Resource use and environmental impacts from Australian export lamb production: a life cycle assessment

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Supplementary Material

System Separation and disaggregation of expenditure data for the RAF analysis

The ABARES survey collects farm expenditure data, grouped into broad categories and aggregated for the whole farm. Three steps were taken to determine impacts for products associated with the sheep system, i) expenditure was divided between farm sub-systems (cropping, beef cattle, sheep), ii) expenditure was separated into individual product types (e.g. "fertiliser" was divided into Urea and superphosphate etc), and iii) expenditure was converted to product mass based on product value.

Inputs were first separated between sub-systems where this was unambiguous. For example, expenditure for fodder and animal health products were directed to livestock (sheep and cattle) not cropping. For expenditure items divided across cropping and livestock such as fuel and fertiliser, these inputs were divided by first estimating fuel and fertiliser requirements for cropping field operations and removing these from the total. Remaining fertiliser was assumed to be superphosphate or lime, based on the CSF dataset and (ABS 2014) and together with the remaining fuel was attributed to livestock. Crop fuel and fertiliser requirements were determined from the total hectares and yield of crop grown on-farm reported for specialist lamb producers in the ABARES survey. Yields were considerably lower on the specialist lamb farms than specialist grain farms in the ABARES dataset, and made up a much smaller proportion of total land occupation. Estimated fertiliser and fuel requirements were determined for the cropping system using assumptions from Wiedemann *et al.* (2010) adjusted to 20 L / ha because of lower reported crop yields and subsequent reduced machinery operations for harvest and grain handling. Fertiliser rates were 52.8, 40.6 and 51.7 kg Urea / ha and 30.9, 24.1 and 30.3 kg MAP / ha, which were adjusted for lower crop yields by matching crop nitrogen and phosphorus requirements to fertiliser applications. Chemical use was assumed to be 4 L / ha glyphosate, 1 L / ha 2,4,D and 0.7 L / ha MCPA per hectare(NSW DPI 2010). Fuel and fertiliser inputs associated with cropping on specialist sheep farms were lower on a per hectare basis compared to previously reported grain LCA data (Brock *et al.* 2012) but impacts were higher per tonne, reflecting the lower productivity associated with reduced yields.

Relative proportions of different products within each expenditure category were determined using data from the CSF dataset either on a state-by-state basis if sufficient data were available, or aggregated across all regions. Expenditure was converted to product mass using unit price values typical of the analysis period (2009-2010).

Table S1. Factors used to disaggregate expenditure data for major items in the ABARES dataset

ABARES expenditure categories ($)	Production sub-system utilising product	Product [A]	Proportion of total expenditure			Unit price, $ per tonne or $ per L
			VIC	NSW	SA	
Fertiliser [A]	Cropping	Urea	0.25	0.31	0.26	450
	Cropping	MAP	0.22	0.21	0.23	700
	Livestock	Superphosphate	0.52	0.46	0.51	330
	Livestock	Lime [B]	0.02	0.01	0.00	40
Fuel, oil and lubricants	Cropping	Diesel	0.33	0.43	0.30	1.09 [C]
	Livestock	Diesel	0.52	0.42	0.55	
	Cropping	Oil	0.04	0.05	0.04	3.00
	Livestock	Oil	0.01	0.00	0.01	
	Livestock	Petrol	0.10	0.10	0.10	1.41
Crop and pasture chemicals	Cropping	Glyphosate	0.48	0.61	0.41	4.97
	Livestock	Glyphosate	0.14	0.07	0.24	
	Cropping	2, 4, D	0.12	0.14	0.09	5.15
	Livestock	2, 4, D	0.09	0.14	0.16	
	Cropping	MCPA	0.17	0.05	0.09	10.00
Livestock materials [D]	Livestock	Drenches	1.00	1.00	0.00	
Fodder [D E]	Livestock	Hay		0.40		250
	Livestock	Protein grain		0.30		300
	Livestock	cereal grain		0.30		300
Overheads [D E]		Accounting		0.20		n.a [F]
		Electricity		0.12		0.27
		Insurance		0.36		n.a [F]
		Communications		0.13		n.a [F]
		Other admin expenses		0.19		n.a [F]
Relative proportion of sheep and cattle [D]	sheep		0.85	0.83	0.77	
	cattle		0.15	0.17	0.23	
Relative proportions of sub-systems based on land occupation used [G]	cropping		0.29	0.12	0.15	
	sheep		0.60	0.73	0.65	
	cattle		0.11	0.15	0.19	

[A] Most common cropping fertilisers are Urea and Ammonium Phosphates (assumed to be MAP) – ABS (2009).

[B] Insufficient data were available to determine lime inputs from the CSF dataset and these were instead determined from lime relative to total fertiliser, reported by ABS (2014).

[C] Diesel unit price quoted after off-road fuel rebate of 38c/L.

[D] Livestock inputs divided on the basis of relative DMI.

[E] Insufficient data were available in the CSF dataset to apply state-specific ratios for these parameters. An average across all regions based on CSF data was applied.

[F] Not applicable. These inputs were modelled from economic input-output inventories from expenditure and did not require market value data.

[G] Fractions used to apportion overheads

Economic allocation between greasy wool and sheep live weight

Economic allocation between greasy wool and sheep live weight was calculated based on sales of each product obtained from individual farms or verified against ABARES sales record.

Table S2. Factors used to determine economic allocation of sheep live weight for the case study farms (CSF) and regional average farms (RAF) from Victoria (VIC), New South Wales (NSW) and South Australia (SA)

	Unit	VIC CSF	VIC RAF	NSW CSF	NSW RAF	SA CSF	SA RAF
Lamb sale value	$/hd	116	97	102	89	95	93
Sheep sale value	$/hd	71	59	54	63	83	63
Lambs sold	no. yr	1906	936	1602	876	1293	842
Sheep sold	no. yr	523	310	748	295	1146	277
Wool sale value	$/kg greasy	3.3	4.3	5.2	4.8	6.8	4.6
Wool sold	kg greasy	18263	8185	13557	8972	29858	7695
Total sheep sales	$	257790	109056	210620	96482	218249	96243
Total wool sales	$	60783	35014	73072	43416	203036	35061

Feedlot ration composition

Table S3. Composition of feedlot ration used in VIC and SA lamb feedlots

Commodity	kg per t ration
Barley	693.9
Field Peas	140
Lime	10
Minor Additives	1.1
Vegetable oil	5
Sheep Pellets	120.0
Agrliq supplement	30

Environmental impacts per kg of greasy wool

To improve the transparency of the analysis, results are also presented for greasy wool in Table S4.

Table S4. Resource use and environmental impacts per kilogram of greasy wool at the farm gate as a co-product for lamb produced from the case study farms (CSF) and regional average farms (RAF) from Victoria (VIC), New South Wales (NSW) and South Australia (SA)

Impact/indicator	VIC CSF	VIC RAF	NSW CSF	NSW RAF	SA CSF	SA RAF
Global warming (kg CO_2-e)	19.6	22.4	22.1	23.1	19.1	20.5
Fossil energy (MJ)	17.3	19.4	10.9	17.1	7.9	22.4
Fresh water consumption (L)	176.8	691.0	182.9	620.4	311.5	741.4
Stress weighted water (L H_2O-e)	18.8	275.7	65.6	437.1	9.1	27.0
Arable land (m^2yr)	3.7	4.0	6.4	3.0	0.8	4.5

References

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