**Carbon Toolkit**
**Section 4.2**
**Pages 36-45 Viresco Report 6.20.2019**

## 4.2 Application of Methodology to Calculators and Tools

### 4.2.1 Bord Bia PAS2050 Carbon Footprinting Model

The Bord Bia PAS2050 Carbon Footprinting Model is a carbon footprint tool developed to explore the effect of varying management practices on GHG emissions from pastoral beef production systems (Crosson et al., n.d.; Foley, et al., 2011). Further information on the PAS2050 Carbon Footprinting Model is provided in Table 3 below.

*Table 3: Bord Bia PAS2050 Carbon Footprinting Model Assessment Summary*

| **Bord Bia PAS2050 Carbon Footprinting Model Assessment Summary** | |
|---|---|
| Developer | Teagasc and Bord Bia |
| Format | Excel based model |
| Geographic Focus | Specific to Ireland and based on average farm conditions. |
| Target Audience | Researchers |
| Cost | Unknown |
| Current Users | Researchers |
| Indicators/metrics | GHG emissions |
| GWP's | • IPCC (2013) 100 year: Biogenic Methane-27.75; Fossil Methane-30.5; Nitrous Oxide-265<br>• Munoz (2016) Methane oxidation, biogenic carbon, and the IPCC's emission metrics. Proposal for a consistent greenhouse-gas accounting |
| Scope and System Boundary | Farm Gate - Direct GHG emissions associated with farm activities and indirect GHG emissions associated with inputs brought onto the farm, nitrate leaching and ammonia (NH3) volatilization are simulated. |
| Notable Omissions in Scope | • GHG emissions generated after cattle have left the farm for slaughter are not included (e.g. meat processing and transport).<br>• GHG emissions associated with buildings and machinery are also excluded as it assumed that they do not differ between the various farming systems examined.<br>• GHG sinks associated with and use are not considered. |
| LCA Approach | Attributional |

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| Guidance on or Threshold for Excluding Emissions | Not addressed in documentation |
| Limitations to Use | Limited to Ireland and limited scope |
| Primary Input Data Requirements | • Farm size<br>• Fertilizer application<br>• Lime application<br>• Herd inventory and dynamics<br>• Finishing age<br>• Manure management<br>• Carcass output<br>• Concentrate consumed |
| Emission Factor Sources | • IPCC Tier 2 for N2O emissions from grazing and fertilizer application<br>• IPCC Tier 2 for NH3 volatilisation from manure management, grazing and fertilizer application<br>• IPCC Tier 2 for enteric fermentation |

| **Bord Bia PAS2050 Carbon Footprinting Model Assessment Summary** | |
|---|---|
| | • IPCC Tier 1 For Nitrate leaching<br>• IPCC Tier 1 for N2O emissions from manure management<br>• Publicly available data and published research |
| Dataset Sources Used for Modeling | Publicly available data including:<br>• EPA (2018) Ireland's Informative Inventory Report 2017<br>• Bretrup (2016) Carbon footprint analysis of mineral fertilizer production in Europe and other world regions<br>• Krol (2016) Improving and disaggregating N2O emission factors for ruminant excreta on temperate pasture soils<br>• Harty (2016) Reducing nitrous oxide emissions by changing N fertiliser use from calcium ammonium nitrate (CAN) to urea-based formulations<br>• IPCC (2006)<br>• Ecoinvent |
| Emission Factor Tier | IPCC Tier 1 and 2 (Nitrogen) and 2 (Farm Emissions) |
| Co-Product Allocation Method | Not addressed in documentation |
| Soil Carbon Sequestration Approach | Facility built into model to include soil carbon sequestration (Soussanna et al., 2010). |
| Land Use Change | Not addressed in documentation |

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| Approach (Direct and Indirect) | |
| Output Unit (i.e. Functional Unit) | Kg $CO_2e$/kg live weight gain |
| Uncertainty Assessment | Stochastic budgeting was used to model the effect of uncertainty around key input variables on production system GHG emissions. The model was first run deterministically to identify the GHG emission sources of most importance. |

**Cool Farm Tool v2.0**

4.2.2 The Cool Farm Tool (CFT) v2.0 - Beef Module and Crop Module can be used to model on-farm Best Management Practice (BMP) impacts and model baselines. The tool is intended to be used by both producers and supply-chain actors. Application Programming Interfaces (APIs) enable assessment of large datasets for agri-businesses to assess supply-shed emissions and opportunities. Further information on the CFT is provided in Table 4 below.

*Table 4: Cool Farm Tool v2.0 – Beef Module and Crop Module Assessment Summary*

| **Cool Farm Tool v2.0 – Beef Module and Crop Module Assessment Summary** | |
|---|---|
| Developer | Cool Farm Alliance |
| Format | Online and off-line (Excel) versions |
| Geographic Focus | • Global application, though some datasets and assumptions are European-centric.<br>• Beginning to develop 'versioning' to allow better specificity to smaller regions – underlying methodology is globally applicable, but emission factors and coefficients will be altered where more refined data are available. |
| Target Audience | • Corporations and agri-businesses sourcing agricultural products.<br>• Individual producers who are motivated to improve environmental and economic attributes.<br>• Consultants wanting to model on-farm emissions and BMP impacts. |
| Cost | Free – but there are membership fees for corporate members of the Cool Farm Alliance. |
| Current Users | Many major agri-businesses worldwide, but a stronger representation of European and North American users.<br>Some individual producers as well. |
| Indicators/metrics | GHGs, biodiversity, water, economics |
| GWP's | IPCC (2007) 100-year: Methane – 25; Nitrous Oxide - 298 |

| | |
|---|---|
| Scope and System Boundary | **Overview**: Cradle to Farm Gate (with transport to next stage of animal's life included)<br>**Start Point**: Various depending on process mapping.<br>• On-farm feed production starts with LCA-based embedded fertilizer and pesticide production emissions pre-farm gate, as well as transport to the farm. However, energy emissions are from on-farm combustion of fuel only.<br>• Off-farm feed production draws from the LCA-based FeedPrint (2013) LCI emission factors - see 'Feedprint' below<br>**End Point**: Farm gate<br>• Transportation emissions from farm gate to next stage/processing is optional but encouraged. |
| Notable Omissions in Scope | Carbon sequestration in grasslands is not considered – this is a deviation from the Feedprint LCI |
| LCA Approach | Attributional |
| Guidance on or Threshold for Excluding Emissions | Not addressed in documentation |
| Limitations to Use | Some limitations when considering different beef production systems globally. Can be used as a partial LCA tool. |
| Primary Input Data Requirements | • Herd data<br>• Fertilizer inputs<br>• Grazing and feed data<br>• Manure management (including bedding)<br>• On-farm energy use – fossil fuels, biofuels, electricity imports and on-farm electricity production.<br>• Transportation – inbound farm inputs and transport of product to next stage/processing. |
| Emission Factor Sources | • IPCC Tier 1 and 2 for on-farm (non-LCA based)<br>• FeedPrint – LCA embedded emissions for off-farm feed production<br>• GHG Protocol Compilation of emission factors for cross-sector tools (2003) |
| | |

| **Cool Farm Tool v2.0 – Beef Module and Crop Module Assessment Summary** | |
|---|---|
| | • DEFRA – Transportation (tonne-km basis) (IPCC-based) |
| Dataset Sources Used for Modeling | • Centraal Veevoeder Bureau – Feed nutrition values<br>• Feedipedia – Feed nutrition values<br>• ASAE Agricultural machinery management data (2006) – default fuel use for on-farm machinery where primary data is unavailable for on-farm feed production. |
| Emission Factor Tier | On Farm is a mix of Tier 1 and Tier 2 |

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| Co-Product Allocation Method | N/A - Emissions are to the farm gate at which point emissions from all co-products are still collectively accounted together (i.e. the functional unit is a live animal). |
| Soil Carbon Sequestration Approach | • Included in direct LUC for on-farm feed production for conversion to/from grassland and forest. Also assesses green manure.<br>• Uses IPCC methods with two deviations:<br>  ○ Conversion to/from grassland uses IPCC factors for set-aside not forest<br>  ○ Organic amendments (compost, manure, residue) are modelled using the methodology from Smith et al. (1997) and IPCC factors.<br>• Off-farm feed production – see FeedPrint LCA database below |
| Land Use Change Approach (Direct and Indirect) | • Direct (on-farm feed production only) - Biomass changes from loss of gain of forest use IPCC Tier 1 methodology and account SOC (see above).<br>• LUC directly from beef production is not considered, nor are biomass changes directly as a result of beef production (such as silviculture systems).<br>• Off-farm feed production – see FeedPrint below |
| Output Unit (i.e. Functional Unit) | Emissions ($CO_2e$) per unit live weight (at farm gate) |
| Uncertainty Assessment | Not addressed in documentation |

#### 4.2.3 CAP 2'ER

CAP 2'ER is a tool for quantifying the impacts of milk and beef production in France and assessing actions that may reduce these impacts. Further information on CAP 2'ER is provided in Table 5 below.

*Table 5: CAP 2'ER Assessment Summary*

| **CAP 2'ER Assessment Summary** | |
|---|---|
| Developer | Institute of Livestock, France |
| Format | Online |
| Geographic Focus | France |
| Target Audience | Farmers, farm consultants, supply chain actors |
| Cost | Not specified |
| Current Users | Dairy and beef farmers; and dairy and beef supply chain firms in France |
| Indicators/metrics | GHGs, carbon, water quality, acidification, biodiversity, and food performance (# of people fed), economics, and work conditions |
| GWP's | IPCC (2007) 100-year: Methane – 25; Nitrous Oxide - 298 |
| Scope and System Boundary | Cradle to gate |

| CAP 2'ER Assessment Summary | |
|---|---|
| Notable Omissions in Scope | Land use change |
| LCA Approach | Attributional |
| Guidance on or Threshold for Excluding Emissions | Not addressed in documentation |
| Limitations to Use | Specific to France and based on data for France |
| Emission Factor Sources | • Uses LCI data from Ecoinvent and Agribalyse for bought feeds |
| Dataset Sources Used for Modeling | • Ecoinvent and Agribalyse - purchased feed inputs<br>• Dia'Terre - purchased energy inputs |
| Emission Factor Tier | Mixture: Tier 1 for N2O from fertilizer, Tier 2 for manure CH4 and N2O (France-specific), Tier 2 (France-specific) for soil carbon and Tier 3 (France-specific) for enteric fermentation. |
| Co-Product Allocation Method | None for beef, milk allocation is based on lifetime energy intake for milk and meat (74% milk, 26% meat) |
| Soil Carbon Sequestration Approach | For land use only. Has emission factors for France based on type of cover – permanent pasture, range, hedges, non-permanent pastures, annual crop in rotation with pasture and annual crop alone. |
| Land Use Change Approach (Direct and Indirect) | Not included in scope |
| Output Unit (i.e. Functional Unit) | GHG emissions / Kg of live weight |
| Uncertainty Assessment | Not addressed in documentation |
| Other Comments on Quantification Approach | Level 1 contains many simplifying assumptions (one housing type, one diet). Level 2 allows using more detailed data and whole farm including cattle and feed production. A major difference between Cap'2er and other LCA methods is that Cap'2er includes automatic carbon sequestration for grassland. |

### 4.2.4 FAO Global Livestock Environmental Assessment Model (GLEAM)

GLEAM is a spatially explicit modelling framework that simulates the environmental impacts of the livestock sector using an LCA Approach. GLEAM differentiates key stages across livestock supply chains such as feed production, processing and transport; herd dynamics, animal feed and manure management. LCA benchmarking is completed relative to a baseline situation where no program or intervention is carried out. GLEAM-i can be also used in the preparation of national inventories and in ex-ante project evaluations assessing technical improvements in animal husbandry, feed and manure management. GLEAM is designed to analyze multiple environmental dimensions, such as feed use, GHG emissions and land use and land degradation. The current version of GLEAM (2.0) focuses on the quantification of GHG emissions related to livestock sector supply chains. Future versions of GLEAM, which are under development, will also include other environmental impacts such as nutrient and water use or interactions with biodiversity. Further information on GLEAM is provided in Table 6 below.

*Table 6: FAO Global Livestock Environmental Assessment Model (GLEAM) Assessment Summary*

| **FAO Global Livestock Environmental Assessment Model (GLEAM) Assessment Summary** | |
|---|---|
| Developer | Food and Agriculture Organization of the United Nations |
| Format | The model runs in a Geographic Information System (GIS) and provides spatially disaggregated estimates of GHG emissions and commodity production by production system, thereby enabling the calculation of an emissions intensity for any combination of commodity and farming systems at different spatial scales.<br><br>GLEAM-interactive (GLEAM-i) brings the core functionalities of the FAO Global Livestock Environmental Assessment Model to the public in a web application. The current version of GLEAM-i allows the direct comparison between Baseline and Scenario conditions, includes feedlot systems for cattle and incorporates the 2010 background data from GLEAM. GLEAM-i is available online. |
| Geographic Focus | Global by coarse geographic regions |
| Target Audience | Producers, policymakers, private sector organizations, academia, standard setting bodies and non-governmental organizations. |
| Cost | Free - GLEAM-i is the first open, user-friendly and livestock specific tool designed to support governments, project planners, producers, industry and civil society organizations to calculate emissions using Tier 2 methods. |
| Current Users | Used in multiple case studies including regional case studies on climate change mitigation and productivity gains in livestock supply chains; addressing enteric methane for food security and livelihoods cost benefit analysis of greenhouse gas mitigation in the livestock sector amongst many others. See the following site for additional information: http://www.fao.org/gleam/in-practice/en/ |

| | |
|---|---|
| Indicators/metrics | Outputs include:<br>• Livestock animal numbers, production systems and their spatial distribution;<br>• Production of manure and its management;<br>• Feed intake and animal feed rations composition and quality;<br>• Land use associated with feed intake;<br>• Production of livestock commodities;<br>• GHG emissions arising from each stage of production;<br>• Nitrogen used at each stage of production |
| GWP's | IPCC (2014) 100-year: Methane – 34; Nitrous Oxide - 298 |
| Scope and System Boundary | Cradle-to-Retail - GLEAM covers the entire livestock production chain, from feed production to the retail point. The system boundary is defined from "Cradle-to-retail of processed animal products." All emissions occurring at final consumption are outside the defined system boundary and are thus excluded from this assessment. |
| Notable Omissions in Scope | • Beef processing – hides, tallow, blood, renderables;<br>• Land use change emissions are limited to soy cultivation and pasture expansion<br>• Carbon stored in products |
| LCA Approach | Attributional |

| **FAO Global Livestock Environmental Assessment Model (GLEAM) Assessment Summary** | |
|---|---|
| Guidance on or Threshold for Excluding Emissions | Not addressed in documentation |
| Limitations to Use | Global by coarse geographic regions |
| Primary Input Data Requirements | • User input data include: herd structure, herd size, weight, age, animal transfers, gestation period, lactation, mineral fertilizer application rates and crop yields (among others).<br>• If user input data is unavailable for variables such as fertilizer application rates, crop yield and herd parameters, these factors are taken from literature, databases, surveys or through expert consultation. |
| Emission Factor Sources | • IPCC Tier 2 for most calculations |

| | |
|---|---|
| Dataset Sources Used for Modeling | • FAOSTAT (2011)<br>• Swiss Centre for Life Cycle Inventories database (EcoInvent) – Embodied energy<br>• Feedipedia, NRC Guidelines for Pigs and Poultry and CVB Tables from the Dutch Feed Board Database – Feed nutrition values<br>• Literature, databases, surveys and expert consultation for data such as crop yield and fertilizer application rates that the user is unable to enter.<br>• LEAP database of GHG emissions related to feed crops – emission factors for feed production, processing and transportation<br>• Regional emission factors for emissions from nitrogen, phosphorus and potassium used for feed production<br>• National inventory reports, expert knowledge and literature reviews – manure management system (MMS) emissions |
| Emission Factor Tier | Gleam uses IPCC Tier 2 methodology - animals are broken into cohorts (adult females, adult males, replacement females, replacement males and male and female fattening animals). GHG emission estimates are completed for each stage of production. The model covers emissions of methane ($CH_4$), carbon dioxide ($CO_2$) and nitrous oxide ($N_2O$). |
| Co-Product Allocation Method | The allocation of total impact between different commodities, products and services is based on both biophysical and economic approaches. |
| Soil Carbon Sequestration Approach | Not addressed in documentation |
| Land Use Change Approach (Direct and Indirect) | • Land use change emissions from soybean, palm oil plantations and pasture expansion are included. It is unclear in the documentation if both direct and indirect LUC are included. |
| Output Unit (i.e. Functional Unit) | • Emissions ($CO_2e$) per kg of edible protein for different livestock commodities.<br>• Average energy requirement of each animal cohort and the necessary feed intake.<br>• Total production of meat, milk and eggs. |

| **FAO Global Livestock Environmental Assessment Model (GLEAM) Assessment Summary** | |
|---|---|
| | • Modules develop different outputs – including herd module, manure module, feed module, system module, allocation module and energy and post farm emissions module. |
| Uncertainty Assessment | Not addressed in documentation |

### 4.2.5 Carbon Neutral Brazilian Beef

The Carbon Neutral Brazilian Beef tool quantifies CH4 emissions and woody biomass carbon gains. The purpose of the tool is to identify beef farms using integrated crop forest systems or integrate livestock forest systems that are carbon neutral (i.e. carbon gains balance CH4 emissions) for labeling purposes. Further information is presented in Table 7 below.

*Table 7: Carbon Neutral Brazilian Beef Assessment Summary*

| **Carbon Neutral Brazilian Beef Assessment Summary** | |
|---|---|
| Developer | EMBRAPA, Government of Brazil |
| Format | Methodology with online software for estimating tree carbon |
| Geographic Focus | Brazil |
| Target Audience | Farmers, supply chain actors |
| Cost | Not specified |
| Current Users | Beef farmers in Brazil, the beef supply chain |
| Indicators/metrics | GHGs |
| GWP's | IPCC (2007) 100-year: Methane – 25; Nitrous Oxide - 298 |
| Scope and System Boundary | Cradle to beef processor gate (consequential LCA - so all emissions other than stocking rate, enteric fermentation and tree carbon gain are assumed to be the same). |
| Notable Omissions in Scope | Some of the harvested wood needs to be used for wood products (lumber, veneers, laminates). However, there appears to be no provision for tracking the fate of tree carbon after harvest. As a consequential LCA, the emissions from harvesting, transporting, processing, and final product manufacture should be included but are not. It is also missing emissions for tree seedlings and planting. |
| LCA Approach | Consequential - basically, consequential in that it quantifies changes from open pasture to integrated production with pasture between treed alleys. |
| Guidance on or Threshold for Excluding Emissions | Not addressed in documentation |
| Limitations to Use | Brazil specific (Brazilian emission factors) |
| Emission Factor Sources | IPCC |
| Dataset Sources Used for Modeling | Brazilian tree growth data |
| Emission Factor Tier | Mixture – Tier 1 or Tier 2 are accepted for enteric fermentation. The carbon in trees is a country specific Brazilian model (Tier 3). |

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|---|---|
| Co-Product Allocation Method | Trees are a new co-product and land area is allocated between pasture and trees. |

| Carbon Neutral Brazilian Beef Assessment Summary | |
|---|---|
| Soil Carbon Sequestration Approach | Not included, but farms need to have initial SOC tested to ensure that SOC does not decrease over time. |
| Land Use Change Approach (Direct and Indirect) | Not considered |
| Output Unit (i.e. Functional Unit) | Kg of meat |
| Uncertainty Assessment | Not addressed in documentation |
| Other Comments on Quantification Approach | The method appears to be based on using tree carbon to balance $CH_4$ emissions. It is easy for the farmers to make the calculations. However, the fate of tree carbon from standing tree to finished products and the fate of those finished products is not considered. This is a fundamental weakness. It also neglects emissions associated with providing and planting tree seedlings. |

#### 4.2.6 Bovid $CO_2$

The BOVID $CO_2$ tool has been developed for use by Spanish beef farmers and other participants in the beef supply chain downstream of the farm gate. The tool quantifies on-farm emissions with some emissions from upstream sources for farm inputs, notably including on-farm infrastructure and building construction. There is a particular focus on manure, slurry and fertiliser emissions and nitrogen balance, although the scope and boundaries are broader than these sources/sinks. The tools include conversion factors to allow the user to choose the functional unit.

| Bovid $CO_2$ Assessment Summary | |
|---|---|
| Developer | Neiker and Asoprovac |
| Format | Excel |
| Geographic Focus | Spain (plus Italy, Ireland and France) |
| Target | Farmers and consultants |

| | |
|---|---|
| Audience | |
| Cost | |
| Current Users | Asoprovac |
| Indicators/metrics | Carbon, protein, nitrogen balance, (biodiversity under development) |
| GWP's | Choice of IPCC (2007) 100-year: Methane – 25; Nitrous Oxide – 298<br>Or IPCC (2013) 100-year: Biogenic Methane-27.75; Fossil Methane-30.5; Nitrous Oxide-265 |
| Scope and System Boundary | Overview: Cradle to farm gate (livestock products)<br><br>Starting points: Origin of raw materials:<br>Does not appear to include the production of equipment/machinery.<br>Does include construction of farm infrastructure and buildings.<br>Manufacture and transport of feed concentrates and forages.<br>Manufacture and transport of synthetic fertilisers Manufacture and transport of seeds<br>Manufacture and transport of plastics, oils and other inputs |

| Bovid $CO_2$ Assessment Summary | |
|---|---|
| | End points:<br>Treatment of livestock by-products |
| Notable Omissions in Scope | Soil carbon sequestration, Losses of feed and product waste, Land use change. |
| LCA Approach | Attributional |
| Guidance on or Threshold for Excluding Emissions | Not included |
| Limitations to Use | The tool uses average values by type of animal for factors such a dry matter intake and feed digestibility. This may change in subsequent versions. |
| Emission Factor Sources | National Inventories of Atmosphere Emissions 1990-2012. Volume 2: Analysis by SNAP Activities.<br>IPCC 2006 – manure and slurry.<br>MAGRAMA-OECC Carbon Footprint Calculator Scope 1 and 2 for organisations (2007-2013) – fuel consumption and electricity consumption (Spanish grid) |
| Dataset Sources Used for Modeling | Embedded emissions for feed and forages are from different sources: Diaterre 1.11 Table 6.1 (2011), COOP France/SNIA (2010), Grignon Energies Positive, and Feedprint.<br>MAGRAMA-OECC Carbon Footprint Calculator Scope 1 and 2 for organisations (2007-2013) – fuel consumption |
| Emission Factor Tier | Manure and slurry emissions – Tier 2 from National Inventory. |
| Co-Product Allocation Method | Allows for four different allocation systems:<br>1. Economic<br>2. Mass<br>3. Protein<br>4. Energy |
| Soil Carbon Sequestration Approach | Not included. |

| | |
|---|---|
| Land Use Change Approach (Direct and Indirect) | Not included |
| Output Unit (i.e. Functional Unit) | Three options for kg of meat by:<br>1. Live weight<br>2. Live weight gain<br>3. Carcass weight |
| Uncertainty Assessment | Not included |
| Other Comments on Quantification Approach | Exact method used to calculate emissions from applied N-P-K is not detailed in the methodology document but is mentioned.<br>Strong focus on farm economics also. |