Appendix*. Available: http://unfccc.int. [2018, August 23].

Putter, T., Smith, H. & Lange, D. 2014. *Transforming the benefits of conservation agriculture into a pro-CA Manifesto*. Available: http://www.grainsa.co.za/transforming-the-benefits-of-conservation-agriculture-into-a-pro-ca-manifesto2 [2017, August 10].