The demand for ecosystem services by different calf-production systems in South Africa

James Blignaut*
Department of Economics, University of Pretoria, Pretoria, South Africa and Honorary Research Fellow, SAEON, Pretoria, South Africa. E-mail: jnblignaut@gmail.com

Doug Crookes
Department of Economics, University of Pretoria, Pretoria. E-mail: d_crookes@hotmail.com>

Ayanda Saki
ASSET Research, Pretoria, South Africa. E-mail: ayandasaki@yahoo.com

* Corresponding author

Abstract

This study compares the environmental impact (i.e. feed intake, water consumption and greenhouse gas emissions) of 12 different calf-production systems to produce a calf weighing 190 kg to 220 kg. A farm-level static model and a national-level dynamic model were both developed to consider the variation in the environmental impact following different cattle management protocols. It was found that aspects related to calf mortality rates, calving percentage, average daily gain and fodder conversion ratios play a significant role in the total environmental impact of calf production. The longer it takes for a calf to reach the target weight and the more animals there are in the herd structure, the higher the environmental impact and the more unsustainable the production becomes. Therefore, the higher the environmental impact, the higher the relative environmental impact to produce a kilogram of beef. This requires a careful yet decisive policy focus and action plan towards sustainable rangeland management.

Key words: sustainability; water; greenhouse gas emissions; fodder consumption; beef production

1. Introduction

Most, if not all, calves prepared for slaughter in South Africa are raised on grass until they are sold either into the feedlot system or directly to an abattoir. The management methods for calf production prior to selling the animals vary greatly, however, and are often linked to the purpose for herding cattle, such as stud breeding, commercial breeding, own consumption or cultural purposes. Some of the extensive calf-production systems include careful land rotational systems, combined with scientifically specified breeding programmes and very specific breeding seasons, with feed supplements or rations provided. Other systems neither allow for rotational grazing nor for specific breeding seasons. Often, in these cases, the provision of supplementary rations is rare, if not non-existent.

Given the wide spectrum of farm management systems, it is uncertain what the environmental impact of each of the different calf-production systems is in producing a calf that weighs about 190 kg to 220 kg that can either be sold to a feedlot or retained. The environmental impact of raising the calves will be estimated by considering the following elements:

- Greenhouse gas emissions – calculating it and striving to reduce it per unit of beef produced as far as possible.
- Water use – measuring it and seeking to increase water-use efficiency by increasing the beef production per litre of water.
- Fodder production – measuring it and seeking to reduce the grazing material required per unit of beef produced as far as possible.

The aim of this study, therefore, was to estimate the environmental impact of different farm management systems to produce calves of the requisite weight.

2. Environmental impact of livestock

There have been a large number of studies that have considered the environmental impact of livestock farming systems. A selection of these studies is given in below (Table 1).

Table 1: A literature review of studies considering the environmental impact of livestock

Author	Methodology	Study	Aim	Emission factors
Picasso *et al.* (2014)	The life cycle assessment (LCA) method was used to study some of the environmental impacts of beef production systems, including farm activities and the production of farm inputs. Greenhouse gas (GHG) emissions were calculated using equations provided by the Intergovernmental Panel on Climate Change (IPCC).	Sustainability of meat production beyond carbon footprint: a synthesis of case studies from grazing systems in Uruguay.	To quantify carbon footprint using various metrics and several other environmental variables: fossil energy consumption, soil erosion, nutrient balance, pesticide eco-toxicity, and impact on biodiversity, in fifteen beef grazing systems in Uruguay.	Beef systems with grazing finishing have greater GHG emissions than feedlot finishing.
Dick *et al.* (2014)	LCA was used. The analysis involved different levels of organisation, which were limited to environmental aspects and did not consider social and economic issues. GHG emission were calculated according to the IPCC (2007) tier 2 methodology.	LCA of beef cattle production in two typical grassland systems of southern Brazil.	To analyse the main environmental impacts of two typical beef cattle production systems from southern Brazil: the extensive system (ES) and the improved system (IS). It further identifies the components and processes that have the greatest environmental impact.	The GHG emissions/kg LWG in the IS was found to be 40.67% of the emissions obtained in the ES. In the ES, the fresh water depletion was found to be higher than in IS. The difference is due to the lower quality of the forage consumed by the animals in the ES compared with the IS and is based on the differences in dry matter intake, digestibility and pasture use efficiency.
Meissner *et al.* (2013)	Life cycle assessment (LCA)	Sustainability of the South African livestock sector towards 2050. Part 2: Challenges, changes and required implementations.	In-depth self-assessment of the challenges facing the sector and to respond to these.	The socio-economic contribution and growth of the livestock sector are satisfactory, in fact increasing as a proportion of total agriculture, and are not over-compromising resources and the environment.

Du Toit *et al.* (2013)	Tier 2 methodology of the Intergovernmental Panel on Climate Change (IPCC)	Direct methane and nitrous oxide emissions of South African dairy and beef cattle.	To estimate direct methane and nitrous oxide emissions of South African dairy and beef cattle in total and per province.	Beef cattle in extensive systems were the largest contributor (83.3%), followed by dairy cattle (13.5%) and feedlot cattle (3.2%).
Subak (1999)	GHG emissions from two livestock production systems at opposite ends of the spectrum regarding energy inputs were assessed according to a range of indicators – biophysical capital loss, topsoil loss and greenhouse gas emissions.	Global environmental costs of beef production.	To evaluate the impact on greenhouse gas emissions of beef produced under different management systems and compare these results with the estimated biophysical capital alteration of these same systems.	Methane emissions from the ES are nearly twice that of the IS. When energy is included, the IS system has a higher GHG emission. The $/kg CO_2 equivalence value estimated in this paper provides a social cost estimate that has an upper limit of about 9% of the current market value of beef and a central value of 3% to 5%.

This study differs from those identified above by assessing the environmental impact of different categories of extensive production systems. Environmental impact will be expressed in monetary values, and profitability will be calculated to determine which production system has higher externality costs. The production efficiency of different production systems will also be calculated to determine which production system is better able to use resources efficiently.

3. Materials and methods

3.1 Introduction and farm profiles

Cattle population, imports, production and herd structure data was sourced from the Department of Agricultural, Forestry and Fisheries (DAFF 2015). Typical farm profiles were developed using primary data provided by private consultants, academics and the literature. Twelve different typical farm-level, extensive calf-production systems were modelled to determine the environmental impact of the farm-level life-cycle of producing a market-ready calf for each of the different systems. A typical farm is a tool that can be used to assess farm profitability and to determine the effect of variations in a range of variables on farm-level profitability (Hoffmann 2010). The concept of typical farms allows for the evaluation and comparison of the effect of various managerial decisions and options (Hoffmann 2010). Farms represent a typical average, a good and a bad version of each, for a commercial operation, an emerging farmer's operation, a communal farmer's operation and a national-level operation. The data representing typical farms was derived from actual data collected by academics and private consultants, verified by industry experts (Table 2). The characteristics of the 12 typical farms are provided in Table 2.

Table 2: Diagnostic specification of different extensive beef production systems[1]

	Calf mortality and theft	Unproductive animals[2]	Calving percentage	Calf birth weight	Calf age at marketing from the farm	Market weight	Income	Fodder consumption	Average daily gain	Avg. feed conversion ratio (calves)[3]
	%	%	%	kg	days	kg	(R/calf)	% of weight	(kg/day)	(kg feed for kg meat)
Farm 1	5%	68	83%	40.0	244.0	220	4 400	2.8%	0.74	4.95
Farm 2	2.5%	60	90%	45.0	213.5	220	4 400	2.8%	0.82	4.56
Farm 3	7.5%	80	73%	35.0	305.0	220	4 400	2.8%	0.61	5.90
Farm 4	5%	76	75%	35.0	305.0	190	3 230	3.0%	0.51	6.66
Farm 5	2.5%	68	81%	35.0	305.0	200	3 400	3.0%	0.54	6.53
Farm 6	7.5%	89	66%	30.0	305.0	180	3 060	3.0%	0.49	6.42
Farm 7	10%	130	37%	25.0	549.0	190	3 230	3.2%	0.30	11.46
Farm 8	7.5%	123	46%	30.0	457.5	200	3 400	3.2%	0.37	9.94
Farm 9	15%	142	29%	25.0	732.0	180	3 060	3.2%	0.21	15.51
Farm 10	7.5%	99	59%	30.0	335.5	190	3 230	3.0%	0.48	6.95
Farm 11	5%	92	65%	35.0	244.0	220	3 740	3.0%	0.76	5.06
Farm 12	10%	112	47%	27.5	366.0	180	3 060	3.0%	0.42	7.49

1. Farms 1 to 3 represent typical average, good and bad commercial operations, Farms 4 to 6 represent typical average, good and bad emerging farmers' operations, Farms 7 to 9 represent typical average, good and bad communal farmers' operations, and Farms 10 to 12 represent typical average, good and bad national-level operations.
2. Unproductive animals refer to the % of non-productive to productive animals (i.e. the number of oxen, non-productive heifers and cows that did not calf) to productive cows.
3. The feed conversion ratio is for live weight of calves of the specified age and the specified weight.
Sources: Corbet *et al.* (2006), Muchenje *et al.* (2008), Strydom *et al.* (2008), Mapiye *et al.* (2009), Scholtz and Bester (2010), Spies (2011), Scholtz *et al.* (2013; 2014). Also D. Motiang, Personal communication and E. Webb, Personal communication.

The data presented in Table 2, combined with the assumptions and descriptions discussed below, were used to estimate three measurable indicators for each of the typical farms, namely:

- GHG/kg beef produced (yield) under various farming systems
- water/kg beef produced (yield) under various farming systems
- biomass consumed/kg beef produced (yield) under various farming systems

3.2 Indicators

3.2.1 GHG emissions

The methods of calculating greenhouse gas (GHG) emissions are based on the 2007 IPCC Guidelines for National Greenhouse Gas Inventories. The emission factors specific to South African conditions (Du Toit *et al*. 2013) and management systems given in Tables 3, 4 and 5 were used to calculate the GHG emissions. In calculating emission factors, Du Toit *et al*. (2013) used a Tier 2 approach for all major cattle sectors in accordance with the 2007 IPCC good practice requirements. In calculating the total emissions, data on the latest national cattle population and the herd structure of the commercial sector was sourced from DAFF (2015), and data on the feedlot population was sourced from SAFA (2015).

Table 3: Methane emission factors (MEF) for commercial beef cattle

Animal class	Average weight (kg)	MEF (enteric fermentation)	MEF (manure)
		kg/head/year	kg/head/year
Bulls	733	113	0.022
Cows	475	92.6	0.018
Heifers	365	75.9	0.016
Oxen	430	89.4	0.018
Young oxen	193	51.6	0.012
Calves	190	51.6	0.012

Source: Du Toit *et al.* (2013)

Table 4: Direct methane emission and nitrous oxide emission factors for South African feedlot cattle

Animal class	Average weight	MEF (enteric fermentation)	MEF (manure)	Nitrous oxide
	kg	kg/head/year	kg/head/year	kg/head/year
Growing animal	335	58.9	0.87	0.475

Source: Du Toit *et al.* (2013)

Table 5: Methane emission factors for communal beef cattle

Animal class	Weight (kg)	MEF (enteric fermentation)	MEF (manure)
		kg/head/year	kg/head/year
Bulls	462	83.8	0.017
Cows	360	73.1	0.015
Heifers	292	62.5	0.013
Oxen	344	72.6	0.015
Young oxen	154	41.6	0.01
Calves	152	40.9	0.01
Average		62.417	0.013

Source: Du Toit *et al.* (2013)

GHG emissions were calculated based on cattle population data and herd structure from the DAFF (2015) and involved applying the GHG factors of Tables 3 to 5 to the 2014 herd profile of the country. The emissions are recorded in Tables 6 and 7.

Table 6: GHG emissions for beef cattle production systems for 2014

Production system	Population	CH_4 enteric (ton)	CH_4 manure (ton)	Nitrous oxide (ton)	CO_2 equiv. (ton)[1]
Feedlot	1 350 000	79 515	1 175	641	2 208 330
Extensive communal/emerging	5 675 600	399 702	83	-	9 994 628
Extensive commercial	5 630 000	530 419	110	-	13 263 215
Total	12 655 600	1 009 636	1 367	641	25 466 173

1. A factor of 25 was used to convert CH_4 to CO_2 and a factor of 298 was used for N_2O (IPCC 2007).

Table 7: Greenhouse gas (GHG) emissions: t/ha/year

	Bulls	Cows	Heifers	Oxen	Young oxen	Calves
Commercial	2.83	2.32	1.90	2.24	1.29	1.29
Communal	2.10	1.83	1.57	1.82	1.04	1.02

Source: Based on Du Toit *et al.* (2013)

The CO_2 was valued at R120 per ton (National Treasury 2013).

3.2.2 Water footprint

Livestock consumes large quantities of water. The water footprint depends on both the farming system and its efficiency. The overall impact of water in livestock production is influenced by several factors, which include feed intake and diet, quality of available water, temperature of water, and the temperature of the ambient environment (Ran 2010). Table 8 shows the estimates of the water footprint of each of the production systems. The amount of water required to produce 1 kg of beef includes drinking water and water used to produce feed.

RPO & NERPO (2014) recommend an intake of three to four litres of water per kilogram of dry feed intake; therefore, an average of 3.5 litres of water per kilogram dry feed intake is used in calculating drinking water per animal. The intake of commercial cattle ranges from 1.3% to 2.6% of body weight (BW), that of communal cattle from 1.6% to 2.7% of BW, and the intake of feedlot cattle has been estimated at 2.5% of BW (Du Toit *et al*. 2013). For this study, 3% of BW dry matter intake is used in drinking water estimates, as it is a recommended norm. The requirement of feed with a high of energy in feedlots is provided in the form of maize, hominy chop or one of the other grains (Spies 2011). Du Plessis (2003) states that 250 litres of water is needed to produce one maize plant, which is estimated to produce 0.35 kg of maize. A growing animal under a feedlot system with an average weight of 335 kg would drink 35.2 litres per day, and 7 179 litres is needed to produce 10.05 kg dry matter intake (feed) per day. Water has been valued at R2/m^3 (own calculation based on Blignaut *et al*. (2008), adjusted for inflation).

Table 8: Water demand by beef cattle in 2014

Sector	Population	Water use/year (m^3)
Extensive commercial	5 630 000	109 899 498.00
Extensive communal	5 675 600	63 950 106.78
Feedlot	1 350 000	876 470 191.07
Total	12 655 600	1 050 319 796.00

3.2.3 Biomass consumption

Feed efficiency depends on the average daily gain (ADG) and feed conversion ratio (FCR) of an animal. ADG is influenced by the quantity of the feed ration and the quality of the animal on feed (Spies 2011). FCR and ADG were calculated to determine the amount of feed needed to produce 1 kg of beef in different production systems. ADG is computed as the final weight of an animal less its birth weight, divided by the number of days of growth to reach the final weight. The FCR is calculated as the ADG divided by the feed consumption per day. The birth and live weights as per Table 2 were used.

Biomass consumption is valued at R871/ton (own calculation based on Department of Agriculture (Limpopo) (2010), adjusted for inflation).

3.3 Description of the system dynamics model

The calf-production externality model was developed as a system dynamics model in Vensim®. This model distinguishes between two production systems (commercial and communal) and three levels of productivity (good, average and bad). Therefore, a total of six different models were developed. There are also six sub-models: a beef herd dynamics model, a land management transition sub-model, an environmental impact sub-model, an import substitution sub-model, a production sub-model, and an economics sub-model. A copy of the model, as well as a list of equations, constants and endogenous parameters, is available from the authors on request.

3.3.1 Herd dynamics sub-model

A model for beef herd dynamics was developed for each production system. Figure 1 presents the stock flow diagram for the herd dynamics sub-model for a commercial production system. Parameters b1 and c1 to c5 reflect growth rates for the different herd characteristics, as well as a weighting (share) for each component. The values were estimated from available historical time-series data on herd dynamics, and then calibrated using optimisation in order to get the best fit with the historical data.

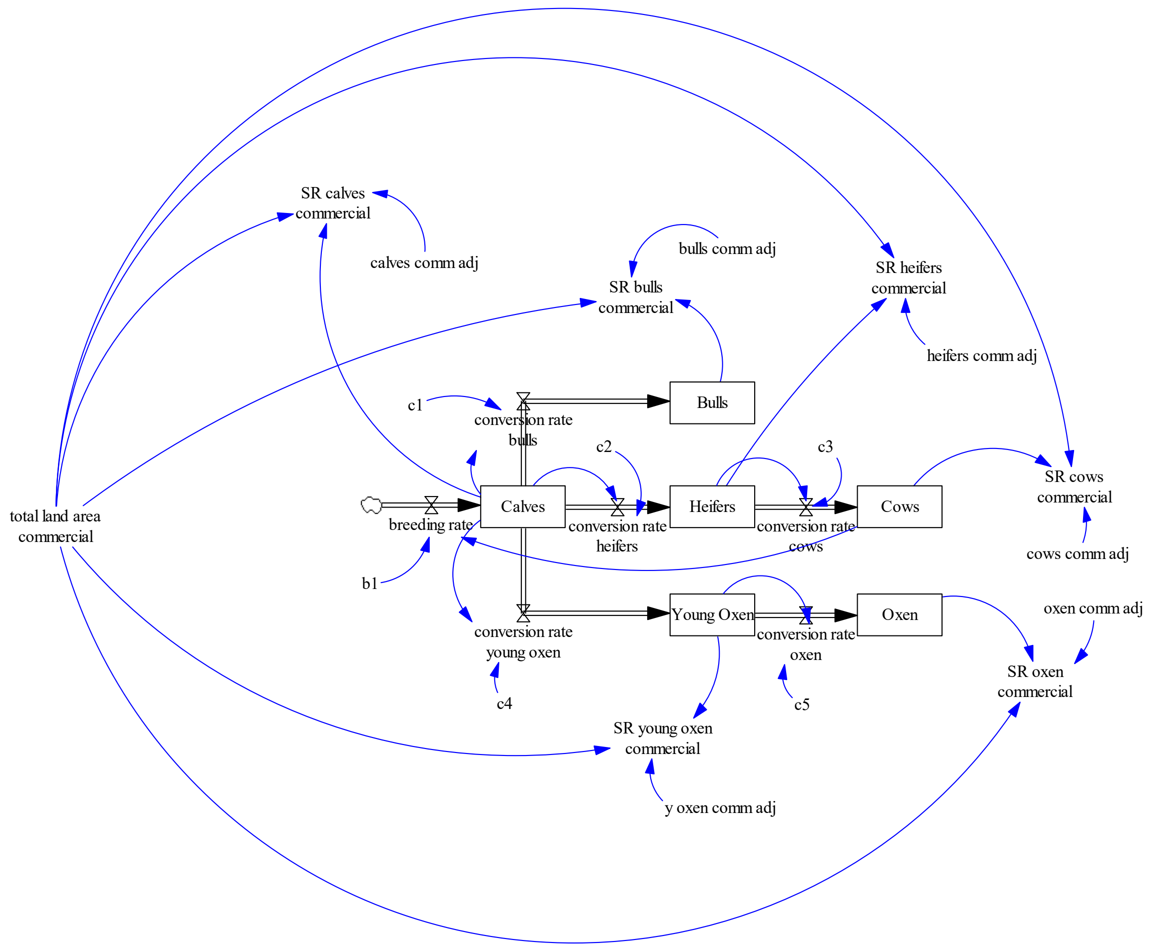

Figure 1: Stock flow diagram for the beef herd dynamics sub-model (commercial production system)

3.3.2 Land management transitions sub-model

Each of the six models, with the exception of the commercial good and average, has a land management transitions component. This model transitions from bad management practices to land management based on the commercial average scenario. The model is developed for three management practices that are assumed to be under the control of the farmer: calf age at marketing, calf daily weight gain, and calf weight at birth. The stock flow diagram for one of these systems is given in Figure 2. For all scenarios that use this land management transition, a transition period of 20 years is modelled.

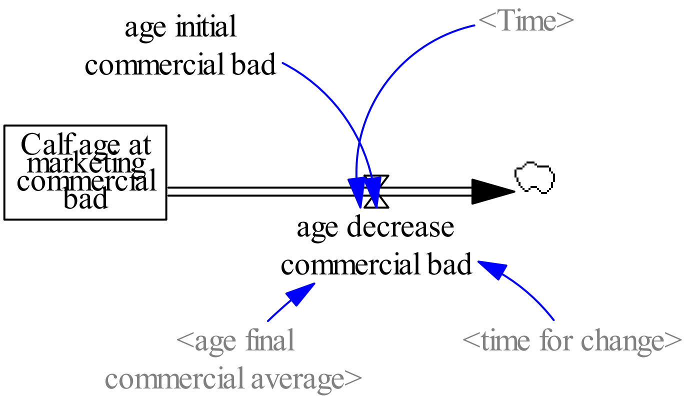

Figure 2: Stock flow diagram for land management transitions of calf age at marketing from commercial bad to commercial average productivity characteristics

3.3.3 Environmental impact sub-model

Three environmental impacts arising from beef production were modelled: methane emissions (converted to CO_2 equivalent), water consumption and biomass consumption. For each class of cattle (bull, heifer, cow, young oxen, oxen), the stocking rate derived from the herd dynamics sub-model was multiplied by the unit value of the environmental impact variable in order to estimate the environmental impact variable per hectare. A similar approach is used for calves, but there is also a function of the age at marketing. The environmental impact of each class of cattle is then summed to get a total environmental impact for each of the six production models. For three environmental impact categories, this means a total of 18 environmental impact sub-models. Figure 3 illustrates the stock flow diagram for one of these 18 models, namely the CO_2-equivalent emissions for the commercial average productivity model.

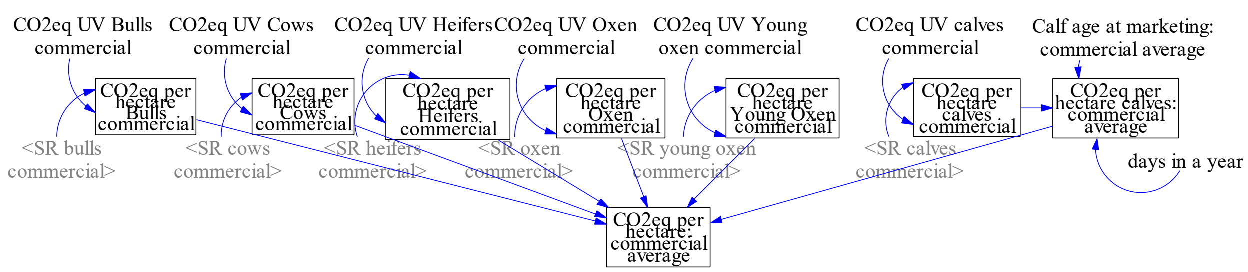

Figure 3: Stock flow diagram for commercial average productivity system (methane emissions)

3.3.4 Import substitution sub-model

Using historical data on local beef production and beef imports, we estimated the elasticity of beef imports to production. It was found that elasticity was -2.52634 (t-statistic = -13.3913, p value < 0.0001, adj. $R^2 = 0.806$, $n = 44$, F statistic model = 179.3), indicating that imports decline with rising domestic production. A number of the scenarios then modelled the effects of an increase in local beef production on net methane emissions, factoring in a decline in "imported" CO_2-equivalent emissions. Figure 4 indicates the stock flow diagram for the import substitution component.

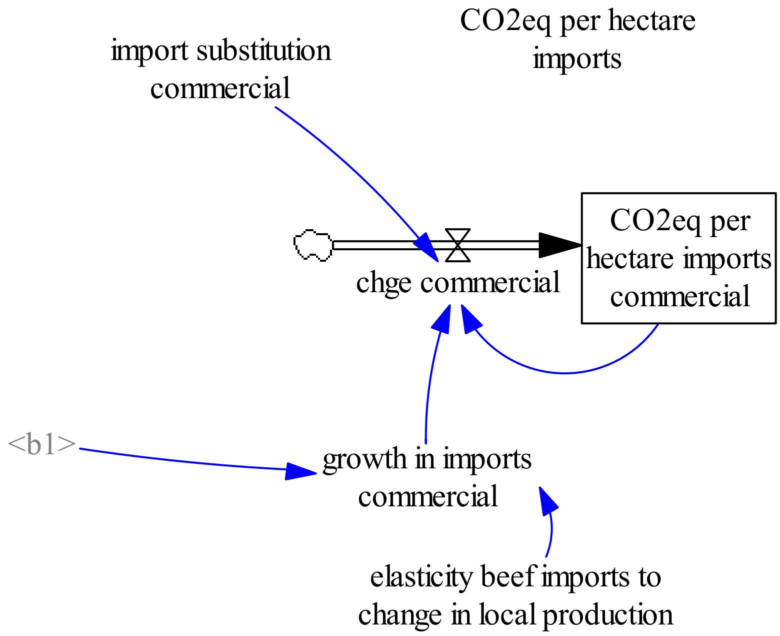

Figure 4: Stock flow diagram for imported commercial methane (CO_2 equivalent)

3.3.5 Production sub-model

The production sub-model estimates the kilograms of meat produced per hectare by multiplying the calf weight at marketing by the stocking rate. The aggregate environmental impact is then expressed as a proportion of kilograms of meat produced for each of the six productivity models (commercial and communal; and average, good and bad for each). Figure 5 indicates the stock flow diagram for one of these productivity models.

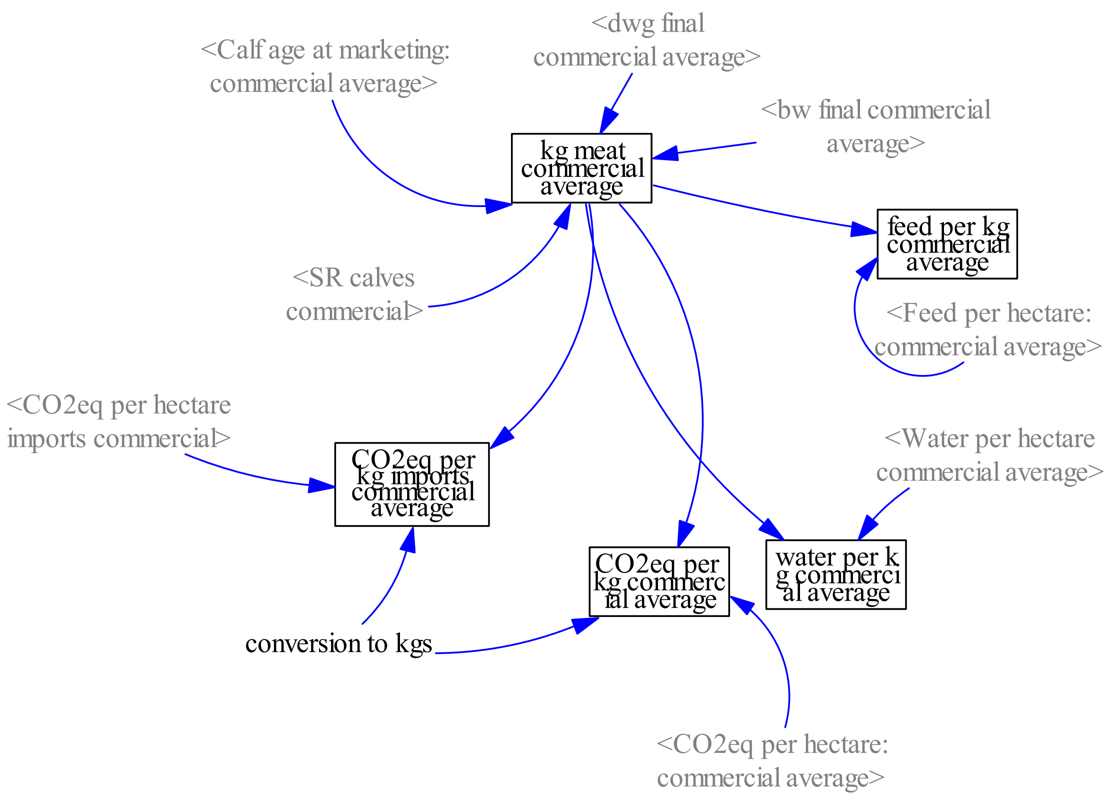

Figure 5: Stock flow diagram for the production sub-model (commercial average productivity model)

3.3.6 Economics sub-model

The economics sub-model estimates the net present values of the revenue streams from the sale of calves to feedlots, and compares this with the total environmental impact for each of the six productivity systems (commercial average, good and bad, and communal average, good and bad). The price of weaners, according to the historical data, increased exponentially between 1971 and 2014 (Figure 6). Some of the scenarios therefore modelled an increase in weaner price over the 30-year period of the model (2014 to 2044). Water and CO_2 values have remained relatively constant in recent years, and therefore remain unchanged in the model. Biomass prices, on the other hand, have fluctuated over the past 10 years. We used the 2013 producer price index for field crops as a proxy for changes in biomass prices, which are based on the latest available published data.

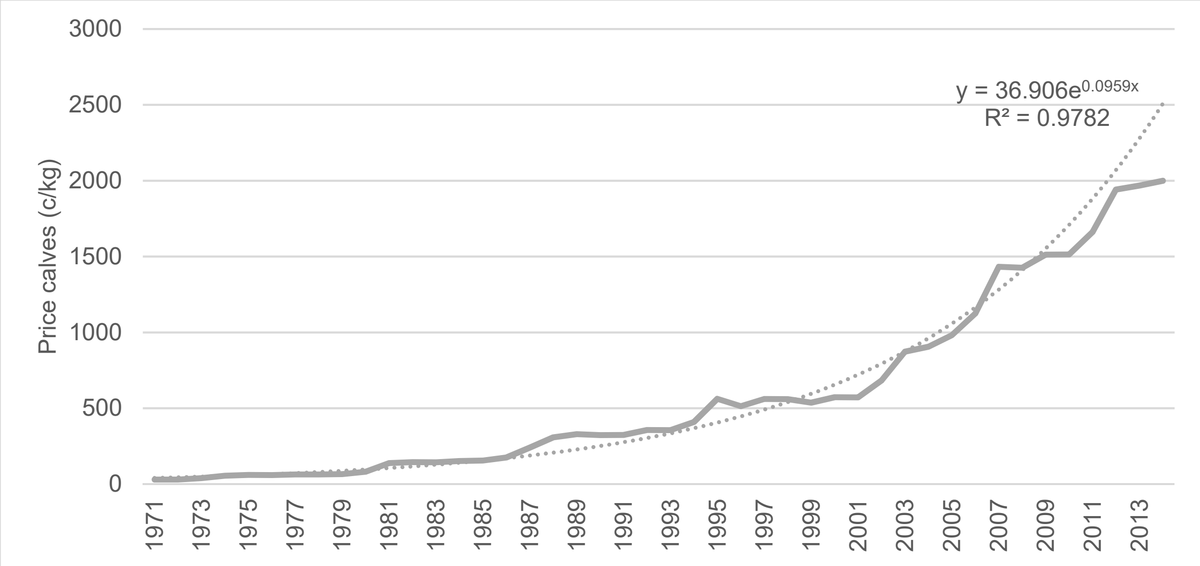

Figure 6: Increase in weaner price between 1971 and 2014
Source: DAFF (2014)

3.3.7 Scenarios

Five scenarios were modelled in this study (see Table 9) – a baseline scenario and four others. The baseline scenario (s0) assumes no change in parameters, while the realistic scenario (s1) models marginal changes in production, prices and production characteristics. The optimistic scenario (s2) models greater production growth and cost savings as improved management interventions take effect. The pessimistic scenarios (s3), on the other hand, models production growth in line with the realistic scenarios, but no improvements in management practices and therefore no cost savings. Finally, the alternative scenario (s4) models strong production growth, cost savings and improved management practices.

Table 9: The five scenarios modelled in the study

Scenarios
s0: Baseline scenario No change in either production or imports over time. The composition and size of both commercial and communal herds are kept constant and there is no adoption of sustainable farming practices, nor any change in production characteristics.
s1: Realistic scenario Production growth at 4% and import substitution at 1.6% in both commercial and communal herds. Herd composition follows historical trends. Calf sale values and input costs increase in accordance with historical data. Change in production structure over 20 years, thereafter constant.
s2: Optimistic scenario Production growth at 11% and import substitution at 4% in both commercial and communal herds. Calf sale values increase in accordance with historical data. Increases in fodder price decrease by 50% from 9.7% to 4.85% as better management of the land results in efficiency gains. No change in production characteristics.
s3: Pessimistic scenario Production growth at 4% and import substitution at 1.6% in both commercial and communal herds. Herd composition follows historical trends. Calf sale values and input costs increase in accordance with historical data. No change in production characteristics.
s4: Alternative scenario Production growth at 11% and import substitution at 4% in both commercial and communal herds. Calf live weight values increase in accordance with historical trends. Increases in fodder price decrease by 50% from 9.7% to 4.85% as better management of the land results in efficiency gains. Change in production structure over 20 years, thereafter constant.
Discount rate = 4%

4. Results

4.1 A static analysis

Based on the farming profiles provided in Table 2 and the subsequent indicators and assumptions discussed above, the environmental impact per farming system was estimated and the results are displayed in Tables 10 and 11.

Table 10: Estimated total farm-level life-cycle environmental impact per farming system[1]

	Total CO_2 equiv.	Total water consumption	Total feed consumption	Total environmental impact	Income hectare	Net income	kg meat @ market age/ha	kg CO_2/ kg meat @ market age	litre water/kg meat @ market age	kg feed/ kg meat @ market age
	ton/ha/yr	l/ha/yr	kg/ha/yr	R/ha/yr	R/ha/yr	R/ha/yr	kg meat/ ha	ratio	ratio	ratio
Farm 1	0.394	2 869.1	797.7	747.8	351.9	-395.95	17.6	22.4	163.1	45.3
Farm 2	0.465	3 402.4	945.8	886.3	457.4	-428.92	22.9	20.3	148.8	41.4
Farm 3	0.323	2 341.5	651.3	610.8	246.3	-364.45	12.3	26.2	190.1	52.9
Farm 4	0.394	2 879.4	800.8	750.5	232.5	-518.06	13.7	28.8	210.6	58.6
Farm 5	0.477	3 457.8	963.7	903.5	318.1	-585.35	18.7	25.5	184.8	51.5
Farm 6	0.319	2 353.4	652.4	611.1	154.2	-456.98	9.1	35.1	259.5	71.9
Farm 7	0.544	3 756.9	1 087.0	1 019.6	162.8	-856.82	9.6	56.8	392.4	113.5
Farm 8	0.460	3 197.6	925.8	867.9	171.3	-696.61	10.1	45.7	317.3	91.9
Farm 9	0.514	3 543.6	1 024.6	961.2	107.9	-853.29	6.3	81.0	558.1	161.4
Farm 10	0.599	3 993.4	1 157.0	1 087.6	325.7	-761.90	19.2	31.2	208.5	60.4
Farm 11	0.428	2 952.1	854.2	801.3	301.7	-499.64	17.7	24.1	166.4	48.1
Farm 12	0.590	3 968.2	1 146.9	1 077.7	246.8	-830.91	14.5	40.6	273.3	79.0

1. Farms 1 to 3 represent typical average, good and bad commercial operations, Farms 4 to 6 represent typical average, good and bad emerging farmers' operations, Farms 7 to 9 represent typical average, good and bad communal farmers' operations, and Farms 10 to 12 represent typical average, good and bad national-level operations.

Table 11: Comparative analysis among the different beef production systems relative to the national average system[1]

	% of kg meat produced/ha	% of CO_2 produced/ha	% of water cons./ha	% of feed cons./ha
Farm 1	92%	72%	78%	75%
Farm 2	119%	65%	71%	68%
Farm 3	64%	84%	91%	88%
Farm 4	71%	92%	101%	97%
Farm 5	98%	82%	89%	85%
Farm 6	47%	112%	124%	119%
Farm 7	50%	182%	188%	188%
Farm 8	53%	146%	152%	152%
Farm 9	33%	259%	268%	267%
Farm 10	100%	100%	100%	100%
Farm 11	93%	77%	80%	80%
Farm 12	76%	130%	131%	131%

1. Farms 1 to 3 represent typical average, good and bad commercial operations, Farms 4 to 6 represent typical average, good and bad emerging farmers' operations, Farms 7 to 9 represent typical average, good and bad communal farmers' operations, and Farms 10 to 12 represent typical average, good and bad national-level operations.

The relative difference in the productive efficiency and environmental impact among the 12 farming systems, derived from Table 10 and expressed relative to Farm 10 (the national average production system), is shown in Figure 7.

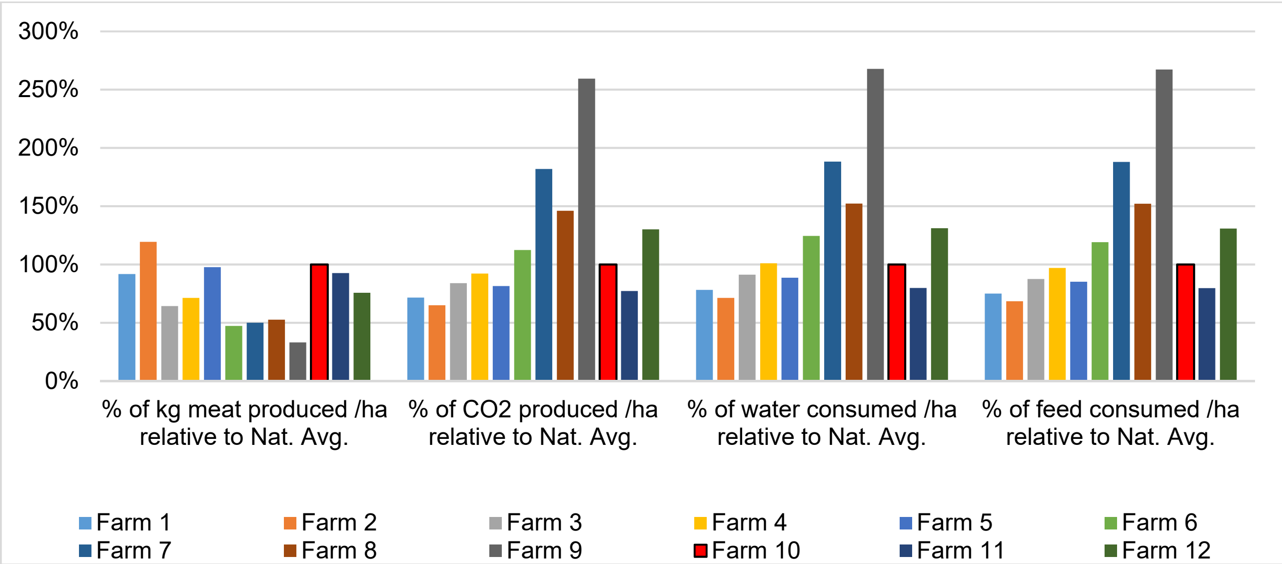

Figure 7: Comparison of the productive efficiency and environmental impact among 12 different farming systems, with Farm 10 (national average) = 100

4.2 A dynamic analysis

From Figure 8 it can be seen that there are very large disparities among the marginal values of producing a kilogram of meat for each of the five scenarios among the six production systems, as represented by differences in the net present values thereof. The net present value represents the discounted net difference (over 30 years) between the value of the calf sales and the value of the environmental impact. As presented in Section 4.1 (Table 10), all the net values were negative, which indicates that the environmental impact exceeds the value of the calf sales. A dynamic analysis makes it clear that, under certain conditions, the values can become positive (under the optimistic and alternative scenarios). The risk, however, lies in the bad communal management practices, where the marginal net present value of producing a kilogram of meat can be as low as -R11 000. However, it has the potential to be -R335, as depicted under the national scenario.

Both the commercial and communal herd managers therefore have to change their prevailing management practices to reduce the current net environmental loss, but the risks among communal farming practices are far greater.

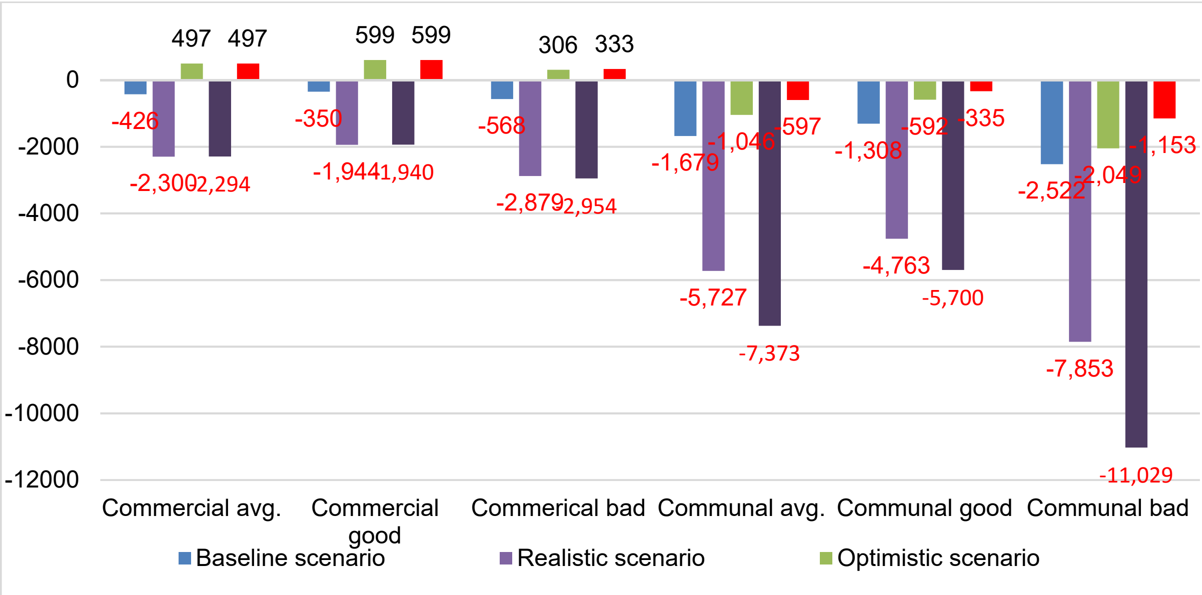

Figure 8: Comparison of net present value (R/kg meat produced over 30 years) among six production systems under five scenarios

5. Discussion and policy implications

The farm management system applied to produce calves does matter when environmental impacts are measured, with further implications for the long-term profitability and sustainability of the sector. The issues to consider are as follows:

- A better average daily gain and feed conversion ratio shortens the time period for a calf to become market-ready, and hence lowers the environmental impact.
- A lower mortality rate and higher calving percentage means more calves and thus more meat produced per cow per unit of environmental impact and per hectare.
- Fewer unproductive animals per hectare (i.e. non-breeding animals such as oxen, bulls and unproductive cows) lowers the environmental impact per unit of beef produced and ensures a more sustainable system.

To rectify the situation requires the following, among others:

- An improvement of the genetic material.
- Improved grazing management, including aspects such as stocking rates and grazing patterns, to allow for soil and veld recovery and enhanced productivity.
- Better cow selection and disease control methods to avoid high mortality rates and improve calving percentages.
- The introduction of formal breeding seasons to avoid cows having calves in winter.

The above can be achieved by, among others, the following actions:

- Appoint dedicated extension officers to the beef sector who can assist commercial, emerging, small and communal cattle farmers in improving the health and genetic quality of the livestock, disease control, grazing management and breeding patterns.
- Improve the general understanding of environmental impact and sustainability of the various farming systems through mechanisms such as social media, publications, conferences and farmers' days.

- Define the various institutional arrangements, especially among communal farmers in rural areas, and strengthen the cattle management systems.
- Manage stock theft as a matter of priority to allow better use of grazing resources.
- Invest in good infrastructure such as dip tanks, roads and marketing support.
- Restore the soils to improve the net primary production of the veld.

References

Blignaut JN, Aronson J, Mander M & Marais C, 2008. Restoring South Africa's Drakensberg Mountain ecosystems and providing water catchment services. Ecological Restoration 26(2), 143–50.

Corbet NJ, Shepherd RK, Burrow HM, Prayaga KC, Van der Westhuizen J & Bosman DJ, 2006. Evaluation of Bonsmara and Belmont red cattle breeds in South Africa. 2. Genetic parameters for growth and fertility. Australian Journal of Experimental Agriculture 46, 213–23.

DAFF, 2014. Newsletter: National Livestock Statistics, Estimated livestock numbers in the RSA (August 2013 and February 2014). Pretoria: DAFF.

DAFF, 2015. Abstract of agricultural statistics. Pretoria: DAFF.

Department of Agriculture (Limpopo), 2010. Enterprise budget for beef cattle in Limpopo. Limpopo: Department of Agriculture.

Dick M, Da Silva MA & Dewes H, 2014. Life cycle assessment of beef cattle production in two typical grassland systems of southern Brazil. Journal of Cleaner Production 96, 426–34.

Du Plessis, J. 2003. Maize production. Pretoria: DAFF.

Du Toit CJL, Meissner HH & Van Niekerk WA, 2013. Direct methane and nitrous oxide emissions of South African dairy and beef cattle. South African Journal of Animal Science 43(3), 320–39.

Hoffmann WH, 2010. Farm modelling for interactive multidisciplinary planning of small grain production systems in South Africa. DPhil dissertation, Department of Agricultural Economics, Faculty of AgriSciences, Stellenbosch University, Stellenbosch, South Africa.

IPCC, 2007. Climate change 2007: Synthesis report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. Geneva: IPCC.

Mapiye C, Chimonyo M & Dzama K, 2009. Seasonal dynamics, production potential and efficiency of cattle in the sweet and sour communal rangelands in South Africa. Journal of Arid Environments 73, 529–36.

Meissner HH, Scholtz MM & Palmer AR, 2013. Sustainability of the South African livestock sector towards 2050. Part 1: Worth and impact of the sector. South African Journal of Animal Science 43(3), 282–97.

Muchenje V, Dzama K, Chimonyo M, Raats JG & Strydom PE, 2008. Meat quality of Nguni, Bonsmara and Aberdeen Angus steers raised on natural pasture in the Eastern Cape, South Africa. Meat Science 79, 20–8.

National Treasury, 2013. Carbon tax policy paper: Reducing greenhouse gas emissions and facilitating the transition to a green economy. Available at http://www.treasury.gov.za/public%20comments/Carbon%20Tax%20Policy%20Paper%202013.pdf (Accessed 10 December 2014).

Picasso D, Modernel PD, Becoña G, Salvo L, Gutiérrez L & Astigarraga L, 2014. Sustainability of meat production beyond carbon footprint: A synthesis of case studies from grazing systems in Uruguay. Meat Science 98, 346–54.

Ran Y, 2010. Consumptive water use in livestock production – Assessment of green and blue virtual water contents of livestock products. Thesis, University of Gothenburg, Gothenburg, Sweden.

RPO & NERPO, 2014. Codes of good practice for sustainable and profitable red meat production. Available at http://www.rpo.co.za/Portals/315/Kode%20van%20Beste%20Praktyke/RPO-NERPO_Code_of_Best_Practice.pdf (Accessed 19 May 2015).

SAFA, 2015. Association history. Available at http://www.safeedlot.co.za/index.asp?Content=90 (Accessed 19 May 2015).
Scholtz MM & Bester J, 2010. The effect of stock theft and mortalities on the livestock industry in South Africa. Applied Animal Husbandry & Rural Development 3, 15–8.
Scholtz MM, Maiwashe A, Neser FWC, Theunissen A, Olivier WJ, Mokolobate MC & Hendriks J, 2013. Livestock breeding for sustainability to mitigate global warming, with the emphasis on developing countries. South African Journal of Animal Science 43(3), 269–81.
Scholtz MM, Theunissen A, Frylinck L & Strydom PE, 2014. Beef cattle management and systems development for optimal production. Report submitted to the Department of Agriculture, Land Reform, and Rural Development, Northern Cape Government, South Africa.
Spies DC, 2011. Analysis and quantification of the South African red meat value chain. PhD thesis, University of the Free State, Bloemfontein, South Africa.
Strydom PE, Frylinck L, Van der Westhuizen J & Burrow HM, 2008. Growth performance, feed efficiency and carcass and meat quality of tropically adapted breed types from different farming systems in South Africa. Australian Journal of Experimental Agriculture 48, 599–607.
Subak S, 1999. Global environmental costs of beef production. Ecological Economics 30, 79–91.