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Systematic eco-efficiency assessment of pork meat production through life cycle assessment and product system value

Qalase, Chule

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ABSTRACT

Pork consumption has increased as a source of animal protein worldwide – in the first world and developing countries such as South Africa. The expanding interest in pig products increases the pressure on natural resources as water and land are needed to produce pork. This study's main goal was to evaluate the pork product system's sustainability through an eco-efficiency assessment based on pork's growing demand.

Two sustainability tools, namely life cycle assessment and environmental life cycle costing, were used to determine pork production subsystems' economic and environmental performances and thus the product system's eco-efficiency. The ratio of three environmental damages – human health, ecosystem quality, and resource availability against the value-added as an economic performance indicator – was used to calculate this study's eco-efficiency. This study specifically used a functional unit of 1 kg of pork carcass from the cradle to the farm gate. These results were determined using the ReCiPe 2016 and Impact 2002 methods through SimaPro 9.0 version with the ecoinvent 3.5 database.

The pork production showed significant environmental impacts: non-renewable energy use was 36.46 MJ, global warming potential was 4.03 kg CO_2-eq, and terrestrial ecotoxicity was 2.85 kg 1,4-DCB. Pork production contributed to freshwater and terrestrial eutrophication of 0.86 g P-eq, fossil resource scarcity of 0.75 kg oil-eq, and terrestrial acidification of 0.16 g SO_2-eq. Other impact categories were land use of 5.8 m^2a crop-eq, marine eutrophication of 4.55 g N-eq, and water consumption of 1.98 m^3. The results revealed that the most significant environmental impacts are from feed production, manure management and, lastly, from the equipment's electric energy at the farm abattoir.

The cost of producing 1 kg of pork from the farm gate was ZAR22.04. The total cost of producing 1 kg of pork from the farm to the abattoir gate was ZAR35.70. The value add of pork was calculated to be ZAR17.17/kg for the entire pork meat production system.

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's eco-efficiency result for the human health environmental impact indicator was 5.61×10^{-07} DALY/ZAR/units. Theresult for the ecosystem quality impact indicator was 2.84×10^{-09} species. yr/ZAR units. The result for resource availability was 1.05×10^{-02} USD2013/ZAR. The findings indicatedthat the pig farm and abattoir were processes where eco-efficient strategic improvements could be made. Mitigation strategies should be developed to concentrate on animal feed production and use renewable energy sources at the abattoir. The use of water could be improved by automating the abattoir processes.

Therefore, this study achieved its goal as it identified economic and environmental areas of interest in this specific case study for South Africa. This framework could be extended to study the eco-efficiency of other meat production chains as well as other sectors.

Keywords: Life Cycle Assessment; Pork Production; Sustainability; Natural Resources; Eco-efficiency, Life Cycle Costing.