Current Approaches of Beef Cattle Life Cycle Assessment: Fact Sheet

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Introduction

The U.S. beef industry has important impacts on the economy and ecosystem services, and contributes to essential societal needs for food and fiber. According to the USDA Economic Research Service (ERS), the total U.S. beef consumption in 2012 was 25.8 billion pounds, and the retail equivalent value of the U.S. beef industry was $85 billion. As public concern about climate change and environmental sustainability continues to grow, the beef industry faces societal pressures to reduce its environmental impact. Beef production in the United States is one of the many contributors to the total greenhouse gas (GHG) inventory. In an attempt to determine if the public's concerns are justified, life cycle assessment (LCA) is utilized to quantify GHG emissions and make comparisons across products from a variety of sectors.

Life cycle assessment is a method of analyzing the environmental impacts of a given product by accounting for all the impacts that occur along the full chain. Most LCAs have focused primarily on GHG emissions, though there is increased interest in other life cycle environmental impacts, as well as social and economic impacts. For beef cattle production, a full LCA would account for all impacts due to feed production (e.g. emissions from soil, fossil fuel combustion in farm equipment), the cattle (e.g. enteric fermentation, manure emissions), processing and transportation (e.g. emissions from packing plants, fossil fuel combustion from trucks), and secondary emission sources (e.g. emissions from the production of fertilizer).

While the International Organization for Standardization (ISO) has set guidelines for LCAs, considerable variation exists in the goals, scale and scope of published LCAs of beef systems. *Current Approaches of Beef Cattle Systems Life Cycle Assessment: A Review* is a published white paper outlining the major areas of LCA methodology and the variable LCA approaches that should be considered before comparing across beef LCA results. Additionally, the review highlights the different methods used to estimate environmental impacts and emphasizes the unique role process-based models can play in reducing the error associated with LCA results. Currently, few LCAs integrate process-based models when assessing animal systems.

Finally, the review underscores how both production efficiency and food waste can potentially impact the life cycle impacts of the beef value chain and recommends future LCAs consider including these components into their assessments.

Variation in LCA Methodologies

Life cycle assessments can quantify the environmental impact of the beef value chain and provide a method of identifying mitigation options suited to reduce those environmental burdens (Beauchemin and McGeough, 2013). The process of a LCA is generally composed of four components: 1. Goal and scope, 2. Life cycle inventory analysis (LCI), 3. Life cycle impact assessment (LCIA) and 4. Interpretation. Creating a LCI of emissions to the environment (e.g. GHG emissions) for an animal agricultural system, such as a beef cattle system, is

challenging. The diversity of management systems across operations and segments of the industry, as well as the biogeochemical processes involved, contribute to the challenges of creating LCI analyses.
The purpose of the white paper is to assess the current LCA methodologies being used in analyses of the beef industry and to compare the complexity and variation between LCA studies. This review addresses areas of current LCA methodologies that are lacking in information to account for the variety of factors that affect beef system inputs and outputs.

Life cycle assessment is essentially an environmental accounting system that sums emissions to the environment (e.g. GHG emissions) across an entire production chain of a product of interest (e.g. beef), including both direct (e.g. enteric methane emissions from cattle) and indirect (e.g. GHG emissions associated with fertilizer production) emissions sources (Rotz and Veith, 2013). The International Organization for Standardization has developed international standards (i.e. ISO 14040 series) for conducting LCAs based on the consensus of stakeholders around the world (Finkbeiner et al., 2006). The method has been adapted from its original use in industrial operations for a wider range of applications including agriculture (Caffrey and Veal, 2013). Beauchemin and McGeough (2013) outline the four phases of a LCA as the following:

1. Goal and scope – Identifying the goal and intended use of the LCA. These considerations set the system boundary of the LCA and determine what will be included and the level of detail needed.
2. Life cycle inventory analysis (LCI) – The inventory includes the collection of input and output data necessary for the LCA.
3. Life cycle impact assessment (LCIA) – The impact assessment explains the environmental implications of the results to the environmental issue(s) of interest.
4. Interpretation – Based on the original goal, the interpretation provides conclusions and recommendations discovered in the LCA.

The four phases outlined create a basic methodology for all LCAs. However, variation regarding the goal, scope, system boundaries and functional unit considered within each LCA still exist (Beauchemin and McGeough, 2013). Differences in LCA approaches generate uncertainty during the comparison of results across LCAs. In an attempt to harmonize LCA methodology in the livestock sector, the Livestock Environmental Assessment and Performance Partnership (LEAP), a collaborative effort of stakeholders from governments, non-governmental organizations and the private sector, released draft guidelines regarding LCAs for feed supply chains, small ruminants and poultry production in early 2014 with plans to release guidelines for large ruminants in the near future. The sector-specific methodology provides five principles that guide users through assessments of GHG emissions and other environmental impacts (LEAP, 2014). The guiding principles include relevance, completeness, consistency, accuracy and transparency (LEAP, 2014). However, the LEAP LCA guidelines have yet to be finalized and widely adopted. The white paper characterizes the ambiguities of LCA methods and results in the published literature for the beef value chain.

Food Waste

Currently, approximately 20% of edible beef is wasted in the United States (USDA, 2011). Losses at the consumer, retail and foodservice portion of the beef supply chain mean all resource use, economic costs and environmental impacts incurred earlier in the product chain have not contributed to human nutrition. Cuéllar and Webber (2010) concluded that the energy wasted in U.S. food waste (across all foods, not only beef) was greater than the amount of energy generated from the conversion of grains into ethanol. As most beef LCAs are not full cradle-to-grave (e.g. consumer) assessments, the impacts of food waste on the life cycle impacts of beef typically go unreported. Beyond simply reducing food waste, recycling food waste into waste streams other than landfills (e.g. anaerobic digestion) may reduce environmental impacts. Considering the challenges of feeding a growing world population with finite resources, reducing and recycling food waste may be an important strategy in sustainably meeting increased demand for animal protein.

Conclusion

Life cycle assessment is a powerful tool for evaluating the environmental impacts of producing beef.
While most published LCAs focus solely on GHG emissions, expanding the impacts considered to other environmental emissions, such as reactive nitrogen, and economic and social concerns will likely improve the usefulness of LCAs. When comparing results across

beef LCAs, consideration should be given to differences in geographic location, system boundaries, allocation methods, functional units and the methodologies used to estimate environmental impacts. Ignoring the considerations above could lead to inappropriate comparisons and conclusions. Future LCAs of beef production should increase the use of process-based models that have been evaluated with experimental data when building input and output inventories.

Expanding the use of process-based models is recommended because of the spatial and temporal variability of resource use and environmental emissions generated from beef production, due to the biogeochemical processes involved. Furthermore, increased consideration should be given in LCAs to aspects of the pre-farm gate supply chain that impact the production efficiency of beef, as there may be opportunities to improve economic, social (i.e. animal welfare) and environmental sustainability in concert. More full 'cradle-to-grave' LCAs of beef are needed to assess the impacts of food waste and identify the potential impacts of reducing or recycling food waste. In conclusion, further strengthening the abilities of LCAs to capture the dynamic nature of the beef industry and harmonizing methods across LCAs will likely improve the accuracy of estimates and lead to more reporting of the uncertainties associated with results.

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