Institution: 10007822

Unit of Assessment: 6

Title of case study: Supporting Food Production Policy through Life Cycle Assessment (LCA)

1. Summary of the impact

Cranfield's research on LCA has informed public debate ranging from ministerial statements to popular science books, underpinned public policy development in the UK and Europe, and provided major contributions to Foresight initiatives. Extensive LCA using advanced integrated systems approaches has led to quantification of environmental burdens and impacts, including greenhouse gas emissions, from production systems such as livestock, arable crops and from changes in land use. The models underpinning these LCA are available publicly and been downloaded by over 800 users across the globe.

2. Underpinning research

Cranfield's Life Cycle Assessment (LCA) led by Audsley and Williams, has pioneered advanced integrated systems approaches to quantification of the environmental burdens and impacts arising from the production of agricultural commodities and products. Such systems-based agricultural LCA has estimated the environmental performance of production systems and supported evaluation of the complex interactions in food systems, providing insights into how they can be improved. This research initially developed LCAs for ten agricultural commodities [1] (supported by Defra project ISO222), immediately prior to and following the research group's transfer from BBSRC to Cranfield in 2006. Since 2006, the research has expanded rapidly to over 20 projects from Defra, the CCC, industry and NGOs.

The research has integrated LCA models of production systems for milk, beef and lamb with models of the interaction between livestock population structures and their land and feed requirements. This has enabled advanced analysis of options for optimal grassland use in relation to societal goals such as the mitigation of greenhouse gas (GHG) emissions (GHGE).

Ground-breaking approaches using integrated systems LCA modelling with resource modelling (notably nitrogen), has produced dynamic models [1] which are able to calculate yield and protein concentrations (e.g. 13% required for bread-making wheat) as a function of available nitrogen supply. Such models can identify the nitrogen supply causing GHGE for a given land area [2]. Integrating LCA with land use change has enabled the modelling of the effect of demand on land use, production and GHGE.

These approaches provide benefits through the flexibility in the questions which can be addressed and rigour in assessing complex systems effects. For livestock systems, this means that they are modelled with animal production parameters such as fecundity and growth rate, which are linked functionally. Thus for example, increasing egg yield demands more metabolisable energy, which increases feed inputs, excretion and all consequent environmental burdens [3].

This approach has been extended to the analysis of commodities from the UK and abroad [4] and delivering Life Cycle Inventory values where data are missing [5], such as in assessing the benefits of improving animal genetics independently of management and nutrition. This research has also been applied outside of typical questions, such as in providing insights into farm energy use from Farm Business Survey data, quantifying energy in the agri-food system for Foresight, and in identifying production limits set by national emission ceilings as a result of production options and technologies. By using national food consumption as a functional unit [6], the consequences of changing diets and other behavioural changes on food-related GHGE have also been explored. This work included the first ever consumption-orientated inventory of GHGE from the entire UK food system.

Key staff	Post	Dates	Research
Eric Audsley	Principal Research Fellow	Nov 2005–present	Agricultural systems modelling; harmonisation of agricultural LCA
Dr Adrian Williams	Senior to Principal Research Fellow	Dec 2005–present	Environmental and agricultural science, LCA

3. References to the research

1. Williams A G, Audsley E, Sandars, D L (2006). Final report to Defra on project IS0205: Determining the environmental burdens, resource use in the production of agricultural, horticultural commodities. Department for Environment, Food, Rural Affairs (Defra): London. http://tinyurl.com/DefraIS0205FinalReport (175 journal paper citations)
2. Williams, A.G.; Audsley, E.; Sandars, D.L. (2010) Environmental burdens of producing bread wheat, oilseed rape and potatoes in England and Wales using simulation and system modelling *International Journal of Life Cycle Assessment*, 15 (8), 855-868. doi: 10.1007/s11367-010-0212-3
3. Leinonen, I., Williams, A.G., Waller, A.H., Kyriazakis, I. (2013) Comparing the environmental impacts of alternative protein crops in poultry diets: The consequences of uncertainty. *Agricultural Systems*, 121, 33-42. doi 10.1016/j.agsy.2013.06.008
4. Webb, J., Williams, A.G., Hope, E., Evans, D. and Ed Moorhouse, E. (2013) Do foods imported into the UK leave a greater environmental footprint than the same foods produced within the UK? *International Journal of Life Cycle Assessment*, 18 (7), 1325-1343. doi: 10.1007/s11367-013-0576-2
5. Milà i Canals L, Azapagic A, Doka G, Jefferies D, King H, Mutel C, Nemecek T, Roches A, Sim S, Stichnothe H, Thoma G, Williams A. (2011) Approaches for addressing Life Cycle Assessment data gaps for bio-based products. *Journal of Industrial Ecology,* 15(5) 707-725 doi: 10.1111/j.1530-9290.2011.00369.x
6. Audsley, E., Brander, M., Chatterton, J., Murphy-Bokern, D., Webster, C., and Williams, A. (2009). How low can we go? An assessment of greenhouse gas emissions from the UK food system and the scope to reduce them by 2050. FCRN & WWF-UK. http://www.fcrn.org.uk/fcrn/publications/how-low-can-we-go (39 journal paper citations)

4. Details of the impact

Cranfield's research on LCA has been used directly by ministers and in public debate, informed public policy, and provided major contributions to Foresight and similar planning.

Ministerial and public debate

Our research has been used directly by government ministers, such as the International Development Secretary when defending international trade [1]. Our work on GHGE from the national food system has also had a major impact on public debate [2, 3]. Such examples have helped lead to national research on improving cattle health and reducing GHGE from milk and beef production. Popular science books about carbon footprints also draw heavily on Cranfield LCA research when considering food [4].

Policy

Cranfield's research underpinned the Cabinet Office Strategy Paper "Food Matters: Towards a strategy for the 21st Century' [5] and the impact of our LCA work has been demonstrated by Defra's requirement for the use of Cranfield's modelling in development of all-embracing assessments of farming systems, including social and economic factors (OF0386).

Our research made a major contribution to the development of a specification for the carbon footprinting of food production (PAS2050) which has become the international approach to the application of carbon footprinting to food. In particular, the research contributed methods for quantifying uncertainty [6] and improving the approach to quantifying GHGE emissions from land

use change (LUC). The method for calculating LUC GHGE, developed for WWF, also now forms the basis of the method the Dutch livestock industry applies for the carbon footprinting of animal feeds [7].

Research on land use per functional unit led to a requirement from Defra to study a number of key policy questions, including the best configuration of livestock systems, and work for WWF on how to achieve very low GHGE from UK food production. The WWF work on dietary change led to policy-enabling work for the Committee on Climate Change, contributing to the 4th Carbon Budget Report [8].

The work on livestock systems also contributed to a major Defra workshop on animal health, led by the Chief Veterinary Officer in March 2010, and to subsequent quantification of the benefits of improving cattle health on GHGE for Defra (AC0120).

Using our systems approach to quantifying the environmental impacts of and water use by grazing livestock has also helped levy bodies develop roadmaps to reduce the impacts of their industries, and contributed to the GHG Action Plan for the English agricultural industry [9].

Foresight

The Government Office for Science Foresight Report – 'The Future of Food and Farming' [10] cited Cranfield's work on the broad spectrum value of systems LCA, based on themed papers on livestock and land use, and participation focused on resource use.

Worldwide

Our LCA models are accessible to anyone to study and analyse as an Excel spreadsheet (https://webapps2.cranfield.ac.uk/webforms/form.jsp?formId=12024). Over 800 users globally have downloaded the models.

5. Sources to corroborate the impact

1. Buy African flowers - UK minister. http://news.bbc.co.uk/1/hi/6356383.stm
2. ENDS (2009) Home-grown food not always the greenest. *ENDS Report*, 413, 29 June 2009, p. 22. http://www.endsreport.com/20874/home-grown-food-not-always-the-greenest
3. Is tofu bad for the environment? *The Guardian*, 15 February 2010. http://www.theguardian.com/environment/green-living-blog/2010/feb/15/ask-leo-tofu-bad-for-environment
4. Berners Lee, Mike (2010) *How Bad are Bananas? The carbon footprint of everything*. Profile Books, 256 pp.
5. *Food Matters: Towards a Strategy for the 21st Century*. The Strategy Unit, Cabinet Office, 2008. http://preview.tinyurl.com/cabinetfood
6. Wiltshire, J, Tucker, G, Williams, AG, Foster, C, Wynn, S, Thorn, R, Audsley, E., Chatterton, JC and D Chadwick (2009). Scenario building to test and inform the development of a BSI method for assessing GHG emissions from food. Final report to Defra on research project FO0404, London. http://preview.tinyurl.com/defra-fo0404
7. Vellinga, T.V., Blonk, H., Marinussen, M., van Zeist, W.J., de Boer, I.J.M., Starmans, D. (2003) Methodology used in FeedPrint: a tool quantifying greenhouse gas emissions of feed production and utilization. Wageningen UR Livestock Research Report 674. ISSN 1570-8616 http://edepot.wur.nl/254098
8. Committee on Climate Change (2010) The Fourth Carbon Budget Reducing emissions through the 2020s http://preview.tinyurl.com/ccc4thbudget
9. Greenhouse Gas Action Plan http://www.ahdb.org.uk/projects/GreenhouseGasActionPlan.aspx
10. Foresight. The Future of Food and Farming (2011) Final Project Report. The Government Office for Science, London.