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The South African Ostrich Industry Footprint

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EXECUTIVE SUMMARY

The South African ostrich industry is the world leader in producing a wide range of ostrich products for both local and international markets. With a long standing and rich history, the production and manufacturing of ostrich products are unique to South Africa with a limited geographical spread of suitable growing regions. Undoubtedly being tested by many difficult periods, it has remained resilient despite challenges of droughts, diseases outbreaks and fluctuating world markets. This report specifically sets out to determine the economic and environmental footprint of the ostrich industry in an attempt to provide a suitable context for decision making towards increased socio-economic development in rural economies and expanding international trade going forward.

The value chain analysis presented in this analysis points to the critical role this industry plays in generating livelihoods to around 5 500 people working on farms and value-adding facilities. The industry, despite recent challenges with market closures, continues to export a variety of ostrich products which play a significant role in the local economy of the Klein Karoo in the Western Cape. In value terms, the output of all final products (meat, feathers, skins and leather) were valued at around R1.9 billion and various primary producers, manufacturers and workers in the region are dependent on a well-functioning and stable ostrich industry.

In recent times, there has been a global move towards refocusing and design sustainable livestock production systems in an attempt to minimise carbon emissions and to preserve natural resources. The carbon emissions that were calculated as part of this report indicate that ostrich production has an extremely low carbon footprint, compared to cattle, dairy, sheep and other livestock systems. A conservative estimate suggests that for every kilogram of ostrich meat produced, an average of 2.79 kg CO_2 equivalents are emitted. This was much lower than the 20.44 kg for sheep, 15.44 kg for beef and 4.62 kg for pork. Ostrich meat was still 0.46 kg CO_2e more per kilogram of meat than chicken meat (2.33 kg of CO_2e). The main reason for this stems from the fact that ostriches are non-ruminant animals with comparatively low methane emissions, which makes it one of the most environmentally friendly meat categories available. The results also confirm that the ostrich industry has close to zero waste as most by-products are used in the production process, with the major contributor to greenhouse gases coming from water use and export travel emissions.

1. INTRODUCTION

The South African ostrich industry is concentrated in the arid, Western Cape's Klein Karoo and its surrounding regions. There is also some production in some parts of the Northern and Eastern Cape, creating economic opportunities and jobs since the establishment of the commercial production of ostriches in the middle of the 1800s. Today, the South African industry is the world leader in the production of ostriches, producing approximately 70% of all ostrich related products globally, which includes meat, leather, and feathers (Brand & Jordaan, 2011). In recent years, several outbreaks of diseases and periods of droughts have adversely affected the industry and restricted its development.

A scan of the relevant literature or reports on the ostrich industry suggest that there is in general a good understanding of the history, production processes and value chain dynamics (NAMC, 2003; WCDoA, 2010), whilst the NAMC (2010) have attempted to identify opportunities for increased transformation. In terms of the industry's contribution to the national economy, Brand & Jordaan (2011) gives insights into the Gross Value Added (GVA), export earnings and the impact on job creation, as well as livelihood opportunities. Attempts to quantify the impact of avian influenza on the industry have been made (Durr, 2011; Pienaar, 2017).

There are however two immediate shortcomings in the literature that this report would like to address. **Firstly**, an updated assessment of the economic contribution of the industry throughout the value chain, with specific reference to the linkages to the rest of the economy and job creation, which will link all value-added activities in the production of ostrich and related products.

Secondly, this report seeks to develop the first carbon footprint estimates for the ostrich value chain in South Africa. Climate change has emerged as the single biggest environmental and development challenge faced by many industries, especially agriculture who has been particularly hard hit by climate-related natural disasters (Barends, 2016). Concerns about agriculture's contribution to greenhouse gas (GHG) emissions and its impact on the environment has inspired the quantification of the carbon footprint contributions to GHG emissions measured in carbon equivalents. The carbon footprint allows for the identification of the main sources of emissions to develop interventions to reduce these and to prioritise efficient resource management (Pandey & Pandey, 2011). With the introduction of the Carbon Tax Act (No.15 of 2015), the agricultural sector has been excluded in the first phase of the carbon tax regulations and will only be directly affected in Phase 2, which is expected to come into effect in 2023. The agricultural sector will still be implicated, just indirectly. The increased sensitivity for market access considerations by importing countries is another obstacle for agriculture and therefore the importance of having a clear understanding of their carbon emissions.

The proposed economic and carbon emissions analysis is primarily informed by semi-structured interviews by the research team, which provides the basis of all industry calculations in this report. A questionnaire with two distinct sections was developed, which includes income and costs for primary production and a section that captures information on various carbon-emitting activities. The latter has been combined with a well-developed set of emission factors (Barends, 2016) and in both cases, the analysis was informed by existing information obtained from various sources such as the South African Ostrich Business Chamber (SAOBC), the Western Cape Department of Agriculture (WCDoA), recent trade statistics and any other related information. Ultimately, this report will provide a comprehensive, economic and environmental footprint of the ostrich industry.

Starting with a brief background on the development of the ostrich industry, the report will then discuss the economic contribution of the industry in terms of production, exports and employment, followed by a value-chain assessment. Next, the results from the carbon calculations will be summarised for the entire industry and some key findings discussed.

2. BACKGROUND

The South African ostrich industry is the undisputed world leader in the production of ostrich and related products. The domestication and eventual commercialisation of these flightless birds from the *Ratitae* family started with the production of feathers in the Klein-Karoo valley in the Western Cape around 1826. Soon thereafter, the country started to export feathers to European markets (OstrichSA, 2018). The strong demand for feathers, as well as the introduction of wire fencing and lucerne farming around the same time meant that ostrich farming became an extremely profitable enterprise, helped by technological advancements such as the invention of the incubator for ostrich eggs in 1869 (NAMC, 2003). South African ostrich feathers at the time, popular around the world as decorative fashion, became the country's fourth largest exported product in the early 20th century (NAMC, 2010).

Since then, the industry has undergone profound structural changes due to both economic and political pressures. Competition from other parts of the world led South Africa to introduce cross-breeding programmes which ensured that the industry developed a domesticated ostrich breed with exceptional feather quality. Despite many challenges, such as world wars, changes in fashion trends and production fluctuations, the industry emerged from the 1950s onwards to become the world leader in ostrich production, producing feathers, meat and leather products (DAFF, 2018a). Combining excellent breeding stock with ideal climatic conditions, supportive infrastructure, expert knowledge and access to markets is what gives the local ostrich industry its competitive advantage (Brand & Jordaan, 2011).

The introduction of the first ostrich meat abattoir for exports that was built in 1993 started a new era where the production of meat has become a significant contributor to farmers' income (StatsSA, 2007). Currently, the industry consists of around 350 ostrich farms registered for slaughtering ostriches and several abattoirs have licenses to export meat and meat products to Europe and various other countries. Ostrich production in South Africa is concentrated in the particular conducive, drier parts and winter rainfall regions, with around 73% of ostriches produced in the Western Cape (StatsSA, 2020). Figure 1 below gives an indication of the main production areas in South Africa according to the newly released census of commercial agriculture (StatsSA, 2020). Clearly, the dark red areas of the Western Cape and in particular the Klein Karoo region centred around Oudtshoorn having the highest population density, which is why this town is also known as the ostrich capital of the world. Other notable growing regions according to provinces were in the Eastern Cape, Limpopo and the Free State.

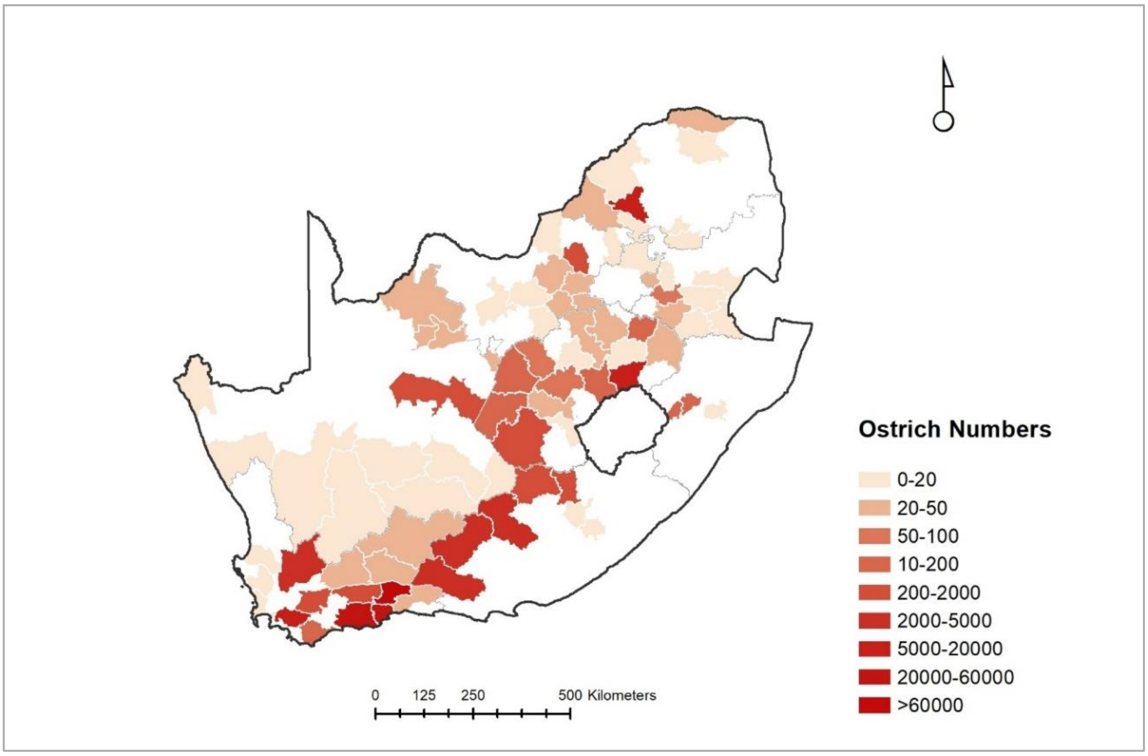


Figure 1: Map of ostrich density in the Western Cape
Source: StatsSA, 2020

3. INDUSTRY ECONOMIC ASSESSMENT

The Department of Agriculture, Forestry and Fisheries (DAFF) published the gross value of production in their abstract of Agricultural Statistics, which gives some indication of the scale of production of ostrich meat and related feather sales. Fortunately, the latest commercial census provides some valuable information on ostrich numbers and income from meat sales. This section on the macro-economic overview of the industry will incorporate the latest statistics as well as describe factors affecting the performance in the past decade. Specific emphasis is placed on the following macro-economic variables: production, exports, employment and value-chain linkages.

3.1. PRODUCTION

The industry is highly dependent on the export of products (>90%) and its competitiveness hinge on having access to growing markets and stable prices. Many boom and bust cycles have occurred throughout the history of the industry due to sudden changes in supply and demand, the impact of changing exchange rates, and more recently the impact of diseases.

Starting from the early 1990s to the year 2000, there was a slow, but steady increase in the export of ostrich meat from South Africa. The outbreak of mad cow disease (Bovine

Spongiform Encephalopathy – BSE) and Foot and Mouth Disease (FMD) in Europe towards the end of 2000 resulted in a significant shortage between the supply of ostrich meat and the demand. This significantly increased global prices (NAMC, 2010; DAFF, 2018). South African producers responded to these price signals, producing around 340 000 slaughter birds in the 2002 season (NAMC, 2010). The growth in the industry was somewhat offset by outbreaks of Avian Influenza (AI) in 2004, followed by two subsequent outbreaks in 2011 and 2017, which have crippled the industry and resulted in significant financial losses (Pienaar, 2017).

The production performance of the ostrich industry and related products is summarised in Figure 2 below. The blue line gives the Gross Value of Production[1] of the industry between 2002 and 2018, whilst the red bars indicate the trend in slaughter numbers. As explained previously, slaughter numbers have been declining since 2002, and more dramatically so after 2011 and 2017, which is also reflected in the lower gross value of production due to the impact of the market closure for meat exports due to the AI outbreaks. In response to these risks, the industry invested in the production of heat-treated meat for exports with good success. This allows for the continued export of ostrich meat even when there is an AI outbreak in the country. In such cases, farms must not be in a 10km radius of affected farms and in areas where no outbreak has taken place for at least the past 30 days (DAFF, 2017).

Unfortunately, additional pressure was placed on the industry in January 2018 when the EU banned South Africa from exporting ostrich and other game meat as a result of the National Department of Agriculture, Forestry and Fisheries' (DAFF) residue testing procedures failing to meet EU requirements (DAFF, 2018b). This, coupled with an ongoing three-year drought in the Klein Karoo has affected the industry's profitability. Some good news, however, is that the EU has announced that the ban has been lifted in March 2019, which means that heat-treated ostrich meat can once again be exported to the EU.

The industry production footprint can be summarised into the specific parts of the value chain, which will be unpacked in Section 4. Although data on local consumption of ostrich and related products are not readily available, the next section on export provides a good estimation of the economic footprint of the industry.

[1] *Information on the gross value of the industry includes only ostrich meat and feathers. The complexity and interconnectedness primary and secondary production, coupled with readily available auction prices complicates the calculation of the true gross value of production difficult.*

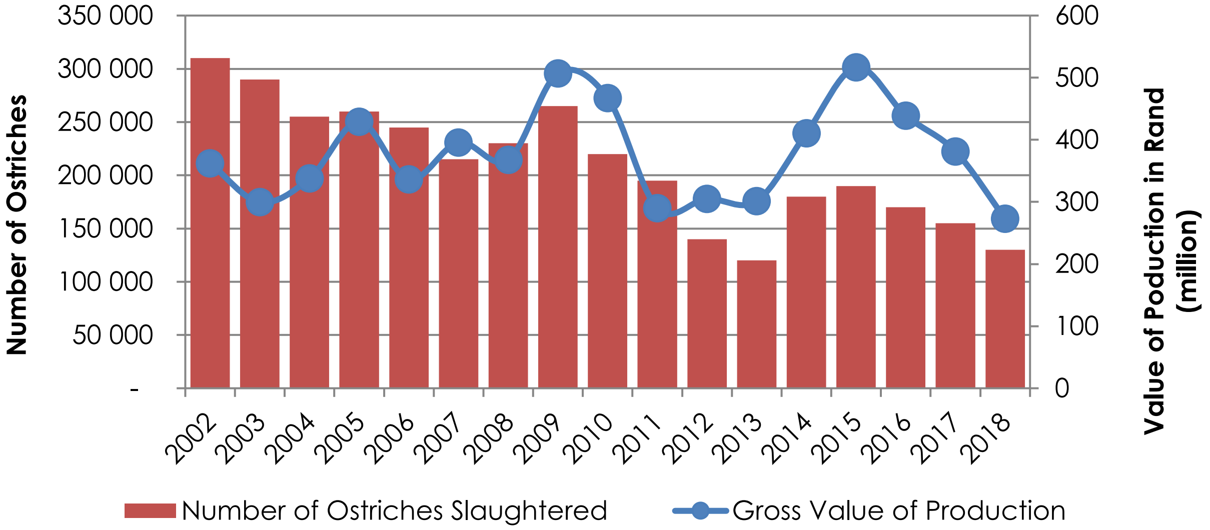


Figure 2: Gross value of ostrich production and slaughter numbers in South Africa
Source: Compiled from DAFF, 2019 & SAOBC, 2019

3.2. EXPORTS

As noted earlier, the export of ostrich products are the dominant source of income to the industry. This section will highlight the trends for all of these products in an attempt to show the importance of the sector in generating foreign income. A broad definition of ostrich and related product exports are used, which includes the following: ostriches; meat; eggs; feathers (and dusters); egg shells; skins; leather and leather products[2].

Starting with ostrich meat, these exports have been extremely volatile because of market closures as already explained. Therefore, two peaks are shown just prior to the AI outbreaks in 2011 and 2017, suggesting that if markets are open, the industry sells ostrich meat in world markets valued on average between R200 to R300 million. Figure 3 also shows the performance of heat-treated meat exports which grew from R21.4 million in 2012 to R74.3 million in 2017; an average annual rate of growth of 28%. Unfortunately, the closure of the market due to the residue testing issues caused this value to decline to R25.6 million in the following year.

[2] *The trade analysis here is done by selecting all products related to ostriches at the national tariff line (or HS-8 codes). Since dramatic changes have occurred in 2007 to these codes, the dates used for the assessment are from 2007 to 2018*

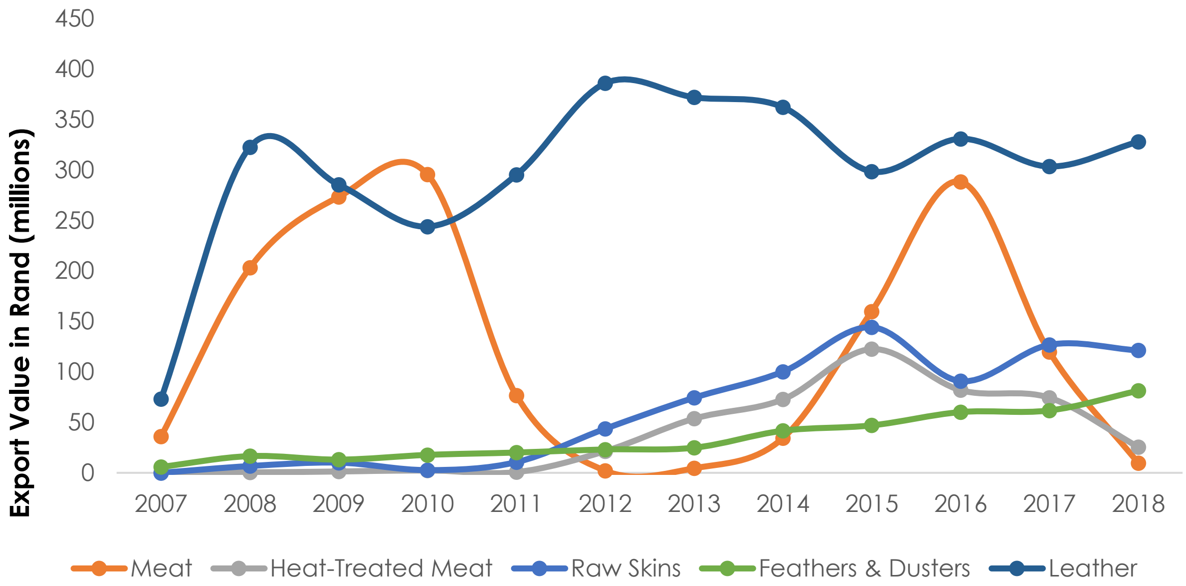


Figure 3: Value of South African ostrich and related products' exports, 2007-2018
Source: Quantec, 2019

As with meat, the sales of ostrich feathers contribute a significant proportion to the income received by farmers. The trade information on ostrich feather exports is problematic since it is difficult to capture all products related to ostrich feathers into a single HS code. The available data however suggest that the value for exported feathers and ostrich feather dusters was around R81 million in 2018 (Quantec, 2019), although some industry representatives estimate this value to be closer to R150 million. Nonetheless, the growth in the export trend given in Figure 3 shows good performance for these products, having grown by R21.6 million per annum since 2012.

Ostrich leather was the most consistent and highest export income earner for the industry since 2007, whilst raw skin exports also performed well in recent years. This aligns to the findings in NAMC (2003) that suggest that leather makes out around 50-70% of all income, followed by ostrich meat with 30-45% and feathers the rest. South Africa is the world's largest supplier of ostrich leather and produces a wide range of different colours. Figure 4 provides the value of exports of ostrich and related products including incubation eggs, shells and leather products. Leather products have seen a decline since 2015, whilst the trend for shells and eggs have been moving sideways over the past decade.

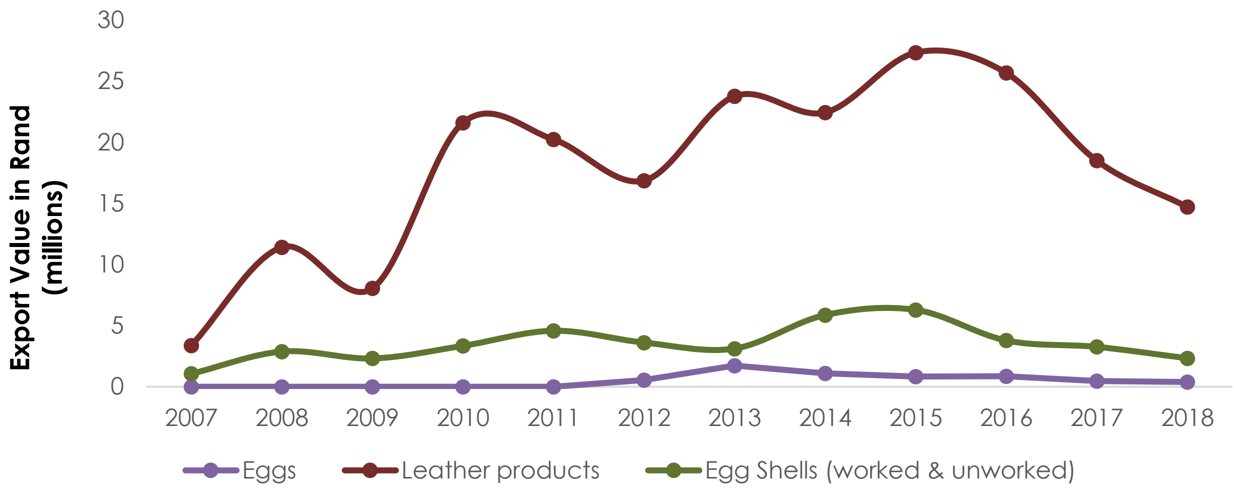


Figure 4: Value of South African ostrich and related products' exports, 2007-2018

The most recent results from the Manufacturing Industry Survey published by Statistics South Africa sheds some light on the production of ostrich leather and confirms this good performance as highlighted in Figure 4 (StatsSA, 2019). A slight decline from R448 million in 2008 to R346 million in 2011 occurred, after which the value of sales grew to R814 million in 2017. Back to Figure 3, the exports of wet blue skins have also shown good growth since 2011, growing from R10.6 million to R121 million in 2018.

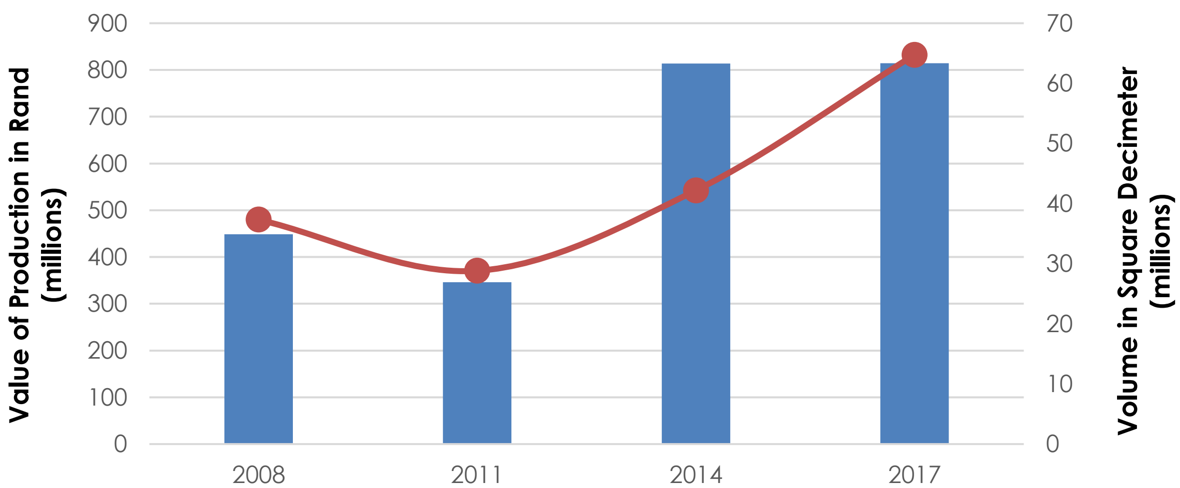


Figure 5: South African ostrich skin leather manufacturing, 2008-2017
Source: StatsSA, 2019

Finally, the exports of leather products such as handbags, shoes, belts and other apparel have seen a period of good growth (2007 to 2015) with a subsequent decline in value of exports to its current level of R14.7 million (Quantec, 2019). To get a sense of the leading trading partners, Figure 5 shows the percentage breakdown by value of ostrich product exported for 2017. As expected, European countries dominate in terms of ostrich meat imports, with Belgium (32%), Germany (26%) and France (12%) absorbing 70% of the total South African ostrich meat exports (Quantec, 2019). The international market for ostrich feathers and dusters are more regionally diverse, with the USA importing 39%, followed by Germany with 16% and Hong Kong with 9%. Finally, France, the USA and Italy were the leading buyers of South African ostrich leather and skins.

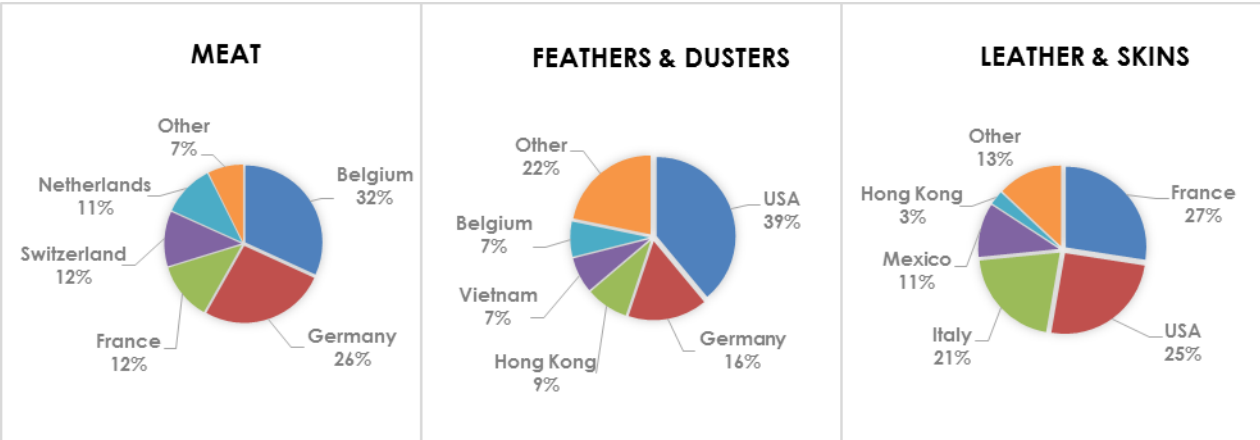


Figure 6: Breakdown of South African ostrich product exports for 2017
Source: Quantec, 2019

4. VALUE CHAIN AND EMPLOYMENT

Previous attempts to illustrate the ostrich value chain have been useful to outline the linkages between different sub-sectors in the ostrich industry, but have not quantified the flow of resources, nor detail the level of employment required (NAMC, 2010; DAFF, 2017). This section addresses this shortcoming by explaining these linkages in monetary terms, as well as providing insights into input and output markets and the labour requirements at each stage of product development.

In short, the methodology used in this value chain assessment is based on information from various sources, including expert advice and from the detailed questionnaires that were completed as part of this study. Combining the gross margin analysis and costing information at the farm level (production economics) with what is known of the aggregate industry (macro-economics), the value chain map provides a good basis to understand the economic footprint, as well as the linkages throughout value adding activities. All values are given for the 2018 season, based on the average structure of the industry for the past several years. Employment numbers are also carefully calculated based on the compensation of employees, employment multipliers and insights from industry role players (GreenCape, 2015; StatsSA, 2019). These are then transformed into fulltime equivalent workers; a worker directly employed for an entire year consisting of 220 working days.

In order to understand the ostrich value chain, Figure 7 simplifies the process of production through the different stages of the bird's life cycle and into the various products developed. From breeding to hatching and rearing to slaughter, the economic footprint of the industry is dependent on the breeder population, productivity, mortality rates and demand for products.

4.1 HATCHERIES

Production of eggs within the value chain consists of a number of farms specialising in reproduction. There is considerable variation in these production systems ranging from extensive to intensive (WCDoA & SAOBC, 2010). These differ with regard to camp sizes and management practises. The breeding season normally starts around May and continues up to January in the following year, followed by a four-month resting period. The current industry average suggests that females produce around 30 eggs per year, although productivity could be higher. Using a standard hatchability rate of 65% of these, the 25 000 breeder birds produce around 500 000 eggs of which approximately 325 000 hatched. Many of the infertile eggs are sold either for consumption or as empty shells.

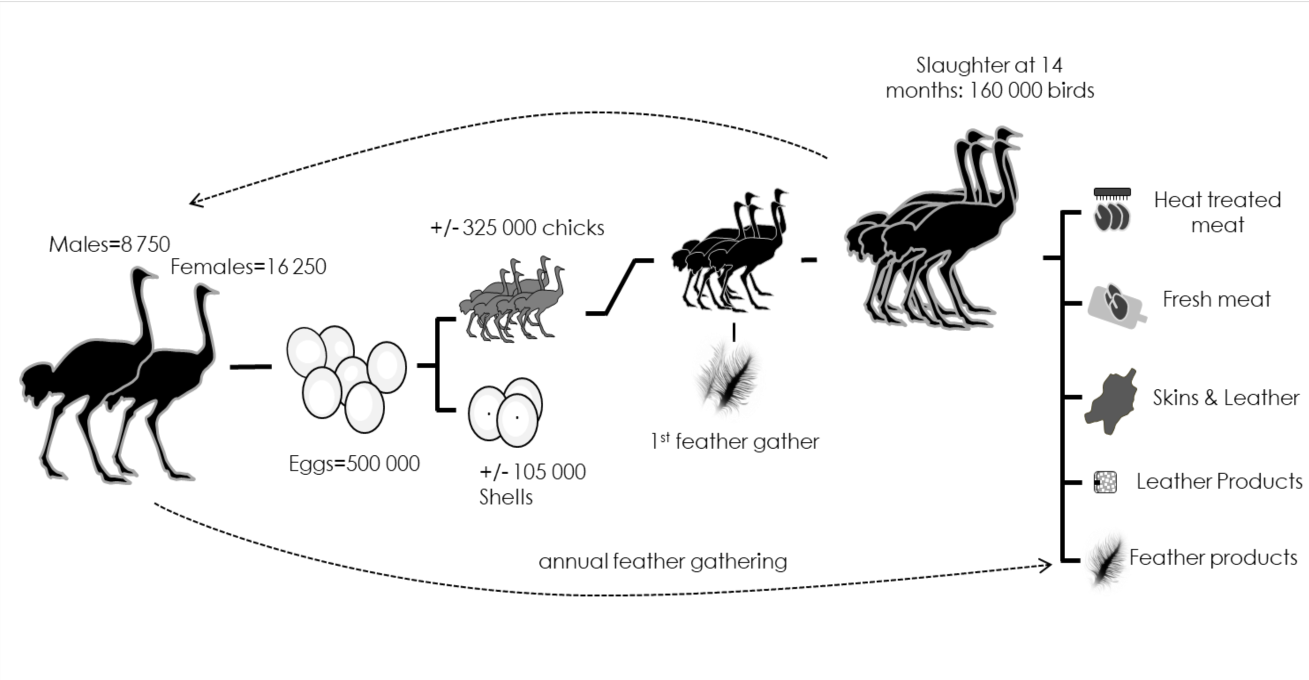


Figure 7: Ostrich population and production process
Source: Own Compilation, 2019

The artificial incubation of ostrich eggs is valued at around R62 million with the sale of around 325 000 chicks providing income to hatcheries. These get around 88% of all income from selling chicks, followed by eggshell sales and contracted eggs (incubating eggs on contract) that contribute 8% and 3%, respectively. Hatcheries normally sell day-old chicks with an average body weight of 750g. Unfertilized eggs are sold to bakeries or shops, while eggshells are sold to both local and export markets. The labour requirement of 43 fulltime workers per annum working in ostrich hatcheries translates to an average labour cost of R2.43 for every egg produced. Chicks that have been hatched will be covered in the next section.

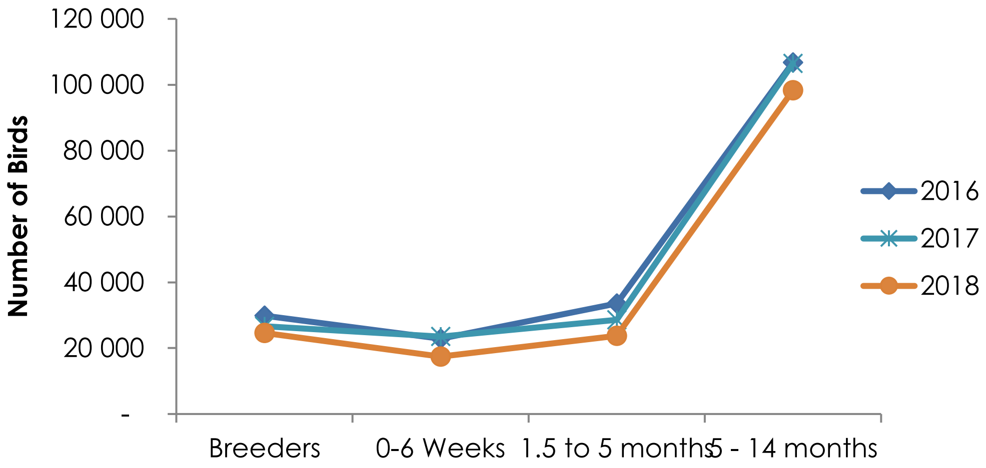


Figure 8: Ostrich population by age
Source: WCDoA, 2019

4.2 REARING

There exist mainly three distinct ostrich production systems; farms that do hatching and rearing, farms that buy day-old chicks and rear them and those that rear chicks from day-old until they reach slaughter weight (10-14 months). The economic feasibility of the different production systems depends on various factors such as market prices, mortality rates of chicks, access to land and investment in equipment.

Figure 9 attempts to simplify these dynamics by dividing the ostrich population in half between those that rear for slaughter and those that rear chicks for selling or on contract. Bird mortalities range depending on the age of the birds and management factors but could be up to 30% with many variations between farmers and seasons.

The number of slaughter birds have been declining over the past few seasons for various reasons, due to economic reasons. Approximately 160 000 ostriches are currently slaughtered annually with farmers receiving income for the meat, skin and feathers of the slaughtered birds. Thus, there is a consistent decline in population numbers from 325 000 hatched eggs towards the end of the life cycle, but some birds are also kept back for breeding purposes as shown in Figure 7. It should also be noted that slaughter numbers have declined significantly since 2015's 190 000 birds. The 160 000 slaughtered birds for the 2017/18 season were estimated to produce around 6 948 tons of meat (including by-products from the carcass), which resulted in income to farmers valued at R146 million.

The norm for ostrich feather productivity is such that a bird would yield approximately 1.36 kg of feathers throughout the 12-14 month life cycle. The feathers are gathered twice per annum, the first at around 6-7 months and the second at slaughter. Using the same approach, ostrich farmers received income from feathers valued at around R40 million for the first harvest and R136 million for the second. Lastly, the farmers obtained R176 million of income from the skins from the 160 000 slaughtered birds, with an average income of R1 100 per bird for the skin.

Combining the total income received by farmers rearing birds only for a limited period (R254 million), while those that take the birds to slaughter generates around R498 million. The primary production of the ostrich industry is therefore valued at R782 million and employs between 1150 - 1 600 workers based on full-time equivalents.

4.3 VALUE-ADDING

The secondary industry transforms the ostrich into various processed products as shown in Figure 9. Abattoirs process the meat into various cuts and some are heat treated for exports. Using an average meat price for all the different cuts and differentiated between local and international sales, the value-added pushes the value of ostrich meat production to R704 million and results in the direct employment of 1 220 workers. The processing of skins by chrome-crusting and tanning produce products with a sale value of R935 million is more labour-intensive than the abattoirs, requiring 1618 workers.

Finally, the sorting, sizing and making of dusters, as well as fashion products from ostrich feathers result in sales of R245 million with around 360 workers employed in this secondary industry. Thus, if one adds the value of the finished products from the ostrich value chain, the ostrich industry generates an income of around R1.9 billion and also creates economic opportunities for input supplying firms.

On the employment front, if one then adds all the workers throughout the value chain, around 5 470 workers are employed in the ostrich industry. This is considerably lower than the 20 000 number listed in other sources (Brand & Jordaan, 2011; NAMC, 2003; DAFF, 2017). However, it aligns with the current industry structure, slaughter numbers and importantly, is calculated in terms of full-time equivalents.

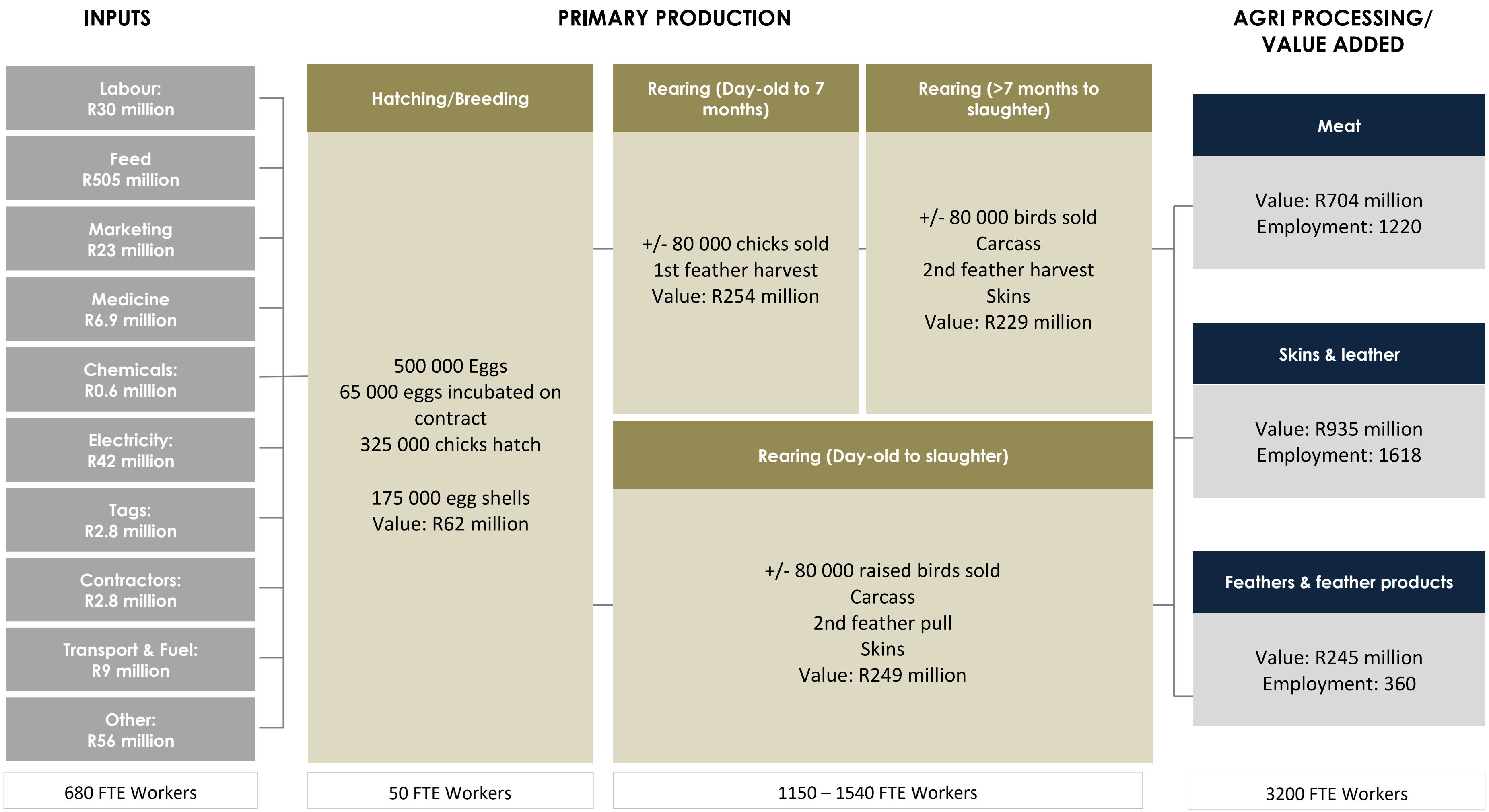


Figure 9: Value Chain Map for the ostrich industry

Source: WCDoA, 2019

5. ENVIRONMENTAL FOOTPRINT

5.1. INTRODUCTION

Climate change is a global challenge and needs cooperation and emission reduction efforts from all countries (DEA, 2018). There is increased interest from various industries to measure and reduce environmental burdens. An environmental footprint can be defined as the effect that a person, company or activity has on the environment and are usually quantitative measures showing the appropriation of natural resources by human activity (Cucek et al., 2015).

In recent years, global efforts such as the 2015 Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) have committed 195 countries to combat climate change (UNFCCC, 2020). South Africa is a signatory of the Paris Agreement and is striving to be a country with low greenhouse gas emissions (Blignaut & Saywood, 2020). 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). This, however, is a much smaller proportion compared to the energy sector that contributes to 72% of the world's total. Within agriculture, livestock production is the largest contributor to agricultural GHG emission by means of enteric fermentation and manure management. 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 make a positive impact in terms of carbon sequestration by using the natural carbon cycle to replenish carbon into the soil (Soussana et al., 2006).

There are also various initiatives underway to drive the sustainable development of livestock sectors worldwide that seeks to simultaneously balance environmental, social and economic challenges and global threats to animal and human health. Since there are around 570 million livestock farmers globally and animal products play a significant role in providing food security to the growing world population, there is a need to align livestock sectors to meet future demand, whilst doing it in an environmentally responsible manner (Livestockdialogue, 2019). Unfortunately, global greenhouse gas (GHG) emissions from livestock are on the rise and there is an urgent need to reduce these. However, the Food and Agriculture Organization (FAO) estimates that improving management practices alone could reduce net emissions from livestock systems by 30% through designing integrated solutions and setting targets (FAO, 2019).

South Africa's agricultural, forestry and related sectors contribute about 9% of the country's greenhouse gasses (AgriSA, 2017; DEA, 2018). One of the strategies that South Africa is putting in place to decrease emissions is the Carbon Tax Act. This Act came into effect on the 1st of June 2019 but is excluding the agricultural sector for now (Rodseth, 2019). Farmers are already putting plans in place, by measuring and monitoring their carbon footprint to make sure they are farming more efficient so that less money can be paid for carbon taxes. The carbon footprint can be defined as "the quantity of GHGs expressed in terms of CO_2-e, emitted into the atmosphere by an individual, organization, process, product, or event from within a specified boundary" (Pandey & Pandey, 2011). Disclosure of carbon emissions are becoming a norm globally and locally, and these days, consumers and retailers are more aware of their impact on the environment and therefore demand to see the products' carbon footprint before making a purchase (de Kock, 2018).

It is within this context that the South African ostrich industry is seeking to understand their environmental footprint, how it compares to other industries and what carbon reduction opportunities exist. In order to do this, the research team from the WCDoA has developed a carbon calculator for the ostrich value chain and in this section both the technical details and results will be discussed.

5.2. CARBON EMISSION CALCULATOR

The reality of global warming and climate change are starting to affect both smallholder and commercial farmers and, as a result, it is becoming imperative for these farmers to monitor and measure their impact on the environment (Barends, 2016). As a result, the need has arisen for carbon calculators and, today, numerous online carbon calculators are available for individuals, households and businesses. Although people are spoiled with options, there are a few shortcomings with the available systems. According to Ross et al. (2010), many of the online calculators have shown to be inconsistent and lacking transparency when it comes to how the calculations are done.

For the purpose of this study, the focus will be on calculators specifically developed to calculate a livestock carbon footprint. Different calculators are suited for different purposes, which has a significant impact on the scope and methodology of each (Little & Smith, 2010). All the different calculators work on a basic principle that consists of two components. These two components are 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. Therefore the formula is as follow:

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

Farm activity data are the emission sources and for the Ostrich Industry the list is:

- ***Fuel*** – this is used for the transportation of eggs, chicks, birds, meat, feathers and skins. Fuel is also used when transporting feed to birds, transporting the workers to check on the birds in the fields or to do maintenance work on the farm, as well as the use of a forklift when needed and generators in case of load shedding.
- ***Electricity*** – electricity is used mostly in hatcheries, abattoirs and tanneries. Hatcheries use electricity for running of incubators and lights, as well as the machinery used for washing and cleaning. Electricity is also used during chick rearing for heating and cleaning. The secondary production parts of the industry, namely tanneries, feather processing facilities and abattoirs, uses electricity for refrigeration and machinery.
- ***Water*** – consumption by the birds, irrigation (if planting pastures) and cleaning.
- ***Waste*** – this ranges from broken shells, to dead birds, to empty medicine bottles and disinfectant cans. Empty feed bags and broken crates can also be slotted under this heading.
- ***Enteric fermentation*** – refers to the "natural part of the digestive process in ruminant animals. Microbes in the digestive tract, or rumen, decomposes and ferments food, producing methane as a by-product" (Morris, 2019). In "non-scientific language", it refers to when an animal burp.
- ***Manure management*** – management of the actual manure/excretions of the animals.
- ***Chemicals*** – this can be fertilisers, herbicides, pesticides, insecticides, cleaning chemicals, etc.
- ***Material used/packaging*** – for the ostrich industry this refers to crates and the rubber mats used to transport the eggs and chicks. As well as carton/cardboard boxes, plastic bags and plastic roll stocks.
- ***Refrigerants*** – used for refrigeration. Normally the following gasses are used and must be replaced regularly: HCFC-22/R-22, R-134/HFC-134, Ammonia, R404 and R410
- ***Export emissions*** – it refers to products being sold abroad. The mode of transport can be by air, sea or road.

The 10 emission sources/categories mentioned above are also used as the boundaries of this study to indicate what is being looked at and what is being measured. These emission sources can be grouped into three scopes. 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 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 travel, procurement, the rest of the waste category, for example, waste to landfill, and water, fall under scope 3 (World Resources Institute & World Business Council for Sustainable Development, 2013).

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

- Farms, in general, are complex systems that tend to be integrated.
- 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% 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; du Toit, et al., 2013a).

Although the process to calculate a farm's carbon footprint is more complex, it still is important to do so to help farmers measure, monitor and reduce their environmental footprints and subsequently to improve the efficiency and performance of their business and to inform 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). This is more so for ostrich products that are largely exported especially to the developed economies where consumers are more environmentally conscious.

Table 1 provides some details of livestock carbon calculators for guidance in the development of the ostrich calculator. The above-mentioned calculators are excellent to be used as a baseline as they are based on the Intergovernmental Panel on Climate Change (IPCC) principles and values, following a Tier 1approach. The different Tiers will be further discussed under the next section, section 5.3. 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. These calculations are often assumption based and include assumptions that animals are consuming highly digestible diets as well as temperate forages. These assumptions are not realistic for South African production systems and specifically for ostriches since they mainly focus on ruminants, like dairy and beef cattle (du Toit, et al., 2013b). No specific carbon tool exists that only focuses on non-ruminants, like ostriches, although emission source data for ostrich activities do exist. The lack of tools that focus on non-ruminants is due to the global perspective, which sees these animals as minor sources of GHG emissions and therefore not having a major impact on total livestock emissions (du Toit et al., 2013a).

Table 1: Livestock calculators

Calculator	Use	Range
Climate Friendly Food (CFF) Carbon Calculator	A UK based tool designed by farmers for farmers to work out the carbon footprint of their business, identify cost savings and offer advice on how to minimise your carbon emissions	Dairy & Beef Cattle, Pigs, Sheep, Goats, Horses, Deer & Poultry
The Cool Farm Tool	The Cool Farm Tool encourages good agricultural practices. It stimulates thinking about management, by showing carbon hotspots and by helping to develop action plans	Cattle, Pigs, Goats, Horses, Game & Poultry

Source: Farm carbon toolkit, 2018; Cool Farm Alliance, 2018

Livestock's greenhouse emissions vary by animal type, growth stage and level of production owing to different diets, feed conversion mechanisms and manure management systems. Animal manure and waste management systems' emissions are also influenced by various factors. These include soil and manure moisture, temperature, manure-loading rate[3] by the animal, depth of manure in the pen, redox potential, available carbon, diets and microbial processes (du Toit et al., 2013a). A difference between ruminants and non-ruminant livestock exist and that causes ruminants to be the main methane contributors for the livestock industry. Although non-ruminants also contribute to the methane emissions through enteric fermentation, it is in much smaller quantities (du Toit et al., 2013a). Ruminant livestock includes dairy and beef cattle, sheep and goats, while non-ruminant livestock includes pigs, horses, mules, ostriches and poultry.

Data for this study was collected through face to face interviews, as well as distributing the questionnaire by e-mail to those producers that could not avail themselves for face to face

[3] The manure-loading rate refer to how many times a day the animal excretes manure.

interviews. Interviews were held with twelve producers, one tannery representative, one feather facility and one abattoir representative. The participants were selected by Dr Adriaan Olivier from the South African Ostrich Business Chamber (SAOBC) and Dr Anel Engelbrecht from the Western Cape Department of Agriculture (WCDOA). Calculations were done based on the information received from the producers and in some cases where information was missing, some assumptions were made. Data collected was for the 2018/19 period. At the time when visits occurred, the producers were facing severe drought conditions so none of them were planting lucerne. Also, as noted earlier, no ostrich meat was exported for this period due to the international markets being closed. International trade data for 2017 meat exports were collected from SARS data. An emission factor list was created to help with the calculations and these emission factors were sourced from different platforms.

5.3. METHODOLOGY: DEVELOPING THE CARBON CALCULATOR FOR THE OSTRICH INDUSTRY IN SOUTH AFRICA

The internationally recognised measure of GHG is "tons of carbon dioxide equivalent" (tCO_2e) and when reporting on the carbon footprint this measure is used for reporting purposes. This recognised measure is also used to compare the different GHGs to one unit of CO_2 (Barends, 2016). To calculate the tCO_2e, each greenhouse gas' emission is multiplied with its global warming potential (GWP). A list of all the GHGs and its GWP values is available on the GHG Protocol.org website, but for the purpose of this report the focus will only be three of the GHGs; CO_2, CH_4 and N_2O. Table 2 gives a summary of the three GHGs and their GWPs.

Table 2: 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

Table 2 states that methane (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).

When measuring livestock's emissions the focus is on measuring enteric fermentation and manure management. The activity data for these two categories are normally the population of the livestock, with additional information such as the amount of methane produced per animal per year. This will not give you the GHG emission though and therefore the emission factor is needed to convert the activity data to GHG emissions. The methane produced through enteric fermentation will be subjective to the characteristics of the animal, the quality and type of feed, and intake (du Toit et al., 2013b). Methane production from manure management will be influenced by temperature, solar radiation and humidity. High temperatures, combined with high solar radiation and low humidity will lead to manure drying faster, resulting in lower methane production (du Toit et al., 2013b).

The vast majority of GHG emissions in livestock systems originate from four main categories of activities: enteric fermentation, manure management, feed production and energy consumption (FAO, 2019; du Toit et al., 2013a). When calculating livestock emissions, methodology from Tier 1, Tier 2 or Tier 3 needs to be taken into account. Tier 1 methodology relies on the basic characteristics of livestock populations to estimate an approximate emission factor. Tier 2 uses enhanced characterisation of populations including information such as feed intake, weight gain, etc. Tier 3 incorporates an even higher level of detail relating to diet composition, seasonal variation, etc. (IPCC, 2006). For this study, Tier 1 methodology will be used due to the limited amount of research available on ostriches to quantify their direct emissions (Pineo, 2015; du Toit et al., 2013a).

It is debated that the generic emission factors as set up by IPCC are not representative of all animal classes, production efficiencies and production systems, especially for South African livestock. This led to studies trying to create emission factors for livestock that are more suitable to what is currently happening in South Africa. Table 3 summarises the literature that focusses on emission factors for livestock in South Africa.

The study by du Toit in 2017, showed that enteric methane emission factors for the different production systems in South Africa were much higher than the IPCC default values used for cattle, dairy and beef in developed and developing countries. Du Toit (2017) also showed that with regards to sheep production, South Africa cannot be compared with the IPCC data for developed and developing countries due to the genetic composition of the animal, the diet of the animal and the production systems. Furthermore, emission factors varied for the different sheep breeds (Pineo, 2015).

Table 3: Enteric fermentation and manure management emission factors for different livestock species

<table>
<tr><th rowspan="2">SOURCE</th><th colspan="2">IPCC (2006)</th><th colspan="2">DU TOIT ET AL. (2013a) & DU TOIT ET AL. (2013b</th><th colspan="2">GREENCAPE (2015)</th><th colspan="2">AUSTRALIAN NATIONAL GREENHOUSE ACCOUNTS, 2009</th></tr>
<tr><th>ENTERIC CH_4[4] (KG/HEAD /YR)</th><th>MANURE CH_4[5] (KG/HEAD /YR)</th><th>ENTERIC CH_4 (KG/HEAD /YR)</th><th>MANURE CH_4 (KG/HEAD /YR)</th><th>ENTERIC CH_4 (KG/HEAD /YR)</th><th>MANURE CH_4 (KG/HEAD /YR)</th><th>ENTERIC CH_4 (KG/HEAD /YR)</th><th>MANURE CH_4 (KG/HEAD /YR)</th></tr>
<tr><td>Beef Cattle</td><td>Range-kept: *53* Feedlot: *53*</td><td>Range-kept: *6.7* Feedlot: *6.7*</td><td rowspan="4">According to the different animal classes and feeding systems.</td><td rowspan="4">According to the different animal classes and feeding systems.</td><td colspan="2" rowspan="2">Emission factors were based on the du Toit et al. (2013) study Manure management based on du Toit et al. (2013) and IPCC (2006).</td><td>Range-kept: *72* Feedlot: *77*</td><td>Range-kept: *0.04* Feedlot: 2.86</td></tr>
<tr><td>Dairy Cattle</td><td>68</td><td>32</td><td>113</td><td>8.8</td></tr>
<tr><td>Sheep</td><td>8</td><td>0.28</td><td colspan="2" rowspan="2">Emission factors were based on the du Toit et al. (2013) study.</td><td>6.8</td><td>0.002</td></tr>
<tr><td>Pigs</td><td>1.5</td><td>20</td><td>1.45</td><td>23</td></tr>
<tr><td>Poultry</td><td>Insufficient data for calculation.</td><td>0.036[6]</td><td>According to bird type and feeding systems. Emission factors for all classes = 0</td><td>According to bird type and feeding systems factors for these classes = 0.0235</td><td colspan="2">Emission factors were based on the du Toit et al. (2013) study.</td><td>No estimate</td><td>0.02</td></tr>
<tr><td>Horses</td><td>18</td><td>2.34</td><td>18</td><td>0.0134</td><td colspan="2">Emission factors were based on the du Toit et al. (2013) study.</td><td>18</td><td>0.0134</td></tr>
<tr><td>Donkeys/Mules</td><td>10</td><td>1.10</td><td>10</td><td>0.0045</td><td colspan="2">Emission factors were based on the du Toit et al. (2013) study.</td><td>10</td><td>0.0045</td></tr>
<tr><td>Ostriches</td><td>No estimate</td><td>No estimate</td><td>5</td><td>0.0016</td><td colspan="2">Emission factors were based on the du Toit et al. (2013) study.</td><td>5</td><td>0.0016</td></tr>
</table>

Source: Australian Government (2011); du Toit et al. (2013a); du Toit et al. (2013b); IPCC (2006); Pineo (2015)

[4] *Based on IPCC default values and developed countries.*
[5] *Figures are based on average annual temperatures of between 15 to 25˚C and for developed countries.*
[6] *The figure is based on a layer operation that manages its dry manure.*

Pineo (2015) noted that the larger the GHG contribution, the more important it is to make use of Tier 2 calculations to get accurate emissions and therefore the detailed emission factors for the cattle and sheep livestock categories. Comparing pig emission factors to IPCC data for developing countries, the study by du Toit et al. (2013) highlights that South African emission factors will be much higher, but are more realistic or similar to IPCC default values for developed countries, such as Australia, Canada and North America (Pineo, 2015).

Poultry methane emission factors show insufficient data (IPCC, 2006), no estimates (Astralian Government, 2011)or relatively small and zero numbers (du Toit et al., 2013a). Therefore, that will not make a difference when calculating methane production and hence the exclusion in most literature (Pineo, 2015). The poultry industry is also known for its direct nitrous oxide production, which comes primarily from manure, and as a result, most studies based their calculations on a Tier 1 approach (Pineo, 2015). The study by du Toit et. al. (2013) made an estimation based on US poultry enteric emission factors that states that the South African poultry enteric emissions will increase and therefore suggested that a Tier 2 methodology approach should be used to capture the poultry emissions accurately.

Table 4: Emissions emitted yearly by animal category

Animal Type	**Emissions emitted yearly**
	CH_4/head/year
Beef cattle	78.9kg
Dairy cattle	76.4kg
Horses	18kg
Donkeys and mules	10kg
Sheep	8.5kg
Ostriches	5kg

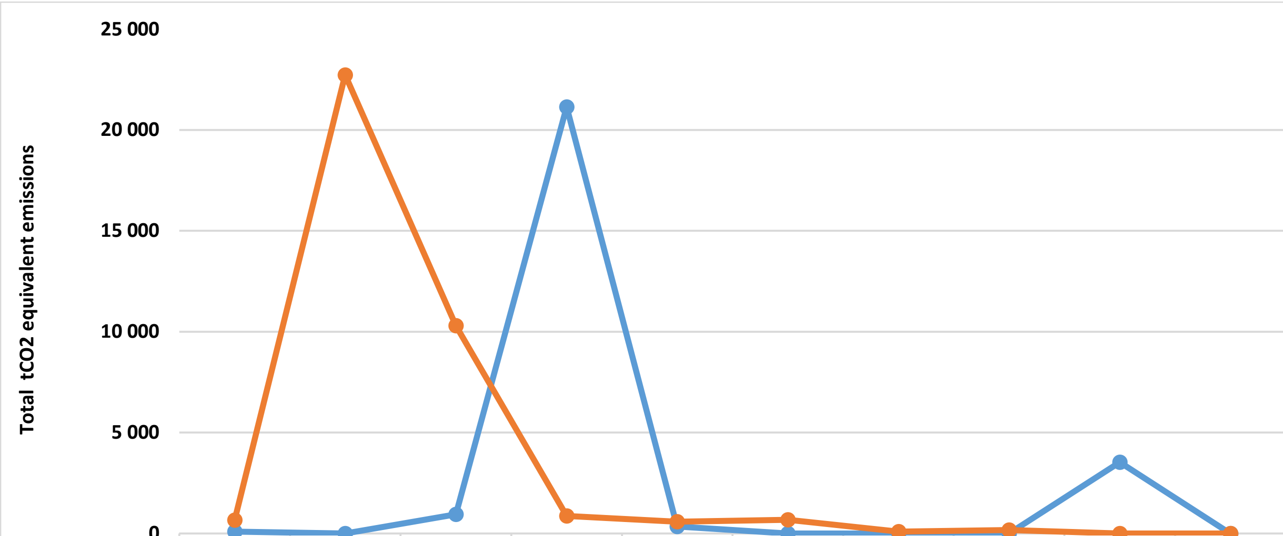
Source: (du Toit, 2017)

Non-ruminant livestock such as horses, donkeys/mules and ostriches, are seen as minor contributors to GHG emissions and their calculations are based on a Tier 1 approach. In the past ostrich and other poultry emissions were excluded in the GHG emission calculations due to their insignificance, but with South Africa being a major global exporter of ostrich products it has become important to look at what the carbon footprint impact of these birds are at the national level. There is also scope to develop emission factors to a Tier 2 approach, but for now the focus will be on the work that du Toit, Meissner & van Niekerk did in 2013. Research has also been done to determine how much methane is emitted per animal type, as shown in Table 4. Table 4 also indicates that Beef cattle are emitting the most CH_4 per head per year, followed by dairy cattle and horses. The lowest emitters are ostriches, followed by sheep and donkeys/mules.

5.4. RESULTS

The results from the carbon emissions were measured by calculating the total tons of carbon equivalent emissions, using the methodology as earlier described. In total, the ostrich industry, including both primary and secondary production, emitted approximately 62 134.55 tCO_2e, as can be seen in Figure 10. Primary production, which includes activities like breeding, hatching and rearing, contributed 41.94% to total emissions compared with secondary production. The latter includes value-adding activities from leather, meat and feather production and contributed 58.06% to total emissions.

Export emissions (22 731.52 tCO_2e) were the highest emitting activity for secondary production, followed by electricity (10 292.17 tCO_2e). Looking at the primary production curve, water (21 143.14 tCO_2e) and enteric fermentation (3 529.68 tCO_2e) are the highest emitters. Enteric fermentation is minimal compared to export emissions, water and electricity.



	Fuel	Export emissions	Electricity	Water	Waste	Refrigerants	Chemicals	Material used/ packaging	Enteric Fermentation	Manure Mangement
Primary	86.36	0.00	948.32	21 143.14	348.39	0.00	0.09	0.00	3 529.68	1.13
Secondary	659.77	22 731.52	10 292.17	873.17	577.86	687.20	89.18	166.55	0.00	0.00

Figure 10: Total tCO_2e for primary and secondary production according to emission sources

Source: Own compilation, 2020

When comparing the water and electricity categories for both primary and secondary production, it is clear that secondary production uses much more electricity units than primary production, while for water it is the other way around, with primary production using exponentially more water units.

Since lucerne production is vitally important for the feasibility of many of the ostrich production systems and also influences the extent of carbon emissions, this exercise will look at two scenarios, total carbon emissions without lucerne production (the orange line) and one that includes lucerne production (the blue line). Please note that scenario 1, without lucerne production, does include the fuel emissions for buying the different feed mixes at the local corporation, Klein Karoo Agri, and transporting it to the farm. For this exercise, the focus is only on fuel emissions within the scope of the farm. If feed sold at the corporation are imported from other countries or provinces those emissions are falling under the scope and boundary of the corporation and not the farm. The farm is only responsible for emissions from the corporation, to the farm and all the activities happening on the farm regarding the feed. Figure 11 gives a comparison between these two and it is important to note that the lucerne producing calculation only focuses on chemical and water use. Water, export emissions and electricity are the highest carbon emitters in both production systems, with the lucerne production curve being slightly higher for water emissions. These are seen as "hotspots". Chemical emissions increase with lucerne production and can be seen as another "hotspot", whilst the smallest carbon-emitting activities were manure management, waste and material used/packaging. The reason for the low waste component is because packaging material such as feed bags are being re-used, and every by-product (feathers, eggshells, skins, etc.) of the bird are used so that nothing goes to waste. Noteworthy changes in the different systems are that water and chemical usage goes up with added lucerne production.

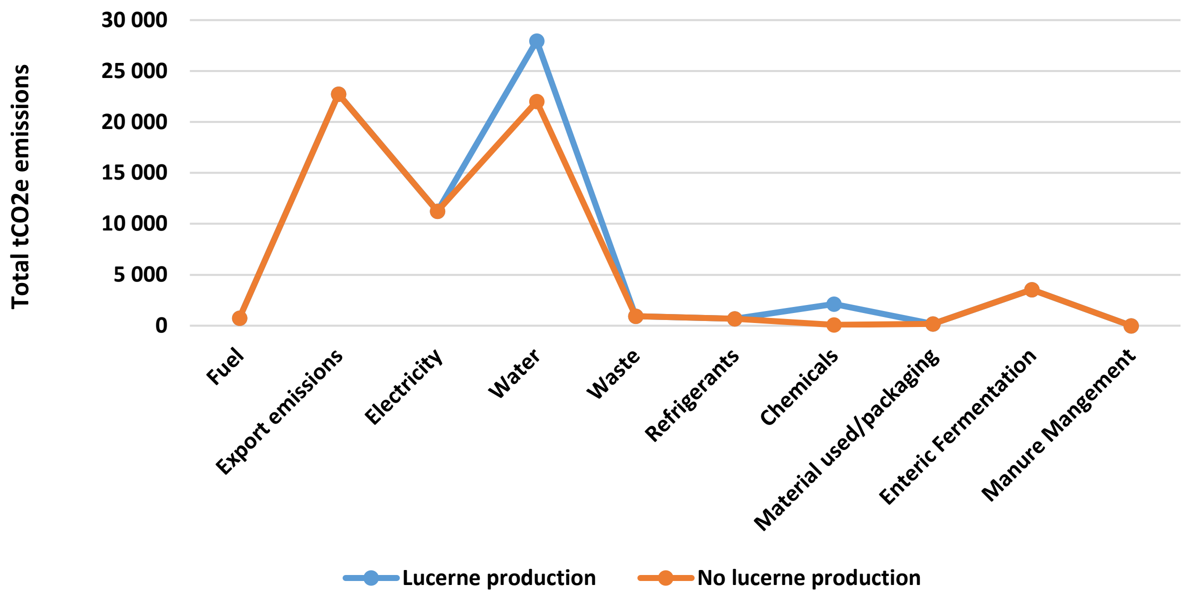
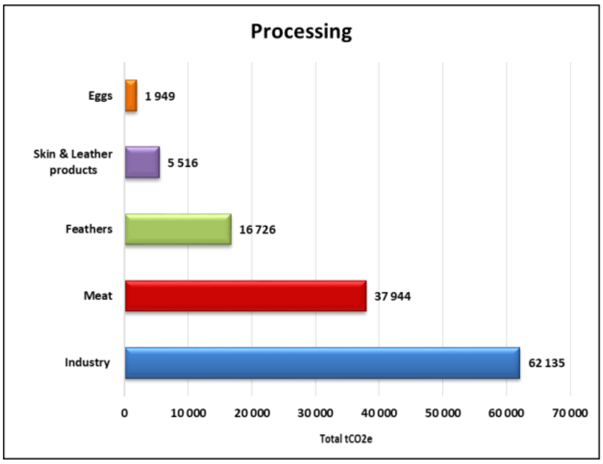


Figure 11: Total co2e (tco2e) emissions for different ostrich production systems
Source: Own compilation, 2019

Figure 12 (graph on the left, labelled processing) indicates the total carbon emission contributions, where the meat subdivision contributes the most emissions (37 944 tCO_2e), followed by feathers (16 726 tCO_2e), leather (5 516 tCO_2e) and lastly ostrich eggs (1 949 tCO_2e). The graph on the right (labelled production) summarises the same scenario but the total emissions related to meat production from the graph on the left are split between the rearers (includes from 1 day old to slaughter) and abattoir. The scenario changes a bit and the highest contributors are rearers (24 298 tCO_2e), followed by feathers (16 726 tCO_2e), then abattoir-meat (13 646 tCO_2e), leather (5 516 tCO_2e) and lastly eggs (1 949 tCO_2e).

The meat subdivision from the graph on the left includes the abattoir data as well as farm data, which consist of the rearing of the chicks. The egg subdivision in both graphs includes hatcheries and breeding birds. The feather category on both graphs refers to feathers being processed and the skin and leather category is based on skins and leather being processed.



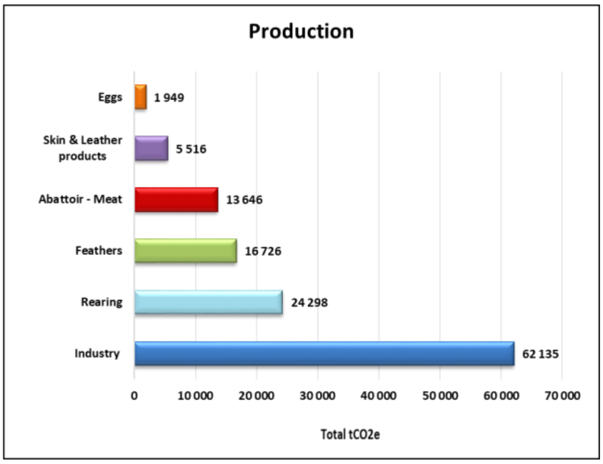


Figure 12: Carbon emissions for the different by-products of the bird compared to total emissions for the industry
Source: Own compilation, 2020

Table 5 gives a summary of different meat types and what their kgCO_2e per 100 grams of serving will be. Three different international sources are looked at. The Table indicates that lamb and beef meat types have the highest kg of CO_2e emissions per serving of 100 grams compared to pork and chicken. Carter (2020) gives an average for each meat group and notes that these numbers are averages and that transport is excluded. Ostrich meat was not looked at and was excluded from all the international sources, but based on the data used to determine the footprint, the kgCO2e for a kg of meat could also be determined. The calculation was based on the total tCO2e emissions for the meat category, divide by the bird population to get the total emissions for one bird. That amount was then divided by the average slaughter weight of the bird to get the kilogram of emissions per kilogram of meat. The answer arrived at was 2.79 kgCO_2e per kg of meat for ostriches.

Table 5: Different meat options expressed in $kgCO_2e$ per kg of meat

Product	International – $kgCO_2e$ per 100 gram of meat (Lewis, 2015)	International – $kgCO_2e$ per 100 grams of meat (Ritchie, 2020)	International – Average $kgCO_2e$ per 100 grams of meat (Carter, 2020)
Lamb	***39.2 kg*** of CO_2e	***20 kg*** of CO_2e	***20.44 kg*** of CO_2e
Beef	***27.0 kg*** of CO_2e	***25 kg*** of CO_2e	***15.44 kg*** of CO_2e
Pork	***12.1 kg*** of CO_2e	***6.5 kg*** of CO_2e	***4.62 kg*** of CO_2e
Chicken	***6.9 kg*** of CO_2e	***4.3 kg*** of CO_2e	***2.33 kg*** of CO_2e
Ostrich	N/A	N/A	N/A

Source: (Carter, 2020); (Lewis, 2015); (Ritchie, 2020)

Comparing the calculated emission with other meat types from the Carter (2020) average data, the conclusion can be drawn that ostrich meat is the second-lowest emitter per kg, after chicken.

5.5. CARBON FOOTPRINT REDUCTION OPPORTUNITIES

In the previous section, the carbon footprint has identified the hotspots of the ostrich industry in terms of its carbon-emitting activities. Even though these are comparatively low when compared to other livestock sub-sectors, there are still opportunities for farmers and agri-businesses to reduce their environmental footprints. Most of the farmers interviewed are already implementing some sort of green initiatives that help with a lower footprint, which shows good intent. These initiatives include solar pumps and lights, re-using feed bags, drip irrigation and optimising water usage by using smaller pumps and having pastures in water abundant areas, as well as using the manure as fertilisers on the pastures and as bedding material for soils. The ostrich is so versatile that no by-product gets wasted; everything from the eggshells to the carcasses gets used. This practise should continue for its obvious economic and environmental benefits.

To monitor and manage emissions continuously will help improve the industry's carbon footprint. It will also lead to better management of resources used. Additional reduction opportunities that can be looked at are:

- ***Energy*** – Insolating the incubation room where the hatchery incubators are kept as well as the rooms that are used during the rearing stage to keep the small chicks warm. This will help to keep the heat inside. Incubators should be in working conditions and if possible to switch to more energy-efficient equipment.

- ***Water*** – Looking at ways to treat and reuse the water used for cleaning of equipment, materials used (rubber matting, crates, etc.) and rooms where the chicks were kept.
- ***Export emissions*** – Instead of exporting small quantities, rather look at combining small quantity trips.
- ***Manure*** – Instead of letting the manure run-off or dumping it, rather use it as fertiliser in the fields or on pastures.

6. CONCLUSION

This report has had two major objectives: 1) to show the economic footprint of the ostrich value chain with specific linkages to the rest of the economy and job creation, and 2) to calculate the carbon footprint of the industry in order to compare it against other industries. The findings from the research conducted show that the ostrich industry plays a significant role in the regional economy of the Klein Karoo by providing livelihoods to around 5 500 workers directly, whilst various agri-businesses continue to generate export earnings from the sales of ostrich and related products abroad. In total, final products that come from the ostrich value chain were valued at R1.9 billion which is essential in the current South African context of low-growth and limited economic opportunities.

The estimates coming from the tailored carbon footprint that was developed as part of this study suggest that ostrich meat is an environmentally clean product compared to other livestock systems such as cattle and dairy. Both primary and secondary producers in the industry emitted around 62 134.63 tCO_2e, coming mainly from activities such as water usage and export emissions. The industry is particularly environmentally clean due to its re-use/recycle approach and because ostriches are non-ruminant animals, emitting very low levels of methane. Some carbon reduction strategies proposed were better energy use, a water recycling and cleaning system and some manure management interventions.

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