



A discussion on the availability of life-cycle assessment studies in New Zealand

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Abstract

Purpose In order to understand the environmental impacts of various products, processes, or services, it should be possible to obtain life-cycle assessment (LCA) reports quickly and easily without having to delve into restricted access or hidden databases. The aim of this study is to assess the availability of environmental LCAs, water footprinting, and carbon footprinting studies conducted in New Zealand.

Methods To review the quantitative availability of life-cycle assessment studies for New Zealand, simple online searches were performed using the Google and Google Scholar search engines. Additionally, ScienceDirect and Scopus were used to determine the availability of other peer-reviewed LCA-related reports.

Results and discussion For the period under review, 20 documents were publicly available. Additionally, other searches conducted via ScienceDirect, Scopus and Google Scholar yielded a further 15 restricted documents. The results included data carbon- and water footprinting studies. The number of LCAs and carbon footprinting reports both exceeded those of water footprinting.

Conclusions Over 35 studies were available through Internet searches. This number excludes wool which had six results (Scopus only) and many more through Google. These were not included due to possible repetition and miscounting of results.

Keywords Carbon footprinting · Global reporting initiative · Life-cycle assessment · New Zealand · Water footprinting

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1 Introduction

The aim of this study was to determine the availability of online environmental assessments such as LCAs, carbon- and water footprinting studies conducted in New Zealand between the years 2006 and 2015.

New Zealand is comprised of a number of islands mostly located just under 1800 km to the southeast of Australia. The total area of the country is roughly 268,000 km² and includes mountain chains which affect the local climate and weather patterns. The temperate and subtropical climates, with regional shifts, allows large amounts of arable land to be used for agriculture, aided by the 600–1600 mm annual rainfall for most of the regions (NIWA 2001).

New Zealand has a large export base; founded in the agricultural, horticultural, forestry, mining, and fishing sectors. However, the country has had environmental difficulties with deforestation and soil erosion along with invasive fauna and flora (US CIA 2016). Nevertheless, the New Zealand Government agreed that sustainable development in the

various facets of its economic as well as social and environmental policies should be underpinned. As such, it was clear that environmental issues, although limited in their expected severity, are to be studied, prevented, and remediated. The Environmental Protection Authority was tasked to review proposals regarding environmental decisions which are of national significance (New Zealand Government 2012).

Life-cycle assessments (LCAs) and carbon- and water footprinting are commonly utilized tools to analyze the environmental impacts of products or services. However, it is important that this data is readily available (Maepa et al. 2017; Bodunrin et al. 2018; Burman et al. 2018) and can be obtained by both local non-specialists and international LCA practitioners. Given the varied and important economic basis of the country, the work presented here therefore aimed to quantitatively determine the availability of life-cycle assessment studies (obtained via LCA and carbon- and water footprint studies) conducted in New Zealand.

2 Methods

To initiate the study, online searches were performed to find recent studies (2006–2015) using non-exclusive combinations of the keywords “life-cycle assessment,” “water footprinting,” “carbon footprinting,” and “New Zealand.” Search engines such as Google and Google Scholar were utilized to ascertain the ease of access to the various literature without the need for academic or government affiliation. Since New Zealand is one the of the largest wool exporters in the world, it was notable that public LCAs for wool, were easily obtained by simple Google searches (Henry 2012). These studies were excluded in quantitative

results as it was noted that many of these studies may have been repeated or were not full LCA studies.

Additionally, to find more restricted and peer-reviewed journal articles, advanced searches on ScienceDirect and Scopus were performed. The search was restricted to documents published in English, for assessments conducted in New Zealand. This excluded studies conducted by researchers from New Zealand but which were not conducted within the borders of New Zealand. Furthermore, assessments undertaken for environmental products imported into New Zealand were not considered for the purposes of this study. Other life-cycle-related studies such as life-cycle costing and social life-cycle assessment studies were also excluded from this study. Lastly, only first click results were included in the findings, i.e., anything that required a user to do additional searches on secondary pages were not included here as these should have been found via the original searches.

3 Results

3.1 Overall

From the searches completed, a total of 35 documents were found and listed. Of these, 14 were LCAs (Table 1), 13 were carbon footprints (Table 2), and 8 were water footprints (Table 3).

The results listed in Tables 2 and 3 contain both publicly available results, which are easily found using simple online searches (and yielded a total of 20 entries), as well as generally restricted academic journal articles which require payment to access (which made up the remaining 15 entries).

Table 1 Summary of LCA results for New Zealand

	Product	Year	Availability	Document type	Reference
1	Analogous exemplar house designs	2010	Public	Journal article	(McDevitt and Allison 2013)
2	Diesel	2011	Public	Contracted report	(Mcdevitt and Seadon 2011)
3	Fertilizer	2011	Public	Report	(Ledgard et al. 2011b)
4	NMIT Arts and Media Building	2011	Public	Contracted report	(John et al. 2011)
5	Wine	2011	Public	Thesis	(Barry 2011)
6	Construction	2012	Public	Journal article	(Mcdevitt et al. 2012b)
7	Multi-story buildings	2013	Public	Professional paper	(Buchanan et al. 2013)
8	Biosolids	2013	Public	Open access journal article	(McDevitt et al. 2013)
9	Apple	2006	Restricted	Journal article	(Milà et al. 2006)
10	Reinforced polypropylene composites	2008	Restricted	Journal article	(Xu et al. 2008)
11	Milk	2009	Restricted	Journal article	(Basset-Mens et al. 2009a)
12	Milk	2009	Restricted	Journal article	(Basset-Mens et al. 2009b)
13	Milk and beef	2012	Restricted	Journal article	(Flysjö et al. 2012)
14	Various manufacturing companies	2013	Restricted	Journal article	(Coelho and McLaren 2012)

Table 2 Summary of carbon footprint results for New Zealand

	Product	Year	Availability	Document type	Reference
1	Berryfruit	2009	Public	Project report	(Sinclair 2009)
2	Apple	2009	Public	Project report	(McLaren et al. 2009)
3	Berryfruit	2010	Public	Contracted project report	(Hume et al. 2010)
4	Lamb	2010	Public	Contracted report	(Ledgard et al. 2010)
5	Laminated veneer lumber	2010	Public	Research report	(Love 2010)
6	Forestry	2010	Public	Project report	(Sandilands and Nebel 2010)
7	Coolstores	2011	Public	Inventory report	(McLaren et al. 2011b)
8	Kiwifruit	2012	Public	Project report	(Holmes et al. 2012)
9	Beef	2012	Public	Contracted report	(Liefvering et al. 2012)
10	Milk	2011	Restricted	Journal article	(Flysjö et al. 2011)
11	Orchard soil	2012	Restricted	Journal article	(Deurer et al. 2012)
12	Agricultural products	2013	Restricted	Journal article	(Reisinger and Ledgard 2013)
13	Lamb	2014	Restricted	Journal article	(Ledgard et al. 2011a)

During the study, it was also found that online websites, such as that of the New Zealand Lifecycle Management Centre (LCM NZ 2016) reported comprehensive, mixed lists of relevant LCAs as well as water and carbon footprinting studies; however, no direct Internet links to these studies were given. Therefore, the various listed publications were individually searched to determine their online availability.

Over 57% of the literature were related to the main export products of New Zealand, which included live-stock products and agricultural products. Of the studies listed, only 20 studies were available for public access; however, not all the papers listed on websites were obtainable, mainly due to restricted access to government or business files, or due to the fact that the studies were not listed anywhere else online. The academic articles listed were easily obtainable by means of ScienceDirect, Scopus, or Google Scholar. Two academic studies were listed which were still under review, and as such, were not available from these sites. A total of 65% of the publicly available work was conducted for industrial and

agricultural businesses as well as for the New Zealand government; hence, many contracted reports were present. These studies were predominantly conducted on behalf of other entities by institutions that included Landcare Research, Scion, AgResearch, and Massey University.

Including a limited Scopus search for “LCA and ‘New Zealand’ and wool” gave six documents for the period (Haropoulou et al. 2013; Hassan 2015; Hassan et al. 2015; Henry et al. 2015; Wiedemann et al. 2015a; Wiedemann et al. 2015b). Half of these were books, and it was not clear how many were strictly for New Zealand since there was mention of global, US and Australian wool and meat supply.

3.2 Publicly available reports

Of the LCAs (Table 1), 57% were found to be publicly available as compared to 69% for carbon footprinting studies (Table 2) and 37.5% for water footprinting (Table 3). Of the publicly available LCAs, 50% were linked to the construction/structure design sector and 62.5% were academically aligned. As many as 44% of the carbon footprinting and 67% of water

Table 3 Summary of water footprint results for New Zealand

	Product	Year	Availability	Document Type	Reference
1	Kiwifruit	2011	Public	Contracted report	(Hume et al. 2011)
2	Merino sheep	2011	Public	Article	(McLaren et al. 2011a)
3	Agricultural products	2013	Public	Thesis	(Herath 2013)
4	Hydroelectricity	2011	Restricted	Journal article	(Herath et al. 2011)
5	Tissue paper	2012	Restricted	Journal article	(Mcdevitt et al. 2012a)
6	Dairy	2012	Restricted	Journal article	(Zonderland-Thomassen and Ledgard 2012)
7	Wine	2013	Restricted	Journal article	(Herath et al. 2013b)
8	Wine	2013	Restricted	Journal article	(Herath et al. 2013a)

footprinting studies were based on agricultural products. While the carbon footprints were not strictly academically based, 67% of the water footprints were from academic institutes.

3.3 Restricted access reports

Of the LCAs' 43% restricted access studies, 67% were based on consumable products such as apples, dairy, and meat. Of the carbon footprinting studies, 31% were restricted, of which 75% were of consumable products. Finally, 63% of the water footprinting studies were restricted and 60% related to consumable products. A graphical comparison of the total publicly available studies versus the total restricted access studies for all the life-cycle management segments can be seen in Fig. 1.

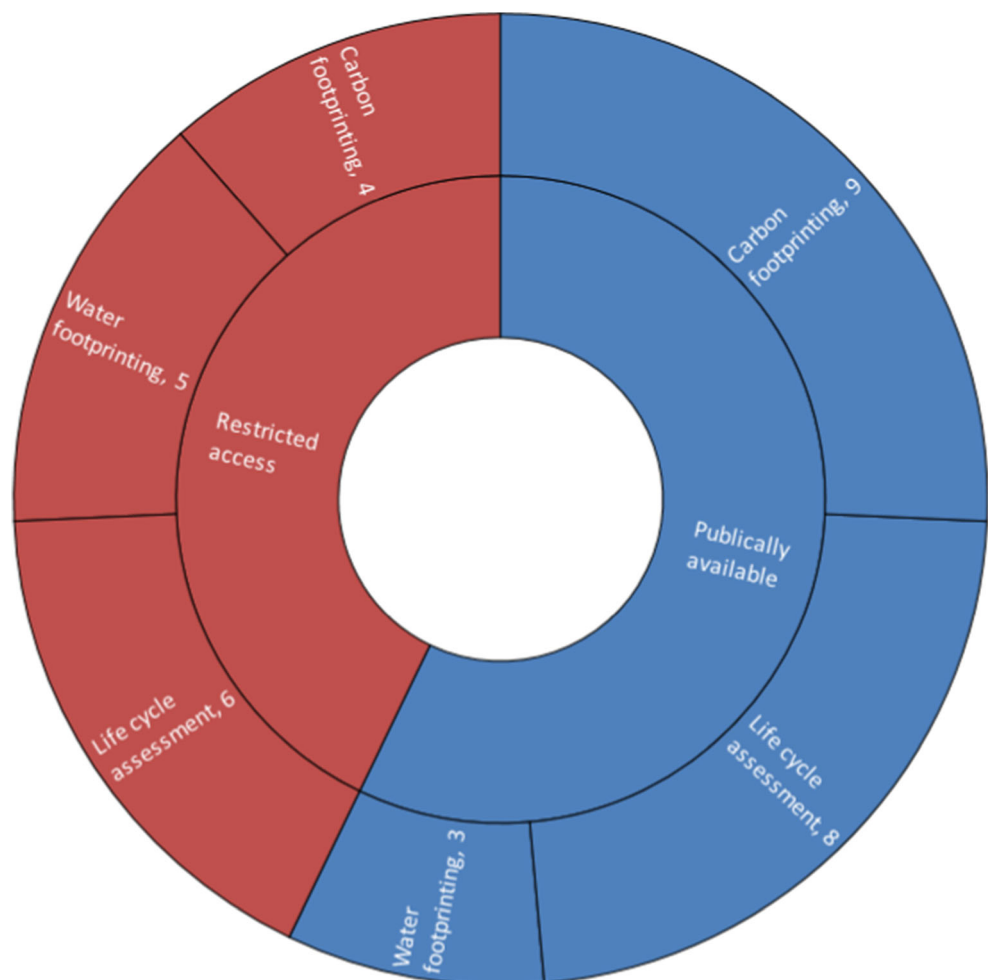
4 Discussion

A total of 35 environmental assessments studies were located. This included LCAs and water and carbon footprinting studies conducted in New Zealand for the period 2006–2015. Most

(18 from 22 studies) of the LCAs and water footprinting studies found were academically aligned. Conversely, the majority (9 from 13 studies) of carbon footprinting studies were seen to be contracted either by the New Zealand government, businesses, or was part of a joint venture between the government and specific industries. Specifically, it was seen that the larger production centers' data, such as that for milk, beef, and lamb, as well as for kiwifruit, was generally easier to obtain than for other products. There were fewer documents found for water footprinting cases as compared to those for LCAs and carbon footprinting, i.e., 8 water footprinting studies compared to 14 LCA and 13 carbon footprinting studies (Fig. 1).

The authors are also aware that roughly 12 datasets are available for New Zealand in the Ecoinvent database (v3.0, e.g., “allocation at point of substitution—unit,” excluding the potential duplicate sets in system and consequential datasets). Of these, five were for energy (electricity) and five for land use. The remaining studies were both for onion production. Additionally, we were aware of the “Life Cycle Association of New Zealand” (LCANZ), which also had case studies listed on their website. However, unless these were accessed via the search engine methods as outlined above, they were not

Fig. 1 Publicly available results versus restricted access results



included in the results, since they would not have been found through single click search result links.

5 Conclusions

The quantitative availability of LCAs and water- and carbon footprinting was investigated. The main objective of the study was to determine the accessibility of environmental LCA and related assessments (water and carbon footprinting studies) that were conducted in New Zealand.

Apart from wool, which had much data (Henry 2012), over 20 studies of publicly available documents were available through Google searches. However, many other studies (15) were restricted to academic journal papers, which often required that a paid subscription was needed to access them. More than 57% of the studies were for the export sector of New Zealand.

References

- Barry MT (2011) Life cycle assessment and the New Zealand wine industry: a tool to support continuous environmental improvement. Massey University. Available at: http://mro.massey.ac.nz/bitstream/handle/10179/2920/02_{ }whole.pdf?sequence=1
- Basset-Mens C, Kelliher FM, Ledgard S, Cox N (2009a) Uncertainty of global warming potential for milk production on a New Zealand farm and implications for decision making. *Int J Life Cycle Assess* 14(7):630–638
- Basset-Mens C, Ledgard S, Boyes M (2009b) Eco-efficiency of intensification scenarios for milk production in New Zealand. *Ecol Econ* 68(6):1615–1625
- Bodunrin MO, Burman NW, Croft J, Engelbrecht S, Goga T, Ladenika AO, MacGregor OS, Maepa M, Harding KG (2018) The availability of life-cycle assessment, water footprinting and carbon footprinting studies in Brazil. *Int J Life Cycle Assess*. <https://doi.org/10.1007/s11367-018-1484-2>
- Buchanan A, John S, Love S (2013) Life cycle assessment and carbon footprint of multistorey timber buildings compared with steel and concrete buildings. *N Z J For* 57(4):9–18
- Burman NW, Croft J, Engelbrecht S, Ladenika AO, MacGregor OS, Maepa M, Bodunrin MO, Harding KG (2018) Review: life-cycle assessment, water foot printing and carbon foot printing in Portugal. *Int J Life Cycle Assess* <https://doi.org/10.1007/s11367-018-1483-3>
- Coelho CRV, McLaren SJ (2012) Rethinking a product and its function using LCA—experiences of New Zealand manufacturing companies. *Int J Life Cycle Assess* 18(4):872–880
- Deurer M, Müller K, Kim I, Huh KY, Young I, Jun GI, Clothier BE (2012) Can minor compaction increase soil carbon sequestration? A case study in a soil under a wheel-track in an orchard. *Geoderma* 183–184:74–79
- Flysjö A, Cederberg C, Henriksson M, Ledgard S (2011) How does co-product handling affect the carbon footprint of milk? Case study of milk production in New Zealand and Sweden. *Int J Life Cycle Assess* 16(5):420–430
- Flysjö A, Cederberg C, Henriksson M, Ledgard S (2012) The interaction between milk and beef production and emissions from land use change—critical considerations in life cycle assessment and carbon footprint studies of milk. *J Clean Prod* 28:134–142
- Haropoulou M, Smallman C, Radford J (2013) Supply chain management and the delivery of ecosystem services in manufacturing. In: *ecosystem services in agricultural and urban landscapes*, pp 157–177
- Hassan MM (2015) Sustainable processing of luxury textiles. *Handbook of sustainable luxury textiles and fashion*, 1, pp 101–120
- Hassan MM, Schiermeister L, Staiger MP (2015) Sustainable production of carbon fiber: effect of cross-linking in wool fiber on carbon yields and morphologies of derived carbon fiber. *ACS Sustain Chem Eng* 3(11):2660–2668
- Henry B (2012) Understanding the environmental impacts of wool: a review of life cycle assessment studies understanding the environmental impacts of studies. Available at: http://www.iwto.org/uploaded/publications/Understanding_Wool_LCA2_20120513.pdf
- Henry BK, Russell SJ, Ledgard SF, Gollnow S, Wiedemann SG, Nebel B, Maslen D, Swan P (2015) LCA of wool textiles and clothing. *Handbook of life cycle assessment (LCA) of textiles and clothing*, pp 217–254
- Herath I, Deurer M, Horne D, Singh R, Clothier B (2011) The water footprint of hydroelectricity: a methodological comparison from a case study in New Zealand. *J Clean Prod* 19(14):1582–1589
- Herath I, Green S, Horne D, Singh R, McLaren S, Clothier B (2013a) Water footprinting of agricultural products: evaluation of different protocols using a case study of New Zealand wine. *J Clean Prod* 44:159–167
- Herath I, Green S, Singh R, Horne D, van der Zijpp S, Clothier B (2013b) Water footprinting of agricultural products: a hydrological assessment for the water footprint of New Zealand's wines. *J Clean Prod* 41:232–243
- Herath IK (2013) The waterfootprint of agricultural products in New Zealand: the impact of primary production on water resources. Massey University. Available at: http://mro.massey.ac.nz/bitstream/handle/10179/4520/02_whole.pdf?sequence=1&isAllowed=y
- Holmes A, Müller K, Clothier B (2012) Carbon storage in kiwifruit orchards to mitigate and adapt to climate change. Available at: http://www.plusgroup.co.nz/downloads/SFF-C09_{ }20-FinalReport.pdf
- Hume A et al (2011) Assessment of the water footprint of fresh kiwifruit: methods and scoping final report
- Hume A, Mithraratne N, Sinclair RJ (2010) Greenhouse gas footprinting and berryfruit production: Blackcurrent project summary. Available at: <http://www.academia.edu/>
- John S, Mulligan K, Perez N, Love S (2011) Cost, time and environmental impacts of the construction of the new NMIT arts and media building. Available at: <http://ir.canterbury.ac.nz:80/handle/10092/5524>. Accessed 29 Mar 2018
- LCM NZ (2016) New Zealand lifecycle management centre. Available at: <http://lcm.org.nz/>
- Ledgard SF, Liefvering M, McDevitt J, Boyes M, Kemp R (2010) A greenhouse gas footprint study for exported New Zealand Lamb. Available at: <https://www.mia.co.nz/assets/MIA-Publications/Greenhouse-gas-footprint-study-for-exported-NZ-lamb.-March-2010.pdf>. Accessed 18 Sept 2017
- Ledgard SF, Liefvering M, Coup D, O'Brien B (2011a) Carbon footprinting of New Zealand lamb from the perspective of an exporting nation. *Anim Front* 1(1):40–45
- Ledgard SF, Boyes M, Brentrup F (2011b) Life cycle assessment of local and imported fertilisers used on New Zealand farms
- Liefvering M, Ledgard SF, Boyes M, Landcorp M (2012) A greenhouse gas footprint study for exported New Zealand beef: a greenhouse gas footprint study for exported New Zealand beef. Available at: http://beeflambnz.com/Documents/Farm/A_greenhouse_gas_footprint_study_for_exported_New_Zealand_beef.pdf

- Love S (2010) Carbon footprint of New Zealand laminated veneer lumber. Available at: <http://www.nelsonpine.co.nz/wp-content/uploads/Carbon-Footprint-of-NZ-LVL-Dec10-FINAL.pdf>
- Maepa M, Bodunrin MO, Burman NW, Croft J, Engelbrecht S, Ladenika AO, MacGregor OS, Harding KG (2017) Review: life cycle assessments in Nigeria, Ghana, and Ivory Coast. *Int J Life Cycle Assess* 22(7):1159–1164
- Mcdevitt J, Seadon J (2011) Life cycle assessment data sets greenhouse gas footprinting project: diesel
- Mcdevitt JE, Allison RW (2013) Environmental life cycle assessment of analogous New Zealand “Exemplar House” designs. *J Green Build* 8(4):127–145
- Mcdevitt JE et al (2012a) An evaluation of alternative water footprint methodologies using an indicative tissue paper supply chain. *Appita J: J Tech Ass Austral NZ Pulp Paper Ind* 65(2):159–164
- Mcdevitt JE, Moore D, Lamm F, McDonnell N (2012b) Estimating injurious impact in construction life cycle assessments: a prospective study. *Int J Construct Supp Chain Manag* 2(1):46–54
- McDevitt JE, Langer ER, Leckie AC (2013) Community engagement and environmental life cycle assessment of Kaikōura’s biosolid reuse options. *Sustainability* 5:242–255
- McLaren J, Drysdale D, Barber A, McLaren SJ, Ledgard S, Nebel B, Maslen, D (2012) Greenhouse gas, energy, eutrophication and water footprint assessment of the New Zealand merino industry. Presentation at 2nd New Zealand Life Cycle Assessment Conference, Waipuna Hotel, Auckland, 28–29 March 2012
- McLaren S, Hume A, Barber A, Clothier B, Deurer M, East, A, Greenhalgh S, McDonald R, Palmer J, Sinclair R (2009) Carbon footprinting the apple supply chain. Available at: https://www.landcareresearch.co.nz/publications/researchpubs/Apple_Summary_Report.pdf. Accessed 29 Mar 2018
- McLaren SJ, Love R, McDevitt J (2011b) Life cycle assessment data sets greenhouse gas footprint project (Inventory report: coolstores). Available at: <http://www.lcm.org.nz/sites/default/files/files/Inventory>
- Milà I, Canals L, Burnip GM, Cowell SJ (2006) Evaluation of the environmental impacts of apple production using life cycle assessment (LCA): case study in New Zealand. *Agric Ecosyst Environ* 114(2–4):226–238
- New Zealand Government (2012) Economic and financial overview
- NIWA (2001) Overview of New Zealand climate. Available at: <https://www.niwa.co.nz/education-and-training/schools/resources/climate/overview> [Accessed 19 Jan 2016]
- Reisinger A, Ledgard S (2013) Impact of greenhouse gas metrics on the quantification of agricultural emissions and farm-scale mitigation strategies: a New Zealand case study. *Environ Res Lett* 8(2):025019
- Sandilands J, Nebel B (2010) Guidelines for greenhouse gas footprinting of forestry. Available at: <http://maxa.maf.govt.nz/climatechange/slm/ghg-strategy/guidelines-for-greenhouse-gas-footprinting-of-forestry.pdf>
- Sinclair RJ (2009) Greenhouse gas footprinting and berryfruit production: a review. Available at: <http://maxa.maf.govt.nz/sff/about-projects/search/C08-012/c08-012-berryfruit-review.pdf>
- US CIA (2016) Central intelligence agency—the world factbook. New Zealand. Available at: <https://www.cia.gov/library/publications/the-world-factbook/geos/nz.html> [Accessed 19 Jan 2016]
- Wiedemann S, McGahan E, Murphy C, Yan M-J, Henry B, Thoma G, Ledgard S (2015a) Environmental impacts and resource use of Australian beef and lamb exported to the USA determined using life cycle assessment. *J Clean Prod* 94:67–75
- Wiedemann SG, Ledgard SF, Henry BK, Yan M-J, Mao N, Russell SJ (2015b) Application of life cycle assessment to sheep production systems: investigating co-production of wool and meat using case studies from major global producers. *Int J Life Cycle Assess* 20(4):463–476
- Xu X, Jayaraman K, Morin C, Pecqueux N (2008) Life cycle assessment of wood-fibre-reinforced polypropylene composites. *J Mater Process Technol* 198(1–3):168–177
- Zonderland-Thomassen MA, Ledgard SF (2012) Water footprinting—a comparison of methods using New Zealand dairy farming as a case study. *Agric Syst* 110:30–40