Eco-efficiency Assessment of Pork Production Through Life Cycle Assessment and Product System Value in South Africa

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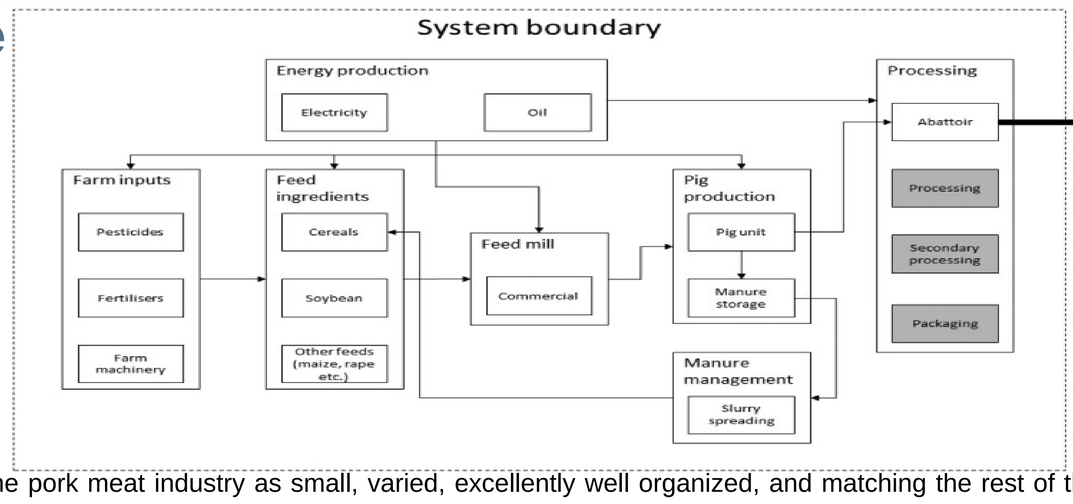
Introduction and Objectives

Worldwide, pork consumption has increased as a supply of animal protein in the developed and developing countries such as South Africa. The expanding interest in pig products is expected to bring extra pressure on natural resources, as water and land are needed to produce pork. There is a growing demand to determine the sustainability of products systems, not only from their environmental performances, but also from the point of view of their economic performance. Eco-efficiency (as a tool) is gaining attention to complement and integrate environmental performance studies. The eco-eco-efficiency framework (ISO 14045 standard), eco-efficiency is a sustainability tool that relates a product system's environmental performance to its value. The main goal of this research project was to determine the baseline eco-efficiency of pork production in South Africa provide insights on eco-efficiency and recommendations to decision-makers. The developed approach, made use of consolidated methodologies based on relevant ISO standards

Pork production Life Cycle



The South African Pork Association (SAPPO) identifies the pork meat industry as small, varied, excellently well organized, and matching the rest of the world's processing outputs. The pork value chain in South Africa is complex. Various vertical integration levels make it extremely hard to identify a specific supply chain that spans the entire industry at various supply chain stages. The process of pork production relates to different physiological stages throughout the life of pigs. Each phase has various stages throughout the growth of pigs, and all these stages require different resources, and the economic and environmental impacts of pigs differ in every phase.This research was focused on assessing the environmental and economic performance of pork production in South African production from farm to abattoir gate.

Eco-efficiency Assessment (LCA/LCC) method

This research's eco-efficiency assessment was performed according to the principles established by ISO 14045 (ISO, 2012) framework as shown in the Figure 1 below. The ISO 14045 (2012) framework for eco-efficiency concept requires that assessment follow LCA methodology in combination with a product system value. Eco-efficiency assesses a product's **environmental, economic impacts** from raw material extraction and product development through to the product's use and final disposal, or in other words, **from the 'cradle to the grave'**. The life cycle environmental performance was determined by the ReCiPe 2016 & IMPACT 2002 methods through Simapro 9.0 version with eco-invent 3.5 database. To determine the economic performance, the Society of Environmental Toxicology and Chemistry (SETAC) code of practice for environmental life-cycle costing (LCC) was used. To quantify eco-efficiency results, equation 1 was used .

Eco-efficiency assessments assists the decision-maker during their evaluation of a product's life cycle by:

- recognising and comparing the **risks and trade-offs between possible impacts and benefits**;
- supporting a **holistic assessment**;
- and facilitating **discussion between diverse stakeholders**.

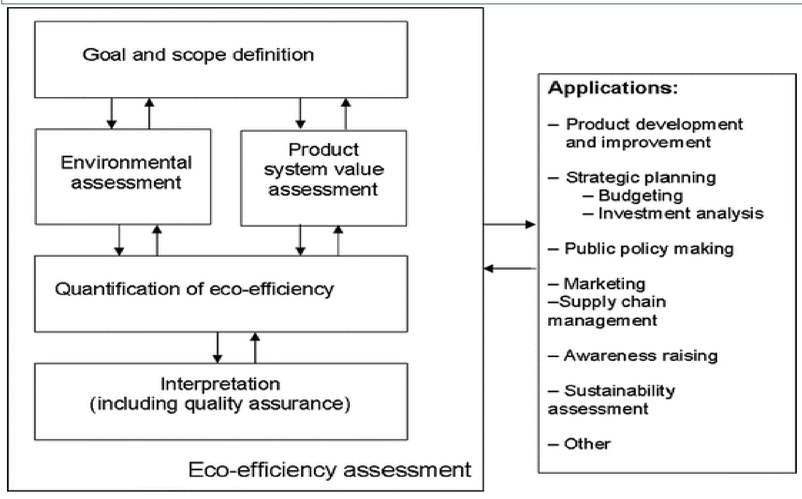


Figure 1. Eco-efficiency assessment framework

Results of Eco-Efficiency of Pork Production

The environmental hotspots in this study were found to be electricity and feed production. Electricity and feed production contributed around 64% for non-renewable use of fossil energy use. The electricity generation and usage alone contributed around 34% and maize 31%..

The economic hotspots for the entire pork product system costs were attributed to animal feed production at the farm subsystem. The feed costs contributed more than 75% of the total costs at the farm. The other costs were attributed to energy, water, and veterinary costs. At the abattoir subsystem, live pigs were the highest cost, followed by utilities such as energy (electricity, coal, and gas) and water, and then labour and cleaning chemicals.

The study results showed that the pork meat production system results of eco-efficiency for the Human Health environmental impact indicator: 5.61x10-07 DALY/ ZAR/units. The results for the Eco-system quality impact indicator were 2. 84x10-09 Species.yr/ ZAR units. The results for the Resource Availability were 1.05x10-02 USD 2013/ ZAR.

$$Eco - efficieny = \frac{environmental\ performance}{product\ or\ system\ value} \quad (1)$$

Eco-efficiency equation 1

Table 1. Eco-efficiency scores Results

End-point	Eco-scores	Units	Value Added	Eco-efficiency Scores	Units
Human Health	$9.63*10^{-06}$	DALY	R17,16	$5.61*10^{-07}$	DAILY/ZAR
Eco-system	$4.87*10^{-08}$	Species.yr.	R17,16	$2.84*10^{-09}$	Species.yr/ ZAR
Resources Availability	$1.81*10^{-01}$	USD2013	R17,16	$1.05*10^{-02}$	USD 2013/ ZAR

Conclusions

1. The findings indicated that the pig farm and abattoir were processes where eco-efficient strategic improvements could be made.
2. Mitigation strategies should be developed to concentrate on (1) animal feed production and, (2) use of renewable energy sources at the abattoir and (3) lastly turn generated waste into valuable products throughout the value chain (circular economy).
3. The use of water could be improved by automating the abattoir processes.
4. Recommendation is that it could also be valuable to consider a socio-economic scenario for the same framework to address the 3rd pillar of sustainability.
5. The study not only provided results of the pork meat production -, but it shows the potential to be replicated to other products' systems (not limited to meat sector only).