Disaggregating headline Smart Inventory figures for Scottish Agriculture

Thomson, SG; Moxey, Andrew P

First published: 20/12/2021

Document Version
Publisher's PDF, also known as Version of record

SRUC

Disaggregating headline Smart Inventory figures for Scottish Agriculture

Disaggregating headline Smart Inventory figures for Scottish Agriculture

Andrew Moxey (Pareto Consulting)

&

Steven Thomson (SRUC)

March 2021

Cover photo: SRUC

Scottish Government
Riaghaltas na h-Alba
gov.scot

This work was funded by Scottish Government Rural and Environment Science

This paper was prepared in parallel to those of the Farmer Led Groups. Hence neither it nor they cross-reference each other and there some differences in the fine detail of reported figures. However, the overall messages are consistent across the different papers.

Introduction

1. The published agricultural Smart Inventory reports emissions under several category headings. In some cases, the categories relate to a specific type of emission from a specific sector. For example, enteric methane from sheep. Yet, in many cases the published figures are aggregated across several sectors. For example, emissions from the combustion of fuel in mobile machinery.
2. This degree of aggregation in published figures masks some of the detail required to identify sectoral emission envelopes for policy purposes. However, calculated but unpublished Inventory figures offer a finer degree of granularity for some categories and further disaggregation can be attempted through recourse to additional information and some assumptions.
3. The results of this approach are outlined below for Scottish reported emissions in 2018, distinguishing between figures that are published in the Smart Inventory, available as unpublished background information for the Smart Inventory, taken from published but unrelated secondary sources, or are derived by combining available Inventory information with other data and/or assumptions.
4. The disaggregated estimates presented below are subject to a number of caveats and should be regarded as indicative rather than definitive, but nonetheless offer some more detailed insights into the likely magnitude of sectoral emission envelopes. However, further exploration of Inventory methods and data would be advisable to support future policy interpretation of reported headline figures.

1A4ci_Agriculture/Forestry/Fishing: stationary fuel combustion

5. On-site combustion of fossil fuels in stationary, fixed machinery is a minor component (c.0.5% in 2018) of overall agricultural emissions. This reflects the fact that most stationary machinery (e.g., milking parlours, grain dryers) is powered by electricity, with emissions from electricity generation logged elsewhere in the Energy Supply Inventory.
6. The published figure is calculated by applying emission factors to different types of static machinery, estimates of the prevalence and usage of which are based on intermittent survey information. The accuracy of this for Scottish agriculture is uncertain. Moreover, the category also includes forestry and fishing.
7. No specific information on the usage of fixed machinery in the forestry or fishing sectors is readily available, so it is assumed that its prevalence and usage in these sectors is trivial and can be ignored here.

8. More helpfully, Warwick HRI (2007)[1] report estimated energy usage in UK agriculture, including for fossil-fuelled static machinery. Heating equipment for horticultural purposes dominates, although some use is made in other cropping enterprises plus in pig and poultry production. Usage in dairying, beef and sheep production is effectively zero. The estimated shares of fuel usage are c.88% for arable (mostly horticulture) and 12% for intensive livestock.

9. Reweighting these shares to account for the different relative sizes of each sector (measured by output value)[2] in Scotland compared to the UK suggests an indicative split of c.92% for arable (almost all horticulture), and c.2% for pigs and c.6% for poultry. This assumes that the machinery profile and usage in each sector in Scotland mirrors that of the UK average (although lower temperatures might increase usage rates for heating in Scotland).

10. On this basis, the indicative sectoral split of the 2018 headline figure is as shown in Table 1.

Table 1: Estimated disaggregation of agricultural static machinery fuel emissions (kt CO2e)

Total	Non-ag	Arable	Livestock	Dairy	Beef	Sheep	Pigs	Other
Published	Assumed	Derived	Derived	Derived	Derived	Derived	Derived	Derived
36.24	0	33.34	2.90	0	0	0	0.72	2.17

1A4cii_Agriculture/Forestry/Fishing: Off-road

11. Combustion of fossil fuels in mobile, off-road machinery is a bigger component (c.10% in 2018) of overall agricultural emissions. This reflects the widespread usage of tractors and other specialised equipment for a variety of field operations and on-farm transport (emissions from road transport are logged in the Transport Inventory).

12. Again, the published figure is calculated by applying emission factors to different types of machinery, estimates of the prevalence and usage of which are based on intermittent survey information. The accuracy of this for Scottish agriculture is uncertain. Moreover, the category also includes forestry and fishing.

13. Inclusion of 'fishing' in the category heading is assumed to be an artefact of the general coverage of 1A4c, with mobile emissions from fishing boats actually reported

[1] AC0401: Direct energy use in agriculture: opportunities for reducing fossil fuel inputs. Report to Defra https://ukerc.rl.ac.uk/pdf/AC0401_Final.pdf

[2] As reported in the Economic Report on Scottish Agriculture https://www.webarchive.org.uk/wayback/archive/20150218195911/http://www.gov.scot/Topics/Statistics/Browse/Agriculture-Fisheries/PubEconomicReport and Agriculture in the UK https://www.gov.uk/government/statistics/agriculture-in-the-united-kingdom-2018

under 1A4ciii in the Transport Inventory. Hence it is assumed that fishing does not need to be considered further here.

14. However, the establishment, maintenance and harvesting of forestry is included and needs to be deducted to give an estimated remaining total for agriculture. Whittaker et al., (2010)[3] suggest c.0.4t CO_{2e}/ha from fuel usage for planting, which implies c.4.0kt CO_{2e} if 10,000 ha are planted. Morison et al., (2012)[4] suggest that harvesting in Scotland emits c.41kt CO_{2e} per year from fuel usage. Together, this amounts to an estimated c.45kt CO_{2e} to subtract from the published total.

15. Warwick HRI (2007) also report estimated fossil-fuel usage in mobile agricultural machinery. Arable usage dominates, reflecting the volume of tillage operations undertaken, with usage in cattle and sheep enterprises also significant, but usage in pig, poultry and other livestock effectively zero. The implied shares of fuel usage are c.69% arable (mainly cropping) and c.16% for dairy, c.11% for beef and c.4% for sheep.

16. Reweighting to account for the different relative sizes of each sector (measured by output value) in Scotland compared to the UK suggests an indicative split of c.69% for arable and c.10% for dairy, c.16% for beef and c.5% for sheep. This assumes that the machinery profile and usage in each sector in Scotland mirrors that of the UK average.

17. On this basis, the sectoral split of the 2018 headline figure is as shown in Table 2.

Table 2: Estimated disaggregation of agricultural mobile machinery fuel emissions (kt CO_{2e})

Total	Non-ag	Arable	Livestock	Dairy	Beef	Sheep	Pigs	Other
Published	Secondary	Derived	Derived	Derived	Derived	Derived	Derived	Derived
770.42	45.00	500.54	224.88	72.54	116.07	36.27	0	0

2D1_Lubricant_Use

18. Emissions from the use of lubricants for machinery are a very minor component (<0.1% in 2018) of overall agricultural emissions. Specific information on this emission category is not readily available, but it is assumed that lubricant use will be proportional to fuel usage in mobile machinery.

19. On this basis, the sectoral split of the 2018 headline figure is as shown in Table 3.

[3] Whittaker, C.L., Mortimer, N.D. & Matthews, R.W. (2010) Understanding the carbon footprint of timber transport in the United Kingdom. https://timbertransportforum.org.uk/attachments/article/117/TTF%20Publications%202010%20Understanding%20the%20Carbon%20Footprint%20of%20Timber%20Transport%20in%20the%20UK.pdf

[4] Morison, J., Matthews, R., Miller, G., Perks, M., Randle, T., Vanguelova, E., White, M. & Yamulki, S. (2012) Understanding the carbon and greenhouse gas balance of forests in Britain. Research Report-Forestry Commission, UK, (018). https://www.forestresearch.gov.uk/documents/318/FCRP018_GVzNxlz.pdf

Table 3: Estimated disaggregation of agricultural machinery lubricant emissions (kt CO_{2e})

Total	Non-ag	Arable	Livestock	Dairy	Beef	Sheep	Pigs	Other
Published	Assumed	Assumed	Assumed	Assumed	Assumed	Assumed	Assumed	Assumed
0.02	0.001	0.014	0.005	0.002	0.003	0.001	0	0

3A & 3B Livestock

20. Livestock emissions are a major component (c.61% in 2018) of overall agricultural emissions, reflecting the significance of enteric methane plus direct methane and nitrous oxide from manure management.

21. Figures are also published for sectoral sub-categories, permitting disaggregation to individual livestock sectors. However, somewhat confusingly, emissions of dairy breeding replacements are included with 'other cattle' not 'dairy cows'. This means that the headline published figure for dairying underplays the dairy sector's actual emissions whilst that for 'other cattle' overplays the beef sector's emissions.

22. The reported population[5] of dairy cows associated with the published dairy emissions totals in the 2018 Smart Inventory is 176k. An additional 155k dairy replacements (over three age-cohorts of heifers) are included amongst the 935k calves, heifers, steers and bulls associated with 'other cattle' emissions, along with 426k beef cows.

23. Following Moxey & Thomson (2020)[6], the emissions from dairy breeding replacements, taking account of their likely age profile, can be estimated for subtraction from the 'other cattle total' and added to the 'dairy' total.

24. Similarly, up to an estimated c.160k dairy progeny are included in the 935k calves, heifers, steers and bulls being reared for beef. Whilst these may be regarded as beef rather than dairy animals, their eligibility for policy support may be different and hence it may be helpful to report Dairy beef separately from suckler-beef. Again, emissions for this three-year cohort of animals can be estimated following Moxey & Thomson (2020).

25. On this basis, the sectoral splits of the 2018 headline livestock figures are as shown in Tables 4a to 4c (NB. 'All Beef' is the sum of 'Scklr beef' and 'Dairy beef' here, and in all subsequent Tables).

Table 4a: estimated disaggregation of 3A enteric methane (kt CO_{2e})

Total	Dairy	(Scklr beef)	(Dairy beef)	All Beef	Sheep	Pigs	Other
Published	Derived	(Derived)	(Derived)	Derived	Published	Published	Published
3,622.7	674.24	(1,894.05)	(142.56)	2,036.62	861.39	11.88	38.60

[5] See 'Coded model pivot table_CH4' tab in the 'Ag_inventory_submission_1970-2018 v2' workbook underpinning the published figures.
[6] Moxey, A. & Thomson, S. (2020) Estimated Suckler Beef Climate Scheme effect within the National GHG 'Smart' Inventory.

Table 4b: estimated disaggregation of 3B manure methane (kt CO_{2e})

Total	Dairy	(Scklr beef)	(Dairy beef)	All Beef	Sheep	Pigs	Other
Published	Derived	(Derived)	(Derived)	Derived	Published	Published	Published
578.58	189.28	(292.41)	(22.01)	314.42	23.80	41.12	9.96

Table 4c: estimated disaggregation of 3B manure direct nitrous oxide emissions (kt CO_{2e})

Total	Dairy	(Scklr beef)	(Dairy beef)	All Beef	Sheep	Pigs	Other
Published	Derived	(Derived)	(Derived)	Derived	Published	Published	Published
384.25	83.59	(227.81)	(17.5)	244.95	4.93	18.10	32.67

3B25 Manure management - N2O and NMVOC - indirect N2O emissions

26. In addition to direct manure management emissions reported above, indirect nitrous oxide emissions from manure management also need to be accounted for, although they only represented c.0.7% of total agricultural emissions in 2018. The published figure is an aggregate total, but an unpublished sectoral disaggregation is available[7] by livestock sector.

27. However, again, further adjustments to the dairy and beef totals are required and have been made assuming proportionate changes consistent with those used in the direct manure management emission calculations above.

28. On this basis, the sectoral split of the 2018 headline figures is as shown in Table 5.

Table 5: estimated disaggregation of indirect nitrous oxide manure management emissions (kt CO_{2e})

Total	Dairy	(Scklr beef)	(Dairy beef)	All Beef	Sheep	Pigs	Other
Published	Derived	(Derived)	(Derived)	Derived	Unpublished	Unpublished	Unpublished
52.57	13.43	(26.19)	(1.97)	28.16	1.54	3.13	6.32

3D11 Inorganic N Fertilizers

29. Inorganic fertilisers make a relatively significant (c.8% in 2018) contribution to overall agricultural emissions. The published figure is a single aggregate, but an unpublished split between arable and grassland usage is available (pers. comm., ADAS/Rothamsted/CEH).

[7] Specifically, by interrogation of the 'N2O' tab in the 'Ag_inventory_submission_1970-2018 v2' workbook underpinning the published figures.

30. As above, further disaggregation across livestock sectors could be made on the basis of each sector's share in overall output. However, the methodology deployed in Moxey (2016)[8] implied sectoral shares of Scottish livestock fertiliser expenditure of c.31%, 54% and 15% respectively for dairy, beef and sheep (usage for other livestock is assumed to be effectively zero) and is the preferred approach here (although the precise split could be revisited).

31. On this basis, the sectoral split of the 2018 headline figures is as shown in Table 6.

Table 6: estimated disaggregation of inorganic N fertiliser emissions (kt CO_{2e})

Total	Arable	Grassland	Dairy	(Scklr beef)	(Dairy beef)	All Beef	Sheep	Pigs	Other
Published	Unpubd	Unpubd	Derived	(Derived)	(Derived)	Derived	Derived	Assumed	Assumed
599.58	214.21	385.37	119.46	(193.53)	(14.57)	208.10	57.81	0	0

3D12a Animal manure applied to soils

32. In addition to emissions from manure management in terms of collection and storage, additional nitrous oxide emissions also arise when manure is applied to land (c.2% of total agricultural emissions in 2018).

33. The published figure is an aggregate total, but an unpublished sectoral disaggregation is available[9] by livestock sector. However, again, further adjustments to the dairy and beef totals are required and have been made assuming proportionate changes consistent with those used in the direct manure management emission calculations above.

34. On this basis, the sectoral split of the 2018 headline figures is as shown in Table 7.

Table 7: estimated disaggregation of emissions from manure applied to soils (kt CO_{2e})

Total	Dairy	(Scklr beef)	(Dairy beef)	All Beef	Sheep	Pigs	Other
Published	Derived	(Derived)	(Derived)	Derived	Derived	Assumed	Assumed
121.09	35.78	**(**62.97**)**	**(**4.74**)**	67.71	3.24	5.24	9.11

3D12b Sewage sludge applied to soils

35. Use of sewage sludge as fertiliser makes a small contribution to overall agricultural emissions (c.0.1% in 2018). The published figure is a single aggregate, but an unpublished split between arable and grassland usage is available (pers. comm., ADAS/Rothamsted/CEH).

[8] Moxey, A. (2016) An Assessment of the Economic Contribution of Scotland's Red Meat Supply Chain. Report to QMS.
[9] Specifically, by interrogation of the 'N2O' tab in the 'Ag_inventory_submission_1970-2018 v2' workbook underpinning the published figures.

36. A further disaggregation across livestock sectors could be made on the basis of each sector's share in overall output. However, the approach here is to use the same proportions as used above for inorganic fertiliser.

37. On this basis, the sectoral split of the 2018 headline figures is as shown in Table 8.

Table 8: estimated disaggregation of emissions from sewage sludge applied to soils (kt CO_{2e})

Total	Arable	Grassland	Dairy	(Scklr beef	(Dairy beef)	All Beef	Sheep	Pigs	Other
Published	Unpubd	Unpubd	Derived	(Derived)	(Derived)	Derived	Derived	Assumed	Assumed
10.63	3.40	7.23	2.24	**(**3.63**)**	**(**0.27**)**	3.90	1.08	0	0

3D13 Urine and Dung deposited by grazing animals

38. In addition to emissions from manure management, in-situ grazing returns also contribute towards overall agricultural emissions (c.2% in 2018). The published figure is an aggregate total, but an unpublished sectoral disaggregation is available[10] by livestock sector.

39. However, again, further adjustments to the dairy and beef totals are required and have been made assuming proportionate changes consistent with those used in the direct manure management emission calculations above.

40. On this basis, the sectoral split of the 2018 headline figures is as shown in Table 9.

Table 9: estimated disaggregation of emissions from grazing deposits (kt CO_{2e})

Total	Dairy	(Scklr beef)	(Dairy beef)	All Beef	Sheep	Pigs	Other
Published	Derived	(Derived)	Derived	Derived	Derived	Assumed	Assumed
156.89	10.62	(52.88)	(3.98)	56.86	77.58	3.54	8.28

3D14 Crop Residues

41. Crop residues make a small contribution to overall agricultural emissions (c.2.5% in 2018). The published figure is a single aggregate, but an unpublished split between arable and grassland usage is available (pers. comm., ADAS/Rothamsted/CEH).

42. Analysis underpinning results presented in Hubbard et al. (2019)[11] estimated the livestock-unit-weighted sectoral shares of grassland utilisation in Scotland as c.14% for dairy, c.59% for beef and c.26% for sheep (the latter assumed all rough grazing

[10] Specifically, by interrogation of the 'N2O' tab in the 'Ag_inventory_submission_1970-2018 v2' workbook underpinning the published figures.

[11] Hubbard, C., Davis, J., Feng, S., Harvey, D., Liddon, A., Moxey, A., Ojo, M., Patton, M., Philippidis, G., Scott, C., Shrestha, S. & Wallace, M. (2019) Brexit: How might UK Agriculture Thrive or Survive? Report to ESRC. https://ukandeu.ac.uk/wp-content/uploads/2019/11/Final-Report-Brexit-and-Agriculture-March2019.pdf

was also used for sheep). As with estimated fertiliser etc. expenditure shares above, this split could be revisited but is used here as a reasonable estimate.

43. On this basis, the sectoral split of the 2018 headline figures is as shown in Table 10.

Table 10: estimated disaggregation of crop residue emissions (kt CO_{2e})

Total	Arable	Grassland	Dairy	(Scklr beef)	(Dairy beef)	All Beef	Sheep	Pigs	Other
Published	Unpubd	Unpubd	Derived	(Derived)	(Derived)	Derived	Derived	Assumed	Assumed
188.05	161.23	26.82	8.31	**(**13.47**)**	**(**1.01**)**	14.48	4.02	0	0

3D15 Mineralisation/immobilisation associated with loss/gain of soil organic matter

44. Nitrous oxide from mineralisation also contributes to overall agricultural emissions (c.2.5% in 2018). The published headline figure actually relates solely to arable activities (pers. comm., ADAS/Rothamsted/CEH).

45. On this basis, the sectoral split of the 2018 headline figures is as shown in Table 11.

Table 11: estimated disaggregation of mineralisation emissions (kt CO_{2e})

Total	Arable	Grassland	Dairy	Beef	Sheep	Pigs	Other
Published	Unpublished	Unpublished	Derived	Derived	Derived	Derived	Derived
194.86	194.86	0	0	0	0	0	0

3D16 Cultivation of Organic soils

46. Cultivation of organic soils makes a small contribution to overall agricultural emissions (c.3% in 2018). The published figure is a single aggregate, but an unpublished split between arable and grassland usage is available (pers. comm., ADAS/Rothamsted/CEH).

47. As for crop residues above, the sectoral grassland utilisation shares estimated by Hubbard et al. (2019) are used to split this category. This assumes that the same average utilisation shares apply across all soil types, including organic soils.

48. On this basis, the sectoral split of the 2018 headline figures is as shown in Table 10.

Table 10: estimated disaggregation of cultivation of organic soils (kt CO_{2e})

Total	Arable	Grassland	Dairy	(Scklr beef)	(Dairy beef)	All beef	Sheep	Pigs	Other
Pubd	Unpbd	Unpbd	Derived	(Derived)	(Derived)	Derived	Unpubd	Unpubd	Unpubd
238.64	36.27	202.33	62.73	**(**101.63**)**	**(**7.65**)**	109.28	30.36	0	0

3D21 Atmospheric Deposition

49. Atmospheric deposition of nitrous oxide from agricultural activities are a small component of overall emissions (c.0.8% in 2018). The published figure is a single aggregate, but an unpublished split between arable and individual livestock sectors is available for part of the total (pers. comm., ADAS/Rothamsted/CEH).

50. However, again, further adjustments to the dairy and beef totals are required and have been made assuming proportionate changes consistent with those used in the direct manure management emission calculations above.

51. On this basis, the sectoral split of the 2018 headline figures is as shown in Table 11.

Table 11: estimated disaggregation of atmospheric deposition emissions (kt CO_{2e})

Total	Arable	Grassland	Dairy	(Scklr beef)	(Dairy beef)	All beef	Sheep	Pigs	Other
Pubd	Unpbd	Unpbd	Derived	(Derived)	(Derived)	Derived	Unpubd	Unpubd	Unpubd
57.53	9.64	47.89	9.70	(20.41)	(1.54)	21.95	9.15	1.64	5.45

3D22 Nitrogen Leaching and Run-off

52. Nitrogen leaching and run-off are a small but important component of overall agricultural emissions (c.3% in 2018). The published figure is a single aggregate, but an unpublished split between arable and individual livestock sectors is available.[12]

53. However, again, further adjustments to the dairy and beef totals are required and have been made assuming proportionate changes consistent with those used in the inorganic fertiliser emission calculations above.

54. On this basis, the sectoral split of the 2018 headline figures is as shown in Table 12.

Table 12: estimated disaggregation of leaching and run-off emissions (kt CO_{2e})

Total	Arable	Grassland	Dairy	(Scklr beef)	(Dairy beef)	All beef	Sheep	Pigs	Other
Pubd	Unpbd	Unpbd	Derived	(Derived)	(Derived)	Derived	Unpubd	Unpubd	Unpubd
221.23	150.05	69.55	16.85	(34.65)	(2.61)	37.26	9.79	2.00	5.28

3F_Field_burning

55. Although a minor component of arable emissions in 1990, field burning has a published value of zero in 2018.

[12] Specifically, by interrogation of the 'N2O' tab in the 'Ag_inventory_submission_1970-2018 v2' workbook underpinning the published figures.

3G1 & 3G2_Liming - limestone

56. The application of lime contributes to overall agricultural emissions (c.3% in 2018). The published figure is a single aggregate, but an unpublished split between arable and grassland usage is available. [13]

57. If grassland usage of lime is assumed to follow the same pattern as that estimated by Moxey (2016) for inorganic fertiliser usage, the grassland total can be disaggregated using the same proportions of c.31%, 54% and 15% respectively for dairy, beef and sheep (other livestock assumed to be zero).

58. On this basis, the sectoral split of the 2018 headline figures is as shown in Table 13.

Table 13: estimated disaggregation of liming emissions (kt CO_{2e})

Total	Arable	Grassland	Dairy	(Scklr beef)	(Dairy beef)	All beef	Sheep	Pigs	Other
Pubd	Unpbd	Unpbd	Derived	**(**Derived**)**	**(**Derived**)**	Derived	Unpubd	Assumed	Assumed
215.55	156.76	58.79	18.22	**(**29.52**)**	**(**2.22**)**	31.75	8.82	0	0

3H Urea Application

59. The application of urea makes a very small contribution to overall agricultural emissions (c.0.3% in 2018). The published figure is a single aggregate, but an unpublished split between arable and grassland usage is available. [14]

60. If grassland usage of urea is assumed to follow the same pattern as that estimated by Moxey (2016) for inorganic fertiliser usage, the grassland total can be disaggregated using the same proportions of c.31%, 54% and 15% respectively for dairy, beef and sheep (other livestock assumed to be zero).

61. On this basis, the sectoral split of the 2018 headline figures is as shown in Table 14.

Table 14: estimated disaggregation of urea emissions (kt CO_{2e})

Total	Arable	Grassland	Dairy	(Scklr beef)	(Dairy beef)	All beef	Sheep	Pigs	Other
Pubd	Unpbd	Unpbd	Derived	**(**Derived**)**	**(**Derived**)**	Derived	Unpubd	Assumed	Assumed
24.68	17.95	6.73	2.09	**(**3.38**)**	**(**0.25**)**	3.63	1.01	0	0

Overall total

62. Table 15 collates all of the individual categories above, reordering them to group all of the emissions arising from livestock themselves first. Table 16 uses the same ordering to show category shares within each sector, and Table 17 shows the share

[13] Specifically, by interrogation of the 'CO2' tab in the 'Ag_inventory_submission_1970-2018 v2' workbook underpinning the published figures.
[14] As above.

of overall agricultural emissions of each category by sector combination. Figure 1 presents the Table 17 figures graphically (ordered by sectoral size).

63. As indicative estimates of sectoral shares, the figures presented in Table 17 and Figure 1 summarise the main sources of emissions and hence where mitigation efforts may need to be directed. The dominance of enteric methane (c.49%) as the main emission category is apparent, as is the significance (c.44%) of the beef sector – but other categories and sectors also contribute.

64. Whilst necessarily based on interpretations, assumptions and other information, the estimates nonetheless reveal the relative magnitude of emission sources and highlight where further attention to measurement is merited. It is recommended that dialogue be maintained with the team responsible for compiling the Smart Inventory, to identify opportunities for refinement in the calculation of reported headline category results but also their disaggregation.

Table 15: estimated sectoral disaggregation of agricultural emissions in 2018 (kt CO_{2e})

empty	Arable	Dairy	(Suckler beef)	(Dairy beef)	All beef	Sheep	Pigs	Other livestock	Non-ag	Total
Enteric methane	0.00	674.24	(1,894.05)	(142.56)	2,036.62	861.39	11.88	38.60	0.00	**3,622.73**
Manure management CH4	0.00	189.28	(292.41)	(22.01)	314.42	23.80	41.12	9.96	0.00	**578.58**
Manure management N2O (d)	0.00	83.59	(227.81)	(17.15)	244.95	4.93	18.10	32.67	0.00	**384.25**
Manure management N2O (i)	0.00	13.43	(26.19)	(1.97)	28.16	1.54	3.13	6.32	0.00	**52.57**
Manure to soils N2O	0.00	35.78	(62.97)	(4.74)	67.71	3.24	5.24	9.11	0.00	**121.09**
Grazing deposits	0.00	10.62	(52.88)	(3.98)	56.86	77.58	3.54	8.28	0.00	**156.89**
Sub-total	**0.00**	**1,006.94**	**(2,556.31)**	**(192.41)**	**2,748.72**	**972.49**	**83.01**	**104.95**	**0.00**	**4,916.11**
Urea	17.95	2.09	(3.38)	(0.25)	3.63	1.01	0.00	0.00	0.00	**24.68**
Inorganic fert	214.21	119.46	(193.53)	(14.57)	208.10	57.81	0.00	0.00	0.00	**599.58**
Liming	156.76	18.22	(29.52)	(2.22)	31.75	8.82	0.00	0.00	0.00	**215.55**
Sewage sludge	3.40	2.24	(3.63)	(0.27)	3.90	1.08	0.00	0.00	0.00	**10.63**
Atmospheric deposition	9.64	9.70	(20.41)	(1.54)	21.95	9.15	1.64	5.45	0.00	**57.53**
Leaching & run-off	150.05	16.85	(34.65)	(2.61)	37.26	9.79	2.00	5.28	0.00	**221.23**
Crop Residues	161.23	8.31	(13.47)	(1.01)	14.48	4.02	0.00	0.00	0.00	**188.05**
Mineralisation	194.86	0.00	(0.00)	(0.00)	0.00	0.00	0.00	0.00	0.00	**194.86**
Cultivation of organic soils	36.27	62.73	(101.63)	(7.65)	109.28	30.36	0.00	0.00	0.00	**238.64**
Field burning	0.00	0.00	(0.00)	(0.00)	0.00	0.00	0.00	0.00	0.00	**0.00**
Static machinery	33.34	0.00	(0.00)	(0.00)	0.00	0.00	0.72	2.17	0.00	**36.24**
Mobile machinery	500.54	72.54	(107.94)	(8.12)	116.07	36.27	0.00	0.00	45.00	**770.42**
Lubricant usage	0.01	0.00	(0.00)	(0.00)	0.00	0.00	0.00	0.00	0.00	**0.02**
Total	**1,478.27**	**1,319.10**	**(3,064.49)**	**(230.66)**	**3,295.15**	**1,130.80**	**87.37**	**117.85**	**45.00**	**7,473.54**

(NB. 'All Beef' is the sum of 'Suckler beef' plus 'Dairy beef').

Table 16: estimated emission category shares within each sector's total emissions in 2018 (%)

empty	Arable	Dairy	(Suckler beef)	(Dairy beef)	All beef	Sheep	Pigs	Other livestock	Non-ag	Total
Enteric methane	0.0%	51.1%	(61.8%)	(61.8%)	61.8%	76.2%	13.6%	32.8%	0.0%	**48.5%**
Manure management CH4	0.0%	14.3%	(9.5%)	(9.5%)	9.5%	2.1%	47.1%	8.5%	0.0%	**7.7%**
Manure management N2O (d)	0.0%	6.3%	(7.4%)	(7.4%)	7.4%	0.4%	20.7%	27.7%	0.0%	**5.1%**
Manure management N2O (i)	0.0%	1.0%	(0.9%)	(0.9%)	0.9%	0.1%	3.6%	5.4%	0.0%	**0.7%**
Manure to soils N2O	0.0%	2.7%	(2.1%)	(2.1%)	2.1%	0.3%	6.0%	7.7%	0.0%	**1.6%**
Grazing deposits	0.0%	0.8%	(1.7%)	(1.7%)	1.7%	6.9%	4.1%	7.0%	0.0%	**2.1%**
Sub-total	**0.0%**	**76.3%**	**(83.4%)**	**(83.4%)**	**83.4%**	**86.0%**	**95.0%**	**89.1%**	**0.0%**	**65.8%**
Urea	1.2%	0.2%	(0.1%)	(0.1%)	0.1%	0.1%	0.0%	0.0%	0.0%	**0.3%**
Inorganic fert	14.5%	9.1%	(6.3%)	(6.3%)	6.3%	5.1%	0.0%	0.0%	0.0%	**8.0%**
Liming	10.6%	1.4%	(1.0%)	(1.0%)	1.0%	0.8%	0.0%	0.0%	0.0%	**2.9%**
Sewage sludge	0.2%	0.2%	(0.1%)	(0.1%)	0.1%	0.1%	0.0%	0.0%	0.0%	**0.1%**
Atmospheric deposition	0.7%	0.7%	(0.7%)	(0.7%)	0.7%	0.8%	1.9%	4.6%	0.0%	**0.8%**
Leaching & run-off	10.2%	1.3%	(1.1%)	(1.1%)	1.1%	0.9%	2.3%	4.5%	0.0%	**3.0%**
Crop Residues	10.9%	0.6%	(0.4%)	(0.4%)	0.4%	0.4%	0.0%	0.0%	0.0%	**2.5%**
Mineralisation	13.2%	0.0%	(0.0%)	(0.0%)	0.0%	0.0%	0.0%	0.0%	0.0%	**2.6%**
Cultivation of organic soils	2.5%	4.8%	(3.3%)	(3.3%)	3.3%	2.7%	0.0%	0.0%	0.0%	**3.2%**
Field burning	0.0%	0.0%	(0.0%)	(0.0%)	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Static machinery	2.3%	0.0%	(0.0%)	(0.0%)	0.0%	0.0%	0.8%	1.8%	0.0%	**0.5%**
Mobile machinery	33.9%	5.5%	(3.5%)	(3.5%)	3.5%	3.2%	0.0%	0.0%	100.0%	**10.3%**
Lubricant usage	0.0%	0.0%	(0.0%)	(0.0%)	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Total	**100.0%**	**100.0%**	**(100.0%)**	**(100.0%)**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

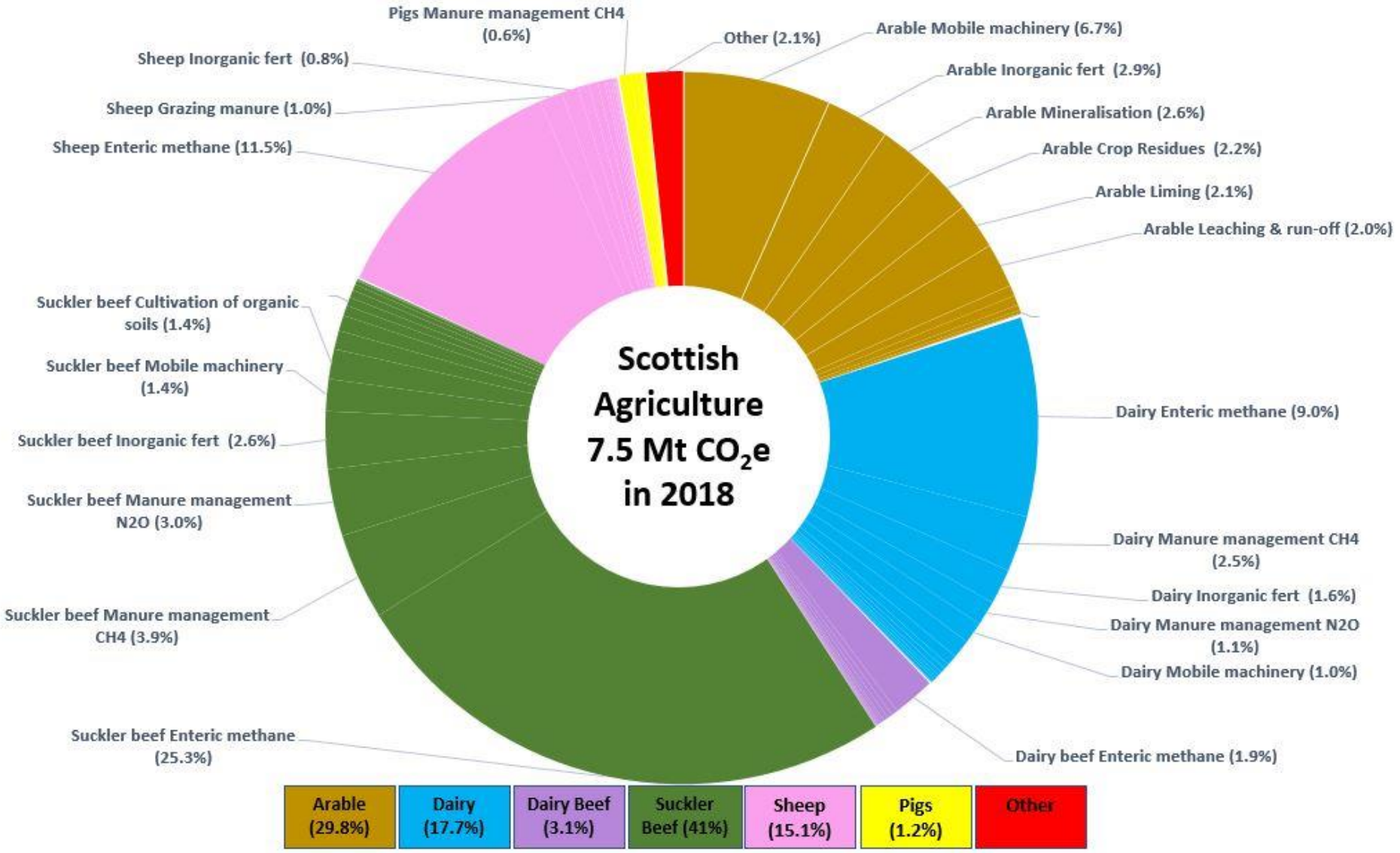
(NB. 'All Beef' is the sum of 'Suckler Beef' plus 'Dairy beef').

Table 17: estimated sector by category share of overall total emissions in 2018 (%)

empty	Arable	Dairy	(Suckler beef)	(Dairy beef)	All beef	Sheep	Pigs	Other livestock	Non-ag	Total
Enteric methane	0.0%	9.0%	(25.3%)	(1.9%)	27.3%	11.5%	0.2%	0.5%	0.0%	**48.5%**
Manure management CH4	0.0%	2.5%	(3.9%)	(0.3%)	4.2%	0.3%	0.6%	0.1%	0.0%	**7.7%**
Manure management N2O (d)	0.0%	1.1%	(3.0%)	(0.2%)	3.3%	0.1%	0.2%	0.4%	0.0%	**5.1%**
Manure management N2O (i)	0.0%	0.2%	(0.4%)	(0.0%)	0.4%	0.0%	0.0%	0.1%	0.0%	**0.7%**
Manure to soils N2O	0.0%	0.5%	(0.8%)	(0.1%)	0.9%	0.0%	0.1%	0.1%	0.0%	**1.6%**
Grazing deposits	0.0%	0.1%	(0.7%)	(0.1%)	0.8%	1.0%	0.0%	0.1%	0.0%	**2.1%**
Sub-total	**0.0%**	**13.5%**	**(34.2%)**	**(2.6%)**	**36.8%**	**13.0%**	**1.1%**	**1.4%**	**0.0%**	**65.8%**
Urea	0.2%	0.0%	(0.0%)	(0.0%)	0.0%	0.0%	0.0%	0.0%	0.0%	**0.3%**
Inorganic fert	2.9%	1.6%	(2.6%)	(0.2%)	2.8%	0.8%	0.0%	0.0%	0.0%	**8.0%**
Liming	2.1%	0.2%	(0.4%)	(0.0%)	0.4%	0.1%	0.0%	0.0%	0.0%	**2.9%**
Sewage sludge	0.0%	0.0%	(0.0%)	(0.0%)	0.1%	0.0%	0.0%	0.0%	0.0%	**0.1%**
Atmospheric deposition	0.1%	0.1%	(0.3%)	(0.0%)	0.3%	0.1%	0.0%	0.1%	0.0%	**0.8%**
Leaching & run-off	2.0%	0.2%	(0.5%)	(0.0%)	0.5%	0.1%	0.0%	0.1%	0.0%	**3.0%**
Crop Residues	2.2%	0.1%	(0.2%)	(0.0%)	0.2%	0.1%	0.0%	0.0%	0.0%	**2.5%**
Mineralisation	2.6%	0.0%	(0.0%)	(0.0%)	0.0%	0.0%	0.0%	0.0%	0.0%	**2.6%**
Cultivation of organic soils	0.5%	0.8%	(1.4%)	(0.1%)	1.5%	0.4%	0.0%	0.0%	0.0%	**3.2%**
Field burning	0.0%	0.0%	(0.0%)	(0.0%)	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Static machinery	0.4%	0.0%	(0.0%)	(0.0%)	0.0%	0.0%	0.0%	0.0%	0.0%	**0.5%**
Mobile machinery	6.7%	1.0%	(1.4%)	(0.1%)	1.6%	0.5%	0.0%	0.0%	0.6%	**10.3%**
Lubricant usage	0.0%	0.0%	(0.0%)	(0.0%)	0.0%	0.0%	0.0%	0.0%	0.0%	**0.6%**
Total	**19.8%**	**17.7%**	**(41.0%)**	**(3.1%)**	**44.1%**	**15.1%**	**1.2%**	**1.6%**	**0.6%**	**100.0%**

(NB. ‘All Beef’ is the sum of ‘Suckler beef’ plus ‘Dairy beef’).

Figure 1: estimated sector by category share of overall total emissions in 2018 (%)



SRUC

At the heart of the natural economy

This publication is available at **www.gov.scot**

Any enquiries regarding this publication should be sent to us at

The Scottish Government
St Andrew's House
Edinburgh
EH1 3DG

ISBN: 978-1-80201-744-1 (web only)

Published by The Scottish Government, December 2021

Produced for The Scottish Government by APS Group Scotland, 21 Tennant Street, Edinburgh EH6 5NA
PPDAS901206 (12/21)