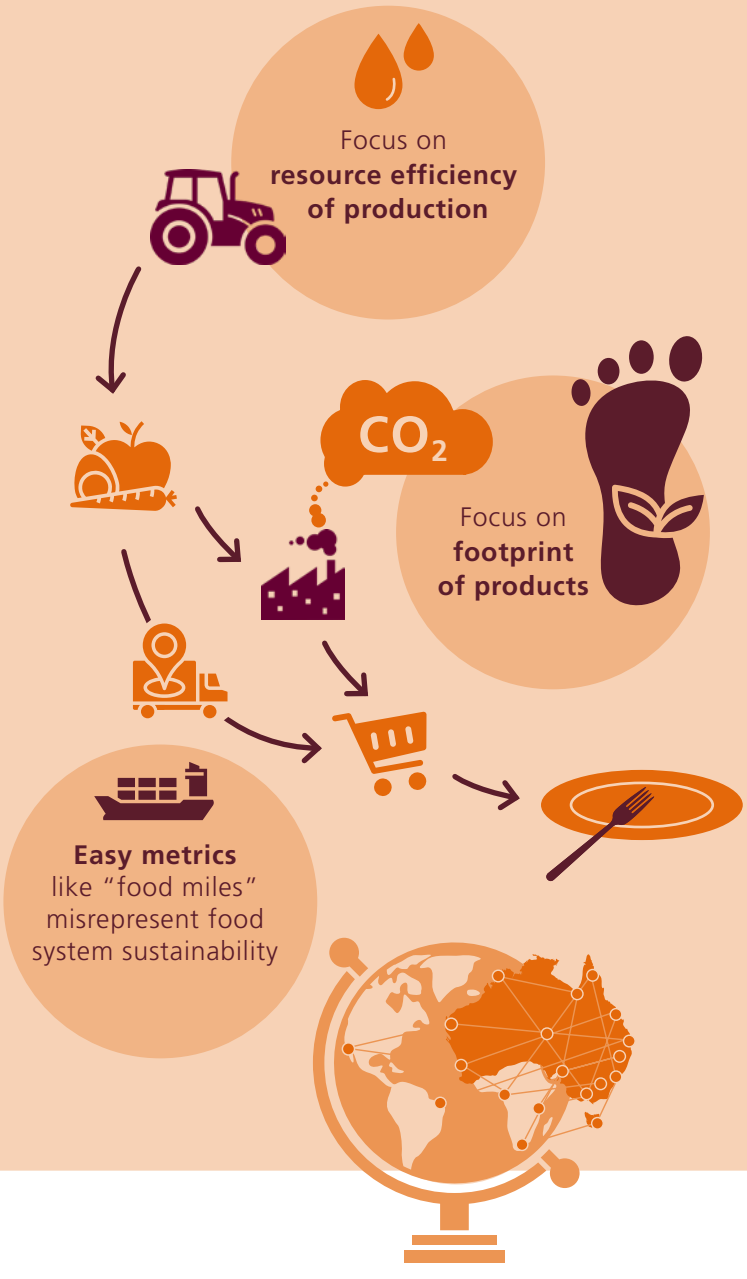
8 Life cycle assessment

Maartje Sevenster

1 STATE OF LIFE CYCLE ASSESSMENT



2 CHALLENGES

- **Siloed approach to research questions** limits understanding of system optimisation
- **Lack of demand** for system-level LCA
- **Individual stakeholders** not interested in system-level effects
- **Narrow perception** of LCA

3 OPPORTUNITIES

- **Consequential LCA** is well-developed
- **Ability to drive system-wide sustainability outcomes** through changes in methodological perspectives

KEY POINTS

- Life cycle assessment (LCA) is a powerful framework for quantifying environmental and other impacts of producing and consuming goods and services.
- The results of product LCA are often overinterpreted to make incorrect inferences about the food system as a whole.
- If a product is currently produced at lower environmental cost than alternatives, there is no guarantee that a future shift in consumption to that product will improve overall food system sustainability.
- To inform decision making for food system sustainability, tailor-made assessments can take into account effects of large-scale shifts

8.1 Is Australia's food system sustainable?

As discussed in the sustainability overview (see Insight 6, Sustainability), it is currently difficult to say whether Australia's food system is sustainable due, in part, to a fragmentation of methods and data. Many assessment methods focus on individual activities, products or components of the food system, and this can obscure our view of how to pursue sustainability for the overall system.

For example, an over-reliance on product-level assessments led early biofuel and bioenergy policy to assume that biofuels have a lesser environmental impact than fossil fuels. However, when demand for biofuels increased, their production was no longer marginal but required significant additional land and potentially deforestation. Policy has evolved to acknowledge the value of avoiding direct and indirect deforestation, but this is still mostly assessed at a product level. A similar example is the effect of replacing dairy with soy milk (Simmons et al., 2023). It is tempting to assume that locally produced food is more sustainable than food transported from elsewhere, but this can prove be a mistake if there are large offsetting differences in in the sustainability of underlying production systems.

One often utilised method for assessing sustainability is LCA. It is often used to identify more 'eco-efficient' products relative to competing alternatives and to make claims that certain products perform environmentally better than others. However, there is no guarantee that independent and incremental improvements in the sustainability of individual food products will result in a sustainable Australian food system.

8.2 Challenges posed by current approaches to sustainability

The sustainability of the food system is not an abstract issue but an absolute necessity if Australia is going to continue to feed its own population and contribute to feeding 10 billion people globally over the next several centuries. When it comes to environmental sustainability, the food system is intimately connected with nature, but current metrics and strategies do not yet adequately reflect this.

LCA is often used to take a snapshot of the current environmental impact of food system components such as the production of agricultural crops, food manufacturing processes or consumer food products. This can lead to a focus on incrementally improving the 'eco-efficiency' of 'hotspots', such as production processes that are intensive in greenhouse gas emissions. However, there is no guarantee that independent and incremental improvements in the eco-efficiency of these hotspots will result in a more sustainable Australian food system. This is because LCA is most often used in its micro-focused 'attributional' form (see Box – Attributional versus consequential LCA), which provides insights into the sustainability of individual products but not into the sustainability of the overall food system. This narrow focus is natural for profit-driven businesses, but relying on it effectively delegates responsibility for pursuing sustainability to the private sector, and this risks not asking bigger questions about the sustainability of the food system as a whole.

There are three main reasons why it can be misleading to treat product-level LCA as an indicator of food system sustainability. First, a focus on individual product supply chains ignores the potential for combined system optimisation. An example is using LCA to assess whether legumes are more sustainable than beef. If changes to diet are to play a role in food system sustainability, dietary choices need to be informed by sustainability information. For the example of legumes versus beef, both come from a huge variety of production systems with an equally huge range of associated environmental impacts. There are also multiple links between these production systems. Legumes can be used as animal feed, while manure can be used as fertiliser on legumes. In some regions in Australia, the production of legumes and red meat are integrated in mixed-farming systems.

If a product is somewhat 'better' in terms of sustainability relative to another product, this doesn't mean that consuming more of it will improve food system sustainability into the future.

Second, an overemphasis on greenhouse gas emissions relative to other forms of environmental impact can lead to blind spots when comparing traditional agriculture with emerging alternatives such as cultured meat. Recent studies suggest that while cultured meat has a lower carbon footprint than beef, full replacement of beef consumption in countries like the United States or Israel would increase overall

energy demand by up to 10% (Meshulam and Makov, 2023). Relying on renewable energy can still pose a sustainability problem because renewables typically reduce greenhouse gas emissions but not other types of pollution.

Third, some LCA metrics implicitly set an unachievable standard by 'benchmarking' agricultural systems against nature. This is the right choice to address certain questions, but the significant gap between agricultural systems and nature has the effect of reducing apparent differences between farming systems. This makes it difficult to inform trade-offs between alternative uses of our natural capital, such as soils and biodiversity, both now and with future potential uses.

In essence, if a good or service is marginally 'better' than a competing alternative at one point in time, it doesn't mean that consuming and producing ever more of it will decrease environmental pressure into the long-term future. This has recently been branded as the 'myth of inevitable sustainability' (Dickson and Clay, 2024). In other words, no product in and of itself can ever be inherently sustainable regardless of quantity. It can only be so as part of a sustainable food system.

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8.3 Driving the sustainability of Australia's food system

A practical step towards assessing the sustainability of Australia's food system is to use so-called 'consequential' LCA (see Box – Attributional versus consequential LCA) and interpret these analyses as part of system-wide sustainability frameworks (see Insight 6, Sustainability). This will require some fundamental changes in perspective, including balancing production perspectives of sustainability with consumption perspectives.

The power of LCA is that it naturally connects consumption with production and has the flexibility to inform larger questions of sustainability by adopting a demand-driven perspective. It can address questions such as what the environmental consequences would be of a considerable increase in the consumption of legumes in the Australian diet. These questions require a different approach than the question of whether the current production of a unit of legumes has a lower footprint than the current production of a unit of beef. As another example, the current Australian diet is quite removed from the 'planetary health diet' (Hendrie et al., 2022) – what does this mean for the Australian environment?

Attributional versus consequential LCA

Important work is already being done in applying system-wide lenses to sustainability and addressing many of the issues raised above (e.g. Dougherty et al., 2023; Ridoutt et al., 2022 and references therein; Simmons et al., 2023; Soimakallio et al., 2025; Willett et al., 2019; Wu et al., 2025). However, more of this research and its application are urgently needed.

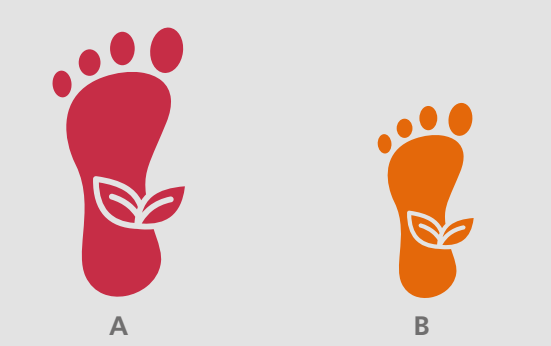
For the past decade, the LCA community has focused on standardising methods and metrics, which has significantly contributed to the practicality and adoption of voluntary and mandatory sustainability reporting. This has been important. However, the risk is that now the proverbial baby is being thrown out with the bathwater. As a framework, LCA was designed to address a broad range of questions by allowing applications to be tailored to context. Standards developed for reporting are typically based on attributional approaches and are therefore not appropriate to apply to questions about future system transitions or more holistic sustainability goals. No company would use last year's tax return to inform long-term strategic planning decisions.

With entity-level ('micro') reporting increasingly being legislated, it is urgent to also get a better understanding of whether this type of reporting will result in the desired ('macro') sustainability outcomes, or what additional approaches may need to be put in place to ensure this (see Insight 6, Sustainability). The food system, with its direct links to nature, land use and biological cycles, is particularly sensitive to methodological nuances, and the Australian food system is possibly even more so than some others (e.g. Sevenster and Cowie, 2024).

ATTRIBUTIONAL VS CONSEQUENTIAL LCA

ATTRIBUTIONAL LCA

Describes what's happening now: what is attributable to product A, what to product B? This is often called a footprint.

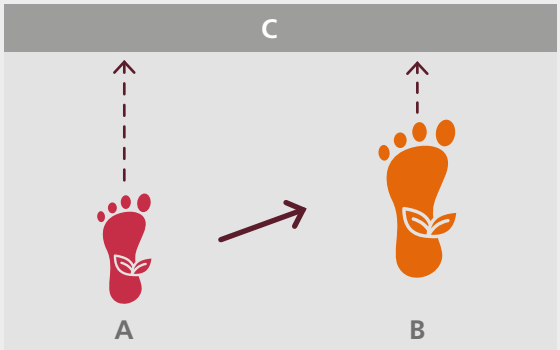


What is the average footprint of a pint of beer?
-> Attributional LCA, with micro focus, using current average effects

What is the ecological footprint of Australian food consumption? -> Attributional LCA, with macro focus, using current average effects

CONSEQUENTIAL LCA

Evaluates the consequences of a change: what is the net effect (C) of a big shift from A to B?



What is the environmental effect of eating one extra steak? -> Consequential LCA, with micro focus, using current marginal effects

What is the environmental effect of 10% of the population replacing dairy milk (A) with soy milk (B)?
-> Consequential LCA, with macro focus, modelling future effects