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Developing a model to quantify the greenhouse gas emission intensity of Scottish agricultural commodities: Summary Report

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1 Aim and objectives

The overall aim of this project was to support the Scottish Government in managing the greenhouse gas (GHG) emissions from Scottish agriculture by improving the measurement of the GHG emissions intensity of the main agricultural commodities at a national level.

The project had three key objectives:

i) to develop a methodology to calculate the GHG emissions intensity of the main commodities produced across all key sectors of Scottish agriculture at a national level;

ii) to use this methodology to calculate 2015 baseline GHG emissions intensity for the main Scottish agricultural commodities;

iii) to assess the potential for continued practical implementation of this method in Scotland.

2 Background

Estimates of the GHG emissions from activities in each sector of the UK economy are reported each year in the UK GHG Inventory. Reductions in emissions reported in the Inventory can arise from a reduction in the amount of domestic production, as well as from reductions in *emissions intensity* of production. For example, simply reducing the number of beef cattle in the UK would achieve lower emissions; however, this would also produce less food. Consequently, emissions reductions from a reduced amount of domestic production can be misleading as, unless overall demand for the commodity has also reduced, this is likely to simply displace production (and the associated emissions) to other countries, rather than reduce global GHG emissions.

To support the Scottish Government in efforts to reduce GHG emissions from Scottish agriculture without displacing production (and emissions), a method of calculating the emissions intensity of the main Scottish agricultural commodities is required.

3 The Method: The Scottish Agricultural Emissions Model (SAEM)

The Scottish Agricultural Emissions Model (SAEM) has been developed. This model calculates the amount of commodity produced per herd/flock or per hectare of crop and the GHG emissions arising from this production. The emissions intensity of the commodity can then be calculated.

Emissions intensity is calculated at the point where the commodity leaves the farm. This includes the emissions arising on-farm as well as the emissions arising pre-farm from the production of inputs such as feed, fuel and fertiliser (irrespective of whether they are produced domestically or imported). SAEM therefore gives a more comprehensive picture of agricultural emissions than estimates that only include on-farm processes. SAEM does not include post-farm emissions arising from the distribution, processing and consumption of commodities.

SAEM quantifies emissions using the 2006 Intergovernmental Panel on Climate Change (IPCC) Tier 2 procedure for national GHG inventories[1]. SAEM results are therefore consistent with the UK GHG Inventory. Using the Tier 2 approach enables SAEM to make emission estimates that reflect the particular features of Scottish agricultural systems, such as specific livestock characteristics, and allows for the effects of any change in these systems to be interrogated. This gives SAEM a significant advantage over approaches which use regional (i.e. Western Europe) default emission factors.

4 2015 GHG Emissions Intensity Baseline

SAEM was used to calculate a 2015 baseline GHG emissions intensity for the nine main Scottish agricultural commodities: cattle meat and milk, sheep meat, pig meat, chicken (broiler) meat, hens' eggs, wheat, barley and potatoes. The results are shown in Table E1.

Table E1. Emission intensities for Scotland in 2015 calculated using SAEM

Commodity	Emissions intensity	Units
Wheat	0.30	$kgCO_2e$/kg dry matter
Barley	0.35	$kgCO_2e$/kg dry matter
Potatoes	0.29	$kgCO_2e$/kg dry matter
Milk	1.20	$kgCO_2e$/kg milk
Beef from the dairy herd[1]	9.20	$kgCO_2e$/kg carcass weight
Beef from the suckler herd	21.20	$kgCO_2e$/kg carcass weight
Sheep meat	20.10	$kgCO_2e$/kg carcass weight
Pig meat	4.50	$kgCO_2e$/kg carcass weight

[1] The IPCC guidelines state that the emissions estimates for a specific source can be calculated using either a Tier 1, Tier 2 or Tier 3 approach depending on the detailed level of data available. Tier 1 are simple methods using default data, Tier 2 uses country-specific emission factors and other data, and Tier 3 are more complex approaches. (Butterfield, 2017).

Chicken (broiler) meat	3.80	$kgCO_2e$/kg carcass weight
Hens eggs[2]	2.10	$kgCO_2e$/kg egg

[1] Beef from the dairy herd has a lower emission intensity than suckler beef as most (~95%) of the emissions from the cows in dairy systems are allocated to milk.

[2] The eggs result is for laying hens in enriched colony cages; eggs from free range systems would be likely to have a slightly higher emission intensity due to the higher feed conversion ratio of hens in free range systems.

5 Assessment of implementation of SAEM

SAEM complements the UK GHG Inventory by providing estimates of the emissions intensities of the main agricultural commodities in Scotland. SAEM uses the IPCC's widely accepted and transparent Tier 2 approach to calculating GHG emissions, which has a clear scientific rationale as is consistent with the UK GHG Inventory approach.

Using SAEM does require a moderate knowledge of MS Excel and some familiarity with agricultural processes and the emissions arising from them. SAEM is therefore not intended for use by the layperson or occasional user but provides experienced users with significant scope for investigating the drivers of agricultural emissions. New scenarios can be created, thus enabling values to be updated as they change over time (or in response to new evidence) and new agricultural systems to be introduced. SRUC have granted the Scottish Government permission to use SAEM for its internal business operations until 31/3/2021.

Whilst the Tier 2 approach is more informative than simpler methods, it is also more demanding and requires values for a wide range of characteristics that define:

- herd structures (fertility rates, mortality rates, replacement rates and ages at sexual maturity and slaughter);
- animal productivity (live weight gain, milk yield and egg yield);
- animal feeding (what animals are fed and the nutritional value of their feed);
- how manure is managed.

SAEM could therefore be developed by improving the input data quality for the features that have the strongest influence on sheep and cattle emissions intensity. These data are (a) the physical performance of breeding females and growing animals and (b) the assumptions made about the relationship between grassland yields, nutrient application rates and nutritional quality.

SAEM would also benefit from better information on pig and chicken ration composition, and on the rates of energy use (and energy sources) used in crop cultivation and processing.

6 Next steps

The primary purpose of this work was to develop a tool that could engage industry stakeholders with the concept of emissions intensity. Further work is needed to clarify the strengths and weaknesses in the underlying assumptions, and examine its practical potential as a communication tool, leading to some form of practical implementation.