Final report

Revision of Beef and Sheep Calculators

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Abstract

The beef and sheep greenhouse gas accounting tools (B-GAF and S-GAF respectively) enable producers to generate farm carbon accounts. A range of revisions were recommended to increase usability and functionality of the tools. This project implemented the most readily achievable changes:

- Merging of B-GAF and S-GAF into one tool (SB-GAF).
- Display of emissions intensity values for beef, sheep meat and wool (including and excluding vegetation sequestration) on the summary page.
- Emissions broken down by scopes and by gas for scope 1 emissions.
- Additional inputs for livestock categories and farm inputs.
- Inclusion of a new, more comprehensive vegetation section from FarmGAS.
- Development of new fuel and electricity worksheets
- Restructure to report impacts in terms of scope 1, 2 and 3 emissions.
- Inclusion of emissions from purchased livestock.
- Background calculation modifications to support updates and ensure maintained functionality.

These improvements have resulted in an upgraded tool that allows mixed enterprises to generate one set of values for the farm, benchmarking between farms of different sizes, an estimation of tree carbon sequestration, and improved accuracy in baseline carbon accounts for beef and sheep farms in the future.

Further, more substantial revisions are recommended to further increase usability and functionality of the tool.

Executive summary

Background

The beef greenhouse gas accounting (B-GAF) and sheep greenhouse gas accounting (S-GAF) tools allow producers to generate a carbon account for their farm. These tools were utilised to generate 50 carbon accounts for beef and sheep producers across Australia in the MLA Carbon Accounting Workshops (V.SCS.0016). Throughout the course of the workshops, many suggested revisions were identified for the tools, both to help with usability and to improve their accuracy and bring them up-to-date with recent changes to carbon accounting. In response, these tools were updated to (1) incorporate common feedback received by producers and to (2) ensure the most up to date methods were being used. These tools were combined into one tool (SB-GAF), allowing mixed enterprises to generate one set of values for their farm. These modifications will allow for improved accuracy in baseline carbon accounts for beef and sheep farms in the future, though further, more substantial revisions would also be beneficial to address remaining limitations with the tool that could not be addressed in the current project.

Objectives

The objective of this project is to update the existing sheep and beef Greenhouse Accounting Framework tool (B-GAF and S-GAF) (http://www.piccc.org.au/resources/Tools) to make them more user friendly single tool, ensure relevant outputs and align with the MLA Minimum Standards for Carbon Accounting and Carbon Footprints for Sheep and Beef Farms (P.PSH.1196).

Methodology

All scope 1 emissions (except for fuel and savannah burning) were calculated from methods in the *National Greenhouse Gas Inventory Report 2018* (Commonwealth of Australia, 2020). Savannah burning calculations remained the same as the previous version of the tool which used methods from the *National Greenhouse Gas Inventory Report 2013*. Scope 1 emissions were broken down by gas on the data summary page. Scope 1, 2 and 3 fuel and electricity emissions were calculated from methods in the *National Greenhouse Accounts Factors* report (Commonwealth of Australia, 2019). All other scope 3 emissions were calculated using life cycle inventory data and published literature.

Results/key findings

The improvements made to B-GAF and S-GAF allow for improved accuracy when generating carbon accounts and simplify the process for producers. Combining the S-GAF and B-GAF tools into SB-GAF to create one user friendly tool simplified the data provision process for producers and will encourage more producers to generate a baseline carbon account for their farm. This is a prerequisite for identifying areas of improvement and strategies to reduce GHG emissions.

Benefits to industry

These modifications to the emissions calculators will allow for improved accuracy in baseline carbon accounts for beef and sheep farms.

Future research and recommendations

Future updates of SB-GAF could include an input section for cattle and sheep on agistment, and there is scope to provide more expansive lists of purchased farm inputs. There are also new components in the NIR (emissions from farm dams, for example) that need to be assessed. A system could be integrated into the tool to flag user input errors and a much wider range of values for purchased livestock from different regions would be beneficial, seeing this is known to vary substantially across the country.

We note that the accuracy of the calculator is highly dependent on the quality of the data and the precision of input. We recommend the new SB-GAF tool be made available to beef and sheep producers in conjunction with the Carbon Accounting Training Manual (V.SCS.0016, which will be available later in 2020) to assist in the generation of accurate farm carbon accounts.

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1. Background

Greenhouse gas (GHG) emissions generated by livestock production and from other farm related operations can be quantified in the form of a carbon account. A carbon account allows producers to (1) establish their current GHG position, (2) understand how GHGs and the management of carbon interact with the productivity of the enterprise, and (3) identify management options to improve the farm carbon balance. Potential benefits of generating a carbon account include increased farm productivity and long-term sustainability, improving the social licence and market support for red meat, and engaging with emerging market opportunities for low carbon products.

B-GAF and S-GAF (i.e. beef- and sheep-greenhouse gas accounting framework tools, http://www.piccc.org.au/resources/Tools) are existing tools that allow producers to quantify their annual farm GHG emissions (Eckard and Doran-Browne, 2018; Eckard, 2020). These tools were used to generate 50 carbon account for beef and sheep producers across Australia in Carbon Accounting Workshops (V.SCS.0016). A great deal of producer feedback on the calculators was provided throughout the course of the workshops. It was also evident that some producers had difficulty using the tools correctly and therefore were not generating accurate and representative results. To ensure the accuracy of results generated by the calculator and to improve their ease of use, the B-GAF and S-GAF tools were combined into one tool and the findings and feedback received in the workshops were incorporated into the revised calculator, SB-GAF.

2. Objectives

The objective of this project was to update B-GAF and S-GAF to make them a more user-friendly single tool, ensure relevant and accurate outputs are generated and align with the MLA Minimum Standards for Carbon Accounting and Carbon Footprints for Sheep and Beef Farms.

This objective was achieved through the successful updating of the tool.

3. Methodology

All scope 1 emissions (except for fuel and savannah burning) were calculated from methods in the *National Greenhouse Gas Inventory Report 2018* (Commonwealth of Australia, 2020). Savannah burning calculations remained the same as the previous version of the tool which used methods from the *National Greenhouse Gas Inventory Report 2013*. Scope 1 emissions were broken down by gas on the data summary page. Scope 1, 2 and 3 fuel and electricity emissions were calculated from methods in the *National Greenhouse Accounts Factors* report (Commonwealth of Australia, 2019). All other scope 3 emissions were calculated using life cycle inventory data and published literature.

The following methodology was followed to make the updates/amendments to S-GAF and B-GAF:

1. Improved the data input interface for livestock – this required:
    a. New categories for the breeding herd – there are currently too few.
    b. A new section for traded cattle, separate from the breeding herd.
    c. Grouping all livestock related data together, including combining the S-GAF and BGAF tools into one.
    d. Adding a ‘sales’ category so that the total beef and sheep meat output from the model is captured. This will allow the calculator to report an emission intensity

(which it doesn't currently do) and that allows benchmarking between farms of different sizes.

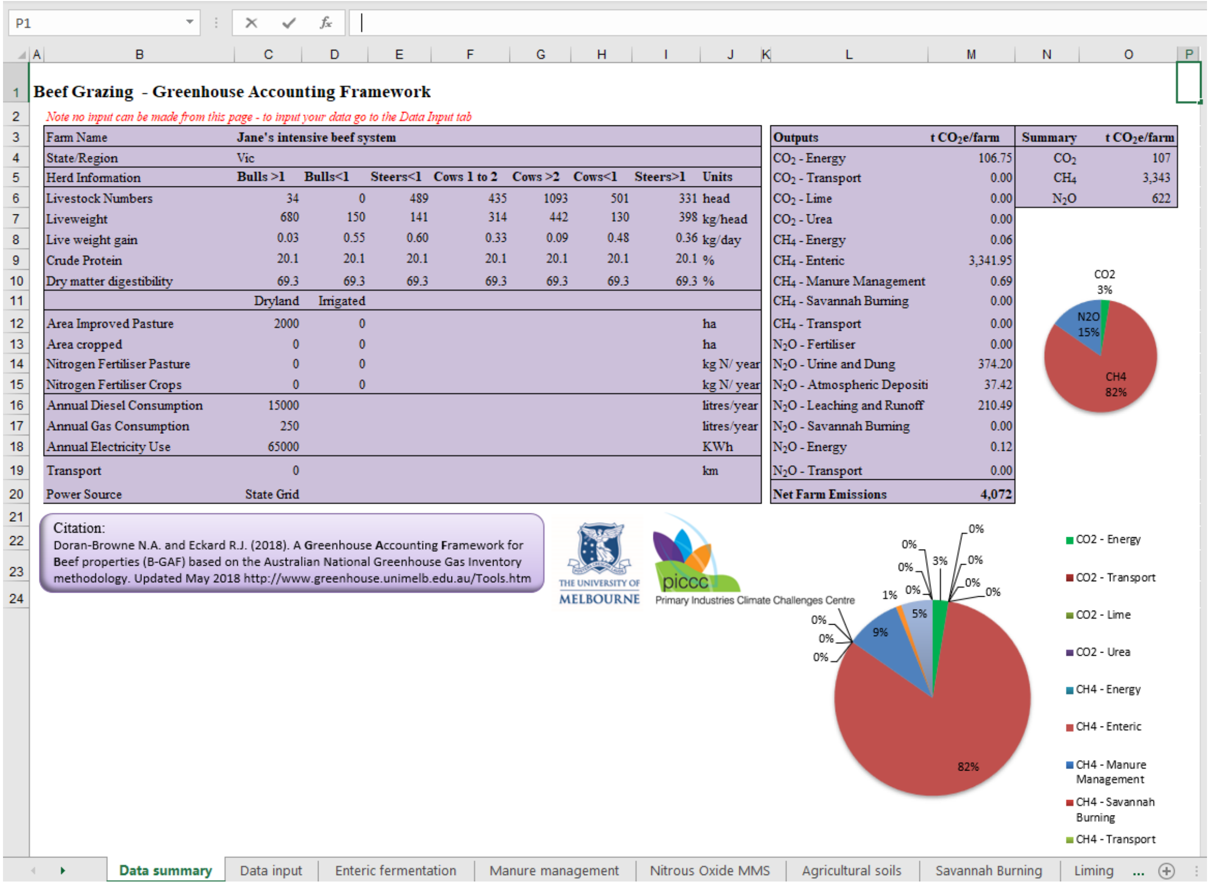
2. Add tree growth calculations from previous GAF versions
3. Change the fertiliser calculations to be more intuitive and require fewer inputs. Add other N fertiliser (other than urea).
4. Remove unnecessary information such as 'sewage sludge' applications.
5. Add inputs for supplementary feed and other major pre-farm emissions (urea, cereal grain, hay, and cotton seed).
6. Necessary changes throughout the calculator to maintain functionality for all the background calculations, and checking to ensure errors have not been generated. All calculations will be checked against the Department of Environment's official test data set.
7. Necessary changes to the summary page, including a section on emission intensity.

4. Results

B-GAF and S-GAF were combined into SB-GAF, allowing mixed enterprises to generate one set of values for their farm. Updates and amendments were made to increase the accuracy of the outputs, allow for benchmarking across farms and to improve the overall user-friendliness of the tool.

The data summary page for the previous B-GAF (V15) calculator can be seen in Fig. 1. The data input page of the S-GAF (V8) used the same format as the B-GAF below.

Figure 1. B-GAF (V15) data summary page



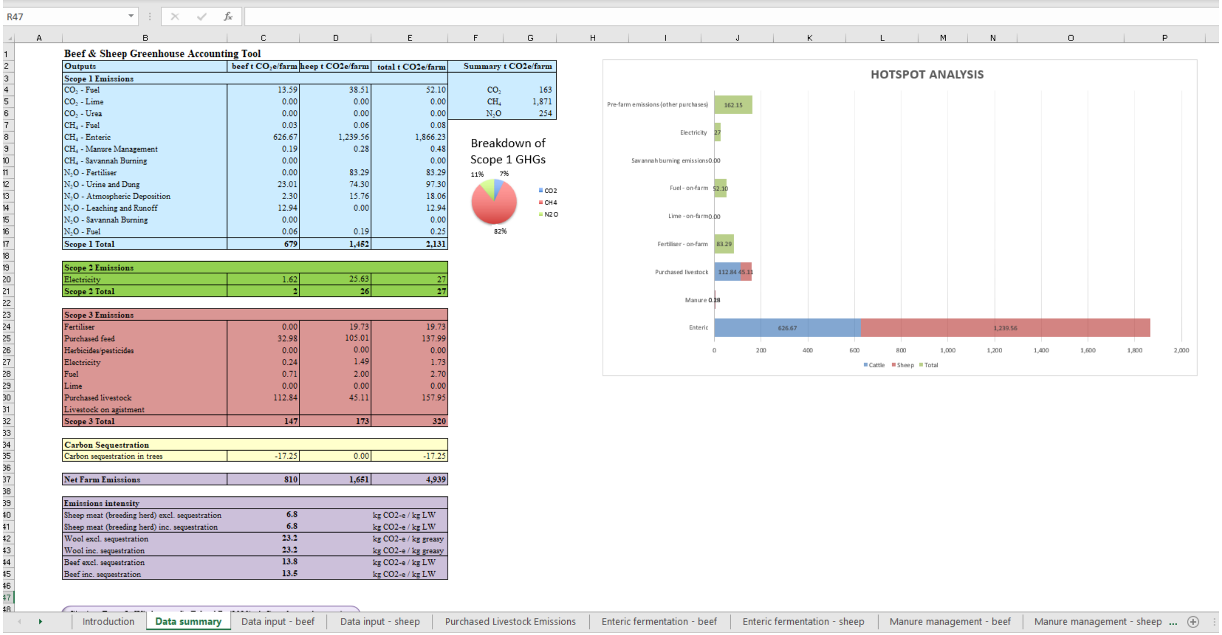
Farm Name	Jane's intensive beef system							
State/Region	Vic							
Herd Information	Bulls >1	Bulls<1	Steers<1	Cows 1 to 2	Cows >2	Cows<1	Steers>1	Units
Livestock Numbers	34	0	489	435	1093	501	331	head
Liveweight	680	150	141	314	442	130	398	kg/head
Live weight gain	0.03	0.55	0.60	0.33	0.09	0.48	0.36	kg/day
Crude Protein	20.1	20.1	20.1	20.1	20.1	20.1	20.1	%
Dry matter digestibility	69.3	69.3	69.3	69.3	69.3	69.3	69.3	%
	Dryland	Irrigated						
Area Improved Pasture	2000	0						ha
Area cropped	0	0						ha
Nitrogen Fertiliser Pasture	0	0						kg N/ year
Nitrogen Fertiliser Crops	0	0						kg N/ year
Annual Diesel Consumption	15000							litres/year
Annual Gas Consumption	250							litres/year
Annual Electricity Use	65000							KWh
Transport	0							km
Power Source	State Grid							

Outputs	t CO_2e/farm
CO_2 - Energy	106.75
CO_2 - Transport	0.00
CO_2 - Lime	0.00
CO_2 - Urea	0.00
CH_4 - Energy	0.06
CH_4 - Enteric	3,341.95
CH_4 - Manure Management	0.69
CH_4 - Savannah Burning	0.00
CH_4 - Transport	0.00
N_2O - Fertiliser	0.00
N_2O - Urine and Dung	374.20
N_2O - Atmospheric Depositi	37.42
N_2O - Leaching and Runoff	210.49
N_2O - Savannah Burning	0.00
N_2O - Energy	0.12
N_2O - Transport	0.00
Net Farm Emissions	**4,072**

Summary	t CO_2e/farm
CO_2	107
CH_4	3,343
N_2O	622

The new data summary page of SB-GAF is shown in Fig. 2. Emissions from beef and sheep are separated and a net emissions value for the farm as a whole is given. It also breaks down emissions sources by scopes as well as by gas for scope 1 emissions. Emissions intensity values for beef, sheep and wool including and excluding carbon sequestration in trees are calculated on the data summary page. These emissions intensity values will allow for benchmarking between farms of different sizes. The livestock summary which featured on the data summary page of the original tools was removed to create more space for the beef outputs, sheep outputs and the emissions intensity section. The pie chart has been replaced with a bar graph which displays both beef and sheep emissions for major hotspots.

Figure 2. New beef/sheep GAF data summary page



Beef & Sheep Greenhouse Accounting Tool

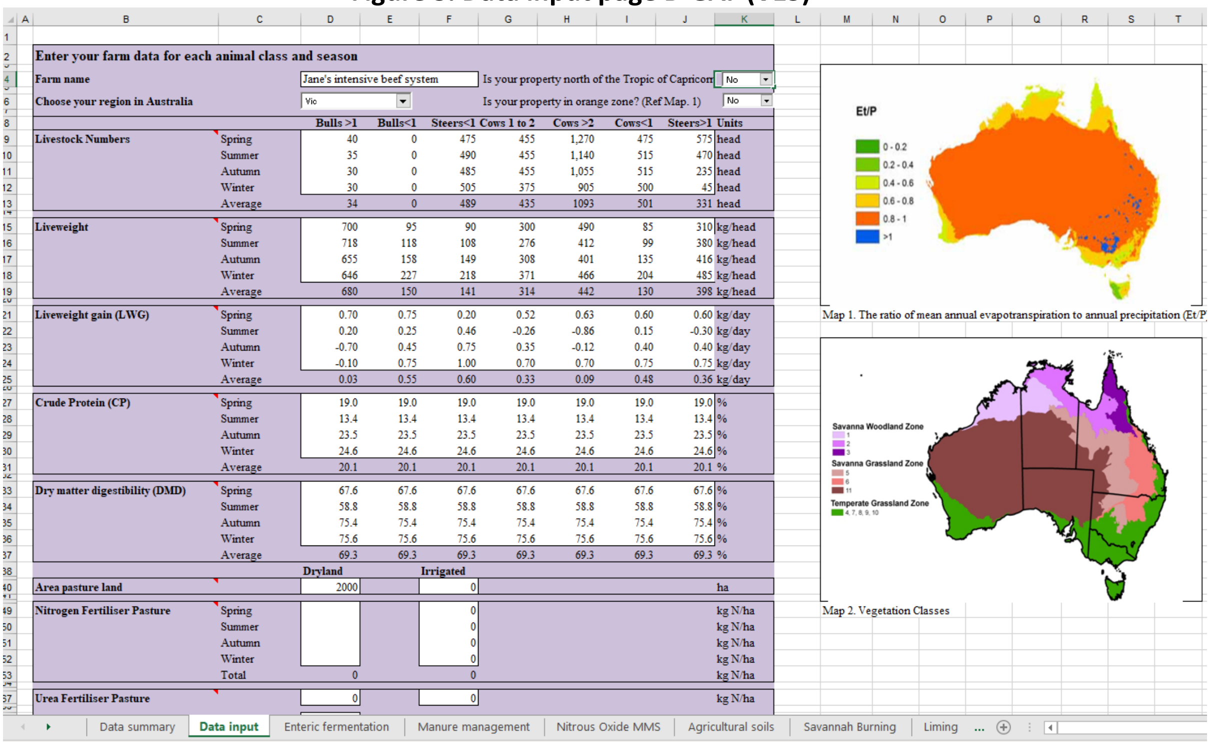
Outputs	beef t CO_2e/farm	heep t CO2e/farm	total t CO2e/farm
Scope 1 Emissions			
CO_2 - Fuel	13.59	38.51	52.10
CO_2 - Lime	0.00	0.00	0.00
CO_2 - Urea	0.00	0.00	0.00
CH_4 - Fuel	0.03	0.06	0.08
CH_4 - Enteric	626.67	1,239.56	1,866.23
CH_4 - Manure Management	0.19	0.28	0.48
CH_4 - Savannah Burning	0.00		0.00
N_2O - Fertiliser	0.00	83.29	83.29
N_2O - Urine and Dung	23.01	74.30	97.30
N_2O - Atmospheric Deposition	2.30	15.76	18.06
N_2O - Leaching and Runoff	12.94	0.00	12.94
N_2O - Savannah Burning	0.00		0.00
N_2O - Fuel	0.06	0.19	0.25
Scope 1 Total	**679**	**1,452**	**2,131**
Scope 2 Emissions			
Electricity	1.62	25.63	27
Scope 2 Total	**2**	**26**	**27**
Scope 3 Emissions			
Fertiliser	0.00	19.73	19.73
Purchased feed	32.98	105.01	137.99
Herbicides/pesticides	0.00	0.00	0.00
Electricity	0.24	1.49	1.73
Fuel	0.71	2.00	2.70
Lime	0.00	0.00	0.00
Purchased livestock	112.84	45.11	157.95
Livestock on agistment			
Scope 3 Total	**147**	**173**	**320**
Carbon Sequestration			
Carbon sequestration in trees	-17.25	0.00	-17.25
Net Farm Emissions	**810**	**1,651**	**4,939**

Summary t CO2e/farm	
CO_2	163
CH_4	1,871
N_2O	254

Emissions intensity		
Sheep meat (breeding herd) excl. sequestration	6.8	kg CO2-e / kg LW
Sheep meat (breeding herd) inc. sequestration	6.8	kg CO2-e / kg LW
Wool excl. sequestration	23.2	kg CO2-e / kg greasy
Wool inc. sequestration	23.2	kg CO2-e / kg greasy
Beef excl. sequestration	13.8	kg CO2-e / kg LW
Beef inc. sequestration	13.5	kg CO2-e / kg LW

The data input page on the B-GAF (V15) can be seen below in Fig.3 and Fig.4.

Figure 3. Data input page B-GAF (V15)



Enter your farm data for each animal class and season

Farm name: Jane's intensive beef system — Is your property north of the Tropic of Capricorn: No

Choose your region in Australia: Vic — Is your property in orange zone? (Ref Map. 1): No

		Bulls >1	Bulls<1	Steers<1	Cows 1 to 2	Cows >2	Cows<1	Steers>1	Units
Livestock Numbers	Spring	40	0	475	455	1,270	475	575	head
	Summer	35	0	490	455	1,140	515	470	head
	Autumn	30	0	485	455	1,055	515	235	head
	Winter	30	0	505	375	905	500	45	head
	Average	34	0	489	435	1093	501	331	head
Liveweight	Spring	700	95	90	300	490	85	310	kg/head
	Summer	718	118	108	276	412	99	380	kg/head
	Autumn	655	158	149	308	401	135	416	kg/head
	Winter	646	227	218	371	466	204	485	kg/head
	Average	680	150	141	314	442	130	398	kg/head
Liveweight gain (LWG)	Spring	0.70	0.75	0.20	0.52	0.63	0.60	0.60	kg/day
	Summer	0.20	0.25	0.46	-0.26	-0.86	0.15	-0.30	kg/day
	Autumn	-0.70	0.45	0.75	0.35	-0.12	0.40	0.40	kg/day
	Winter	-0.10	0.75	1.00	0.70	0.70	0.75	0.75	kg/day
	Average	0.03	0.55	0.60	0.33	0.09	0.48	0.36	kg/day
Crude Protein (CP)	Spring	19.0	19.0	19.0	19.0	19.0	19.0	19.0	%
	Summer	13.4	13.4	13.4	13.4	13.4	13.4	13.4	%
	Autumn	23.5	23.5	23.5	23.5	23.5	23.5	23.5	%
	Winter	24.6	24.6	24.6	24.6	24.6	24.6	24.6	%
	Average	20.1	20.1	20.1	20.1	20.1	20.1	20.1	%
Dry matter digestibility (DMD)	Spring	67.6	67.6	67.6	67.6	67.6	67.6	67.6	%
	Summer	58.8	58.8	58.8	58.8	58.8	58.8	58.8	%
	Autumn	75.4	75.4	75.4	75.4	75.4	75.4	75.4	%
	Winter	75.6	75.6	75.6	75.6	75.6	75.6	75.6	%
	Average	69.3	69.3	69.3	69.3	69.3	69.3	69.3	%

		Dryland	Irrigated	Units
Area pasture land		2000	0	ha
Nitrogen Fertiliser Pasture	Spring		0	kg N/ha
	Summer		0	kg N/ha
	Autumn		0	kg N/ha
	Winter		0	kg N/ha
	Total	0	0	kg N/ha
Urea Fertiliser Pasture		0	0	kg N/ha

Figure 4. Data input page B-GAF (V15) (continued)

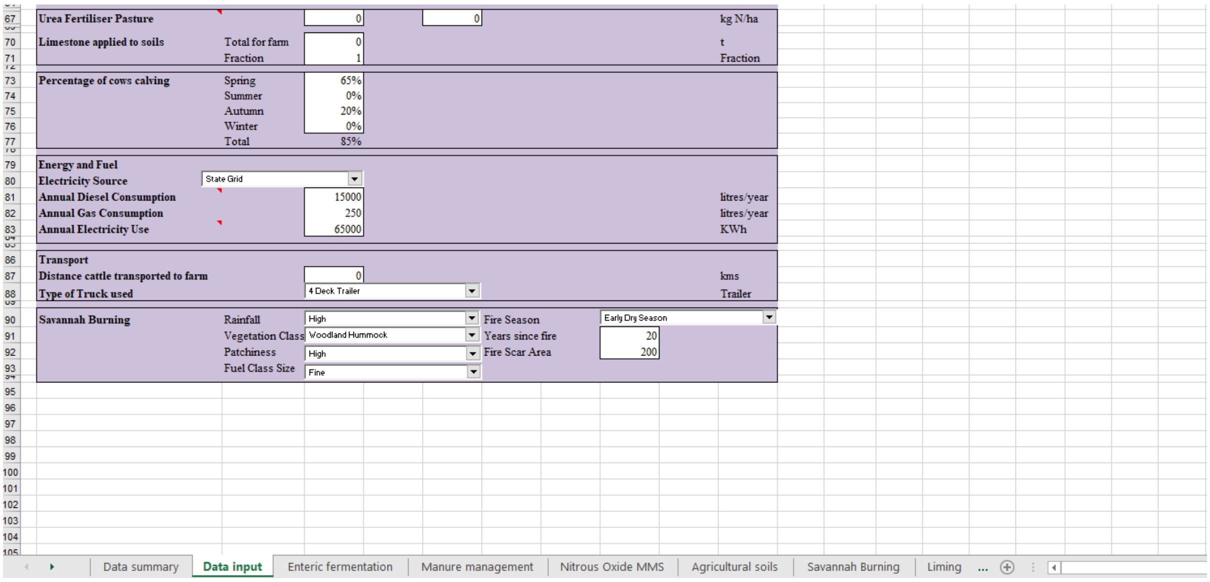


Fig.5 and Fig.6 show the new data input page for beef cattle in SB-GAF. On the data input page for both beef and sheep, additional livestock categories were added for the breeding herd and a separate section for trade animals was included. A sales inventory, purchase inventory and liveweight (LWG) section were added to calculate emissions intensity. State default values for crude protein and dry matter digestibility automatically populate these sections based on the region selected to simplify the data input process and limit inaccuracies. The input section for fertiliser was simplified to include an input section for urea fertiliser (pasture or crops and dryland or irrigated) and a section for other nitrogen fertiliser (pasture or crops and dryland or irrigated). Additional inputs such as superphosphate, herbicide/pesticides and purchased feed such as grain, cottonseed and hay were added as many producers commented on the lack of incorporation of these commonly used inputs. Gas was replaced with petrol as the consumption of petrol on-farm is typically greater and more common than that of gas. The transport section was removed to avoid confusion and a note was added on the diesel input cell clarifying what is required in that section to ensure transport is accounted for. The vegetation section from the FarmGAS tool was incorporated into the calculator as it is more comprehensive than the vegetation section included in previous versions of B-GAF and S-GAF.

Figure 5 - Data input page - beef page in SB-GAF

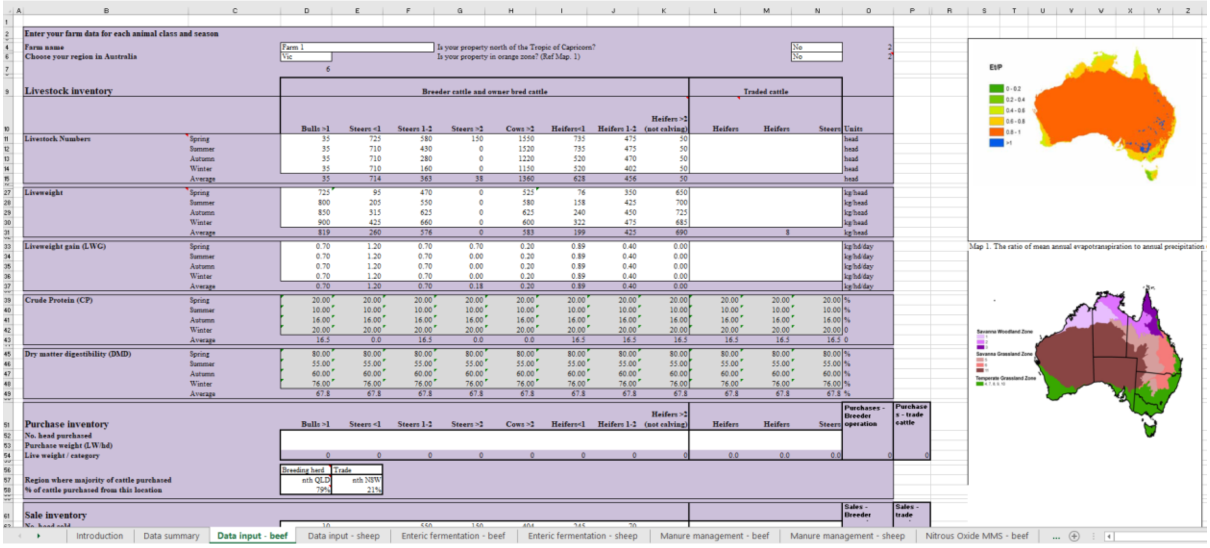
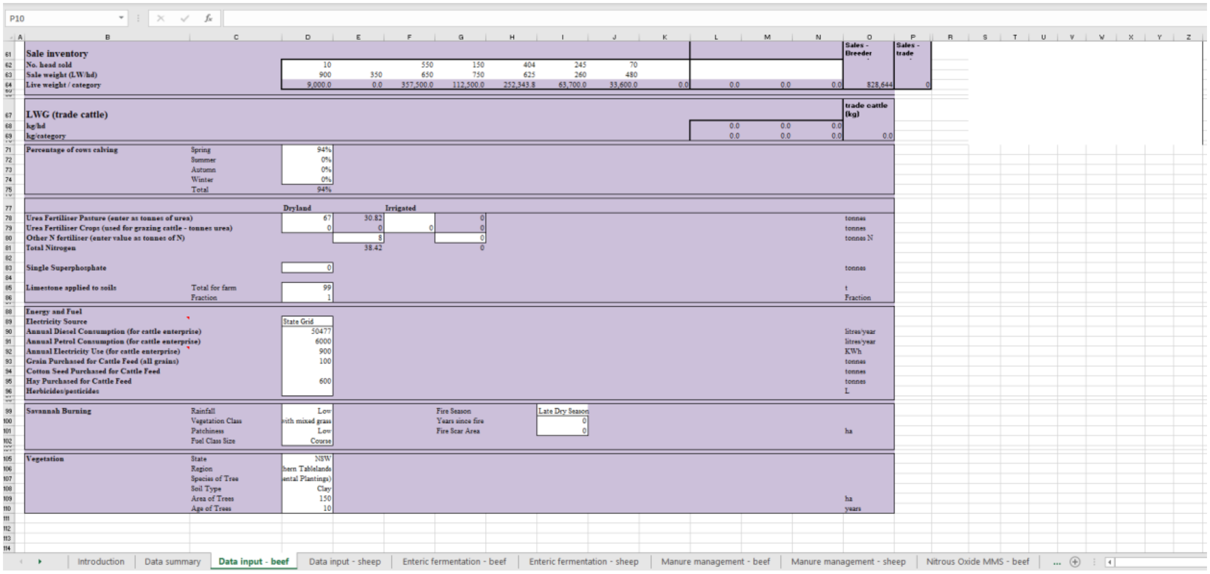


Figure 6 Data input page - beef in SB-GAF (continued)



Formulas for nitrogen retention, nitrogen excreted in urine, and nitrogen excreted in the faeces on the nitrous oxide page were updated in accordance with the *National Inventory Report 2018* (Commonwealth of Australia, 2020). Global warming potential factors were updated and are linked throughout the spreadsheet (IPCC, 2014). The sewage sludge sections on the agricultural soils pages were removed and these pages were simplified to only include the necessary information. Fertiliser calculations were modified to be more intuitive and require fewer inputs.

Emissions from purchased livestock are now accounted for in the calculator and reported under scope 3 emissions. For cattle this is based on region of origin and for sheep it is based on breed (Merino or cross-bred). An embedded emissions page was added to calculate scope 3 emissions from urea fertiliser, single superphosphate fertiliser, purchased feeds, and herbicides/pesticides. Electricity and fuel calculations are now derived from *National Greenhouse Gas Accounts* 2019, which separates GHG emissions from fuel and electricity into the relevant scopes (Commonwealth of

Australia, 2019). Other necessary changes were made throughout the calculator to maintain the functionality of background calculations.

The emissions intensity values generated by the calculator when using accurate and representative farm data for stable, self-replacing herds and flocks were within the ranges of those reported in the literature. Using data from a Western Australian sheep enterprise, the calculator generated an emissions intensity of 7.5 kg CO2-e/kg LW for sheep meat and 25.9 kg CO2-e/kg for greasy wool. These values were comparable to values reported in the literature (Wiedemann *et al.*, 2016). Reliable data from a NSW beef cattle enterprise was used to populate the beef data input page of the calculator, generating emissions intensity value of 8.9 kg CO2-e/kg LW, which is slightly lower than those reported by Wiedemann *et al.* (2015) for beef cattle enterprises in NSW. However, this enterprise is highly productive and efficient so a slightly lower emissions intensity value could be expected. The GHG profile generated by the calculator for scope 1 emissions for both of these farms was within the range typical of a ruminant livestock enterprise (methane 80-90%, nitrous oxide 11-7% and carbon dioxide ~3%). Based on our experience, the net farm emissions and emissions intensity generated by SB-GAF are expected to be accurate to within ± 20%. The accuracy of results generated by this calculator are highly dependent on the quality and accuracy of data entered. The most accurate and useful outputs are generated using data representative of an enterprise (based on an average year or an average across multiple years) in which the herd or flock is stable and self-replacing.

5. Conclusion

5.1 Key findings

Notable improvements include the SB-GAF data summary page, which provides a breakdown of emission sources for both beef and sheep and provides net farm emissions. Emissions are broken down by scopes and by gas for scope 1 emissions. Emissions associated with a range of inputs, including purchased livestock can now be estimated to produce a scope 3 emission estimate and carbon footprint. Emissions intensity values for beef, sheep meat and wool both including and excluding vegetation sequestration are displayed on the SB-GAF data summary page, allowing benchmarking between farms of different sizes. A new graph was generated to show emission hotspots.

SB-GAF includes additional livestock categories for both the breeding herd and traded animals on the data input pages. A sales inventory, purchase inventory and liveweight gain section were added to allow for the generation of emissions intensity values. Additional inputs such as fertiliser, purchased feeds, herbicides and pesticides were added to the input page and the relevant background calculation sheets were developed. New fuel and electricity worksheets were developed to differentiate between scope 1,2, and 3 emissions. Emissions from purchased livestock were also captured in the tool. The vegetation section from the FarmGAS tool was incorporated in SB-GAF to generate emission intensities with and without carbon sequestration. Modifications to background calculations were made throughout the spreadsheet to support all updates and ensure the functionality of the spreadsheet was maintained.

5.2 Benefits to industry

These modifications to the emissions calculators will allow for improved accuracy in baseline carbon accounts for beef and sheep farms.

6. Future research and recommendations

To further increase the user friendliness of the interface of the tool and to simplify the process for producers future modifications are needed. These modifications include:

- Modifying the livestock inventory section on the data input pages to be monthly rather than seasonal;
- Simplification of the input pages to ensure each set of data is only entered once;
- Adding an input section for cattle and sheep on agistment;
- A more expansive lists of purchased farm inputs;
- A much wider range of values for purchased livestock from different regions would be beneficial, seeing this is known to vary substantially across the country;
- Integration of a system into the tool to flag user input errors; and
- Assessment of new components in the NIR (emissions from farm dams, for example).

We note that the accuracy of the calculator is highly dependent on the quality of the data and the precision of input. We recommend the new SB-GAF tool be made available to beef and sheep producers in conjunction with the Carbon Accounting Training Manual (V.SCS.0016, which will be available later in 2020) to assist in the generation of accurate farm carbon accounts.

The modifications made will allow for improved accuracy in baseline carbon accounts for beef and sheep farms in the future, though further, more substantial revisions would also be beneficial to address remaining limitations with the tool that could not be addressed in the current project.

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