Majumdar, S., McLaren, S., Sorensen, S., & Siebert, B. (2022). Carbon and water footprinting of avocado production in New Zealand. In: Adaptive Strategies for Future Farming. (Eds. C.L. Christensen, D.J. Horne and R. Singh). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 34. Farmed Landscapes
Research Centre, Massey University, Palmerston North, New Zealand. 2 pages.

CARBON AND WATER FOOTPRINTING OF AVOCADO PRODUCTION IN NEW ZEALAND

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Abstract

The avocado sector in New Zealand is growing rapidly and is driven particularly by demand in overseas markets. To develop a better understanding of the environmental impacts associated with the New Zealand avocado supply chain, an environmental Life Cycle Assessment (LCA) was undertaken of this sector, focusing on climate change and water use.

For the carbon footprint, it was found that fertiliser production and use, and fuel use, dominated the climate change impact category for orchard activities. The water footprint was dominated by water inputs on the orchard for irrigation. However, there was wide variability between the orchards in the three regions with respect to the various inputs and impacts.

These results can potentially be used to guide development of a life cycle-based environmental monitoring system for avocado growers in New Zealand. If such a scheme is developed, it is recommended that the variability between orchards be considered for a targeted approach to environmental profiling and monitoring.

Introduction

The New Zealand avocado sector has been growing rapidly over the last two decades. This growth has been mainly driven by strong demand from export markets. Figure 1 shows the steady increase in the export earnings of New Zealand avocados since 2000.

	2000	2005	2010	2015	2019	2020
Fresh fruits						
- Kiwifruit	462.0	720.2	995.7	1,181.9	2,302.2	2,533.6
- Apples	404.5	387.0	324.6	561.8	828.8	876.3
- Avocados	25.2	29.0	59.9	115.5	104.3	112.3
- Cherries	5.6	10.5	22.7	52.3	68.9	51.3
- Blueberries	6.8	9.2	16.0	23.4	38.9	44.4
- Other fresh fruits	58.5	31.8	36.0	47.2	48.9	45.4
Total fresh fruit	962.6	1,187.7	1,454.9	1,982.1	3,392.0	3,663.3

Figure 1 Horticultural exports ended June 2020 ($ million fob) (Source: Plant and Food Research, 2020)

Studies have pointed to the resource- and input-intensive nature of avocado production and the related environmental impacts (large scale deforestation, biodiversity loss, soil quality degradation due to monoculture cropping, water scarcity and climate change) (Ayala, 2020;

Sommaruga & Eldridge, 2020; Cho et al., 2021; De la Vega-Rivera & Merino-Perez, 2021; Esteve-Llorens et al., 2022; Finney, 2021; Krosofsky, 2021; Richie & Roser, 2021; Denvir et al., 2022).

However, these studies refer to the main avocado growing regions in the world like Mexico, Chile and Peru. There have been no studies to identify and quantify the environmental impacts of avocado production in New Zealand.

The twofold aims of this research project were:

1) To understand the environmental impacts of conventional avocado production in New Zealand

2) To identify the environmental 'hotspots' in the orchard phase of the value chain

To achieve these aims, an environmental Life Cycle Assessment (LCA) was conducted of conventional avocado cultivation in New Zealand. The LCA assessed two impact categories – climate change and water use.

Methodology

Environmental LCA is a systems-based analysis tool – it usually adopts a cradle-to-grave approach in quantifying environmental impacts. However, it can also be used to identify impacts across truncated system boundaries within the overarching value chain. The LCA for this study was carried out as per International Organization of Standardization (ISO) standards (ISO 2006a, ISO 2006b) in the four phases shown in Figure 2. A 'cradle-to-orchard gate' system boundary was adopted, and a mass-based functional unit was chosen – 1kg Hass avocados at orchard gate.

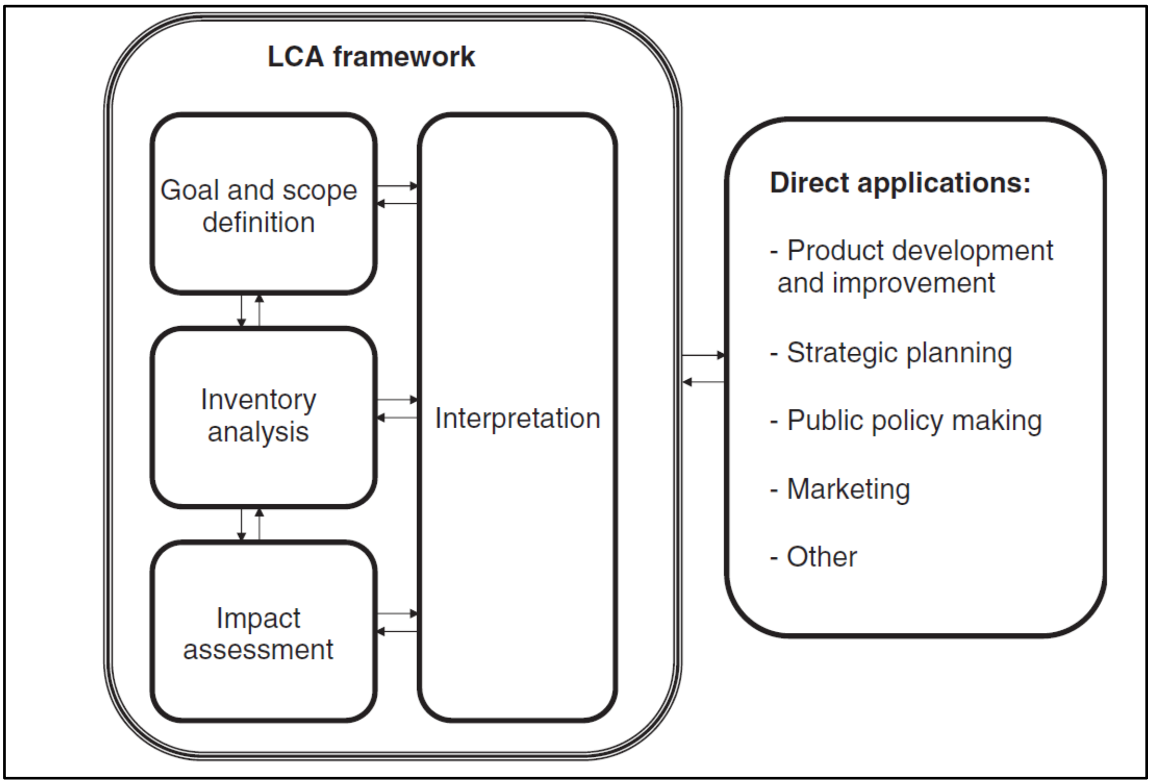

Figure 2 Four phases of LCA framework as per ISO 14040 (Source: Klöpffer & Grahl, 2014)

For data collection, disproportionate stratified sampling was undertaken for subgroups (based on region, size of orchard and practice). Detailed questionnaires were sent to 108 orchards, of which 53 responded from the Far North, Mid-North and Bay of Plenty – the three main avocado growing regions in the country. Data were collected for several inputs to the orchard (agrichemicals, fertilisers, water, fuel and electricity).

Model development choices were guided by the framework provided in the International Environmental Product Declaration (EPD) Product Category Rules (PCRs) for fruits and nuts (EPD International, 2019). Impacts were modelled using ecoinvent datasets. Climate change was modelled using the GWP_{100} characterisation factor of the IPCC 2013 model, using the CML baseline (2016) methodology. Water use was modelled using the Water Use in Life Cycle Assessment (WULCA's) Available Water Remaining (AWARE) methodology. This provides a mid-point indicator representing the 'available water remaining per area in a watershed, after the demand of human and aquatic ecosystems have been met' (Boulay et al., 2018).

Results

The quantified climate change and water use impact scores for each region were calculated as the weighted average of all the sampled orchards in each region. They were normalised to the Bay of Plenty results to demonstrate how the regions performed relative to each other. As Figure 3 shows, the Far North and Bay of Plenty climate change results were almost the same, and the Mid-North region had a slightly higher result. However, the water use impact score for the Far North was much higher than the other two regions.

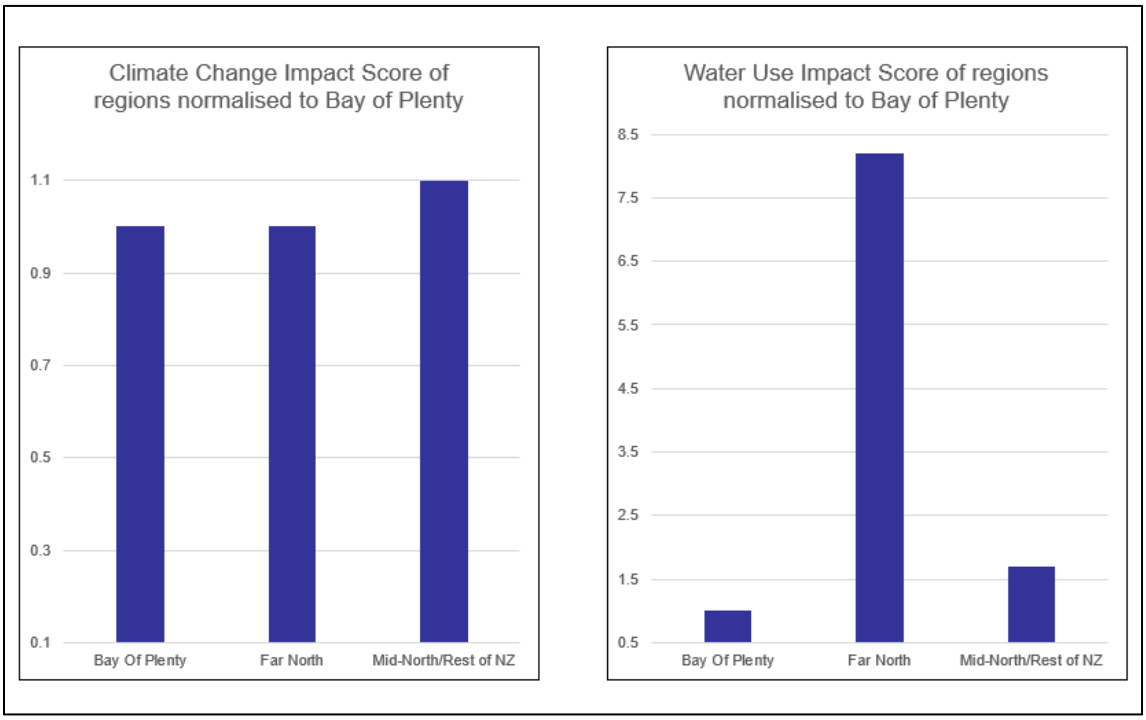

Figure 3 Climate change and water use impact score normalised to the Bay of Plenty

The main contributor to the climate change impact category was the use of fertilisers and fuels. Figure 4 shows the contribution of fertiliser and fuel use to the GWP of selected orchards (selected based on best data quality); these two inputs account for >75% of the impacts for each individual orchard on the graph. Of the fertilisers, lime and nitrogen-based fertilisers were the biggest contributors to the climate change results. Fertiliser use had production- and application-related impacts, whereas with fuel, the impacts were mainly associated with the on-orchard use. Nitrogen-based fertilisers as well as lime, gypsum and magnesium oxide contributed the most to the production-related GWP impacts of fertilisers. For the application-related impacts, two themes emerged: 1) when lime and nitrogen-based fertilisers were used together, CO_2 emissions to air from lime accounted for most of the GWP impacts of the ‘fertiliser, lime and dolomite application activity’, followed by N_2O (nitrous oxide); and 2) when lime was not applied, GWP impacts from the ‘fertiliser, lime and dolomite application activity’ were mainly caused by N_2O oxide emissions from nitrogen-based fertilisers.

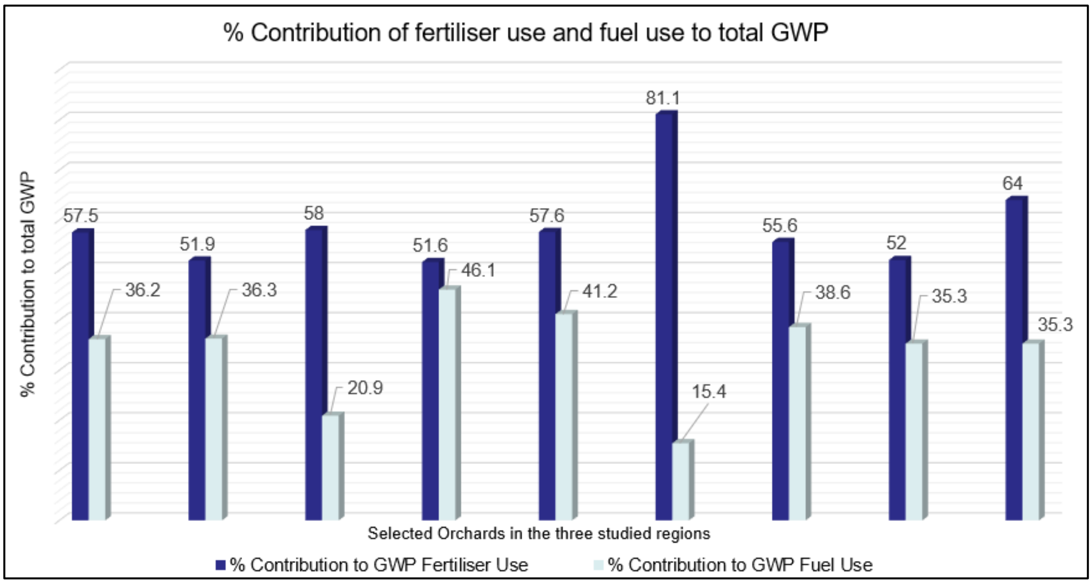

Figure 4 Contribution (%) of fertiliser and fuel use to total GWP values for selected individual orchards

Water use impacts were mainly driven by irrigation. Figure 5 shows the percent contribution of different orchard activities to the water use category in selected irrigated orchards. The graph shows water use on orchard (for irrigation) to be the single largest contributor to the water use impact category.

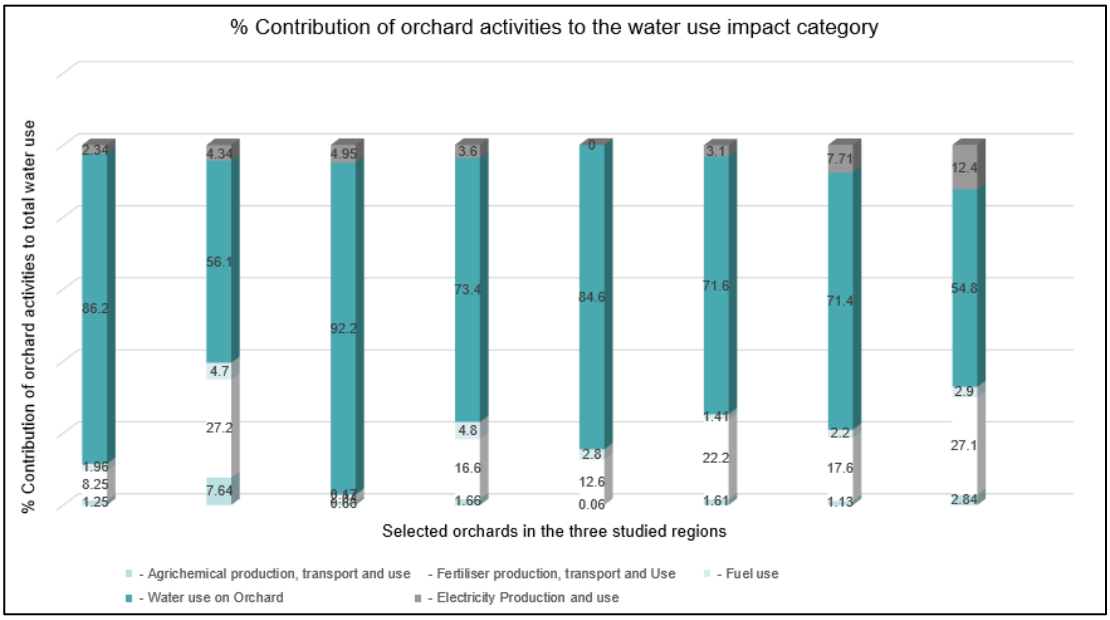

Figure 5 Contribution (%) of orchard activities on individual orchards to the water use impact category

Another finding was the significant variability in impact scores between orchards in all the three studied regions (Figure 6 and Figure 7).

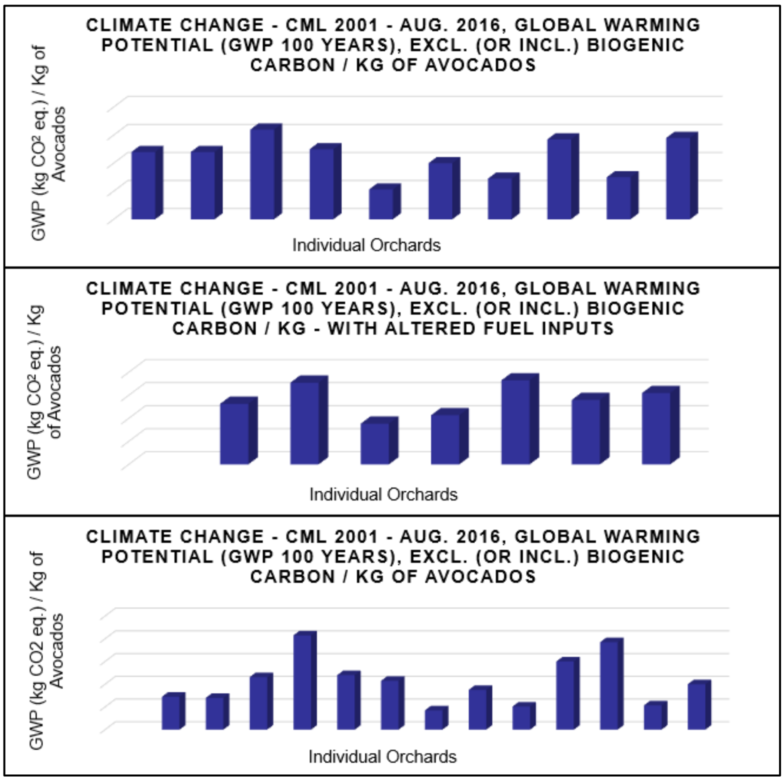

Figure 6 Variability in climate change impact scores between selected orchards in the Far North, Mid-North/Rest of New Zealand and Bay of Plenty (top, middle and bottom graphs respectively)

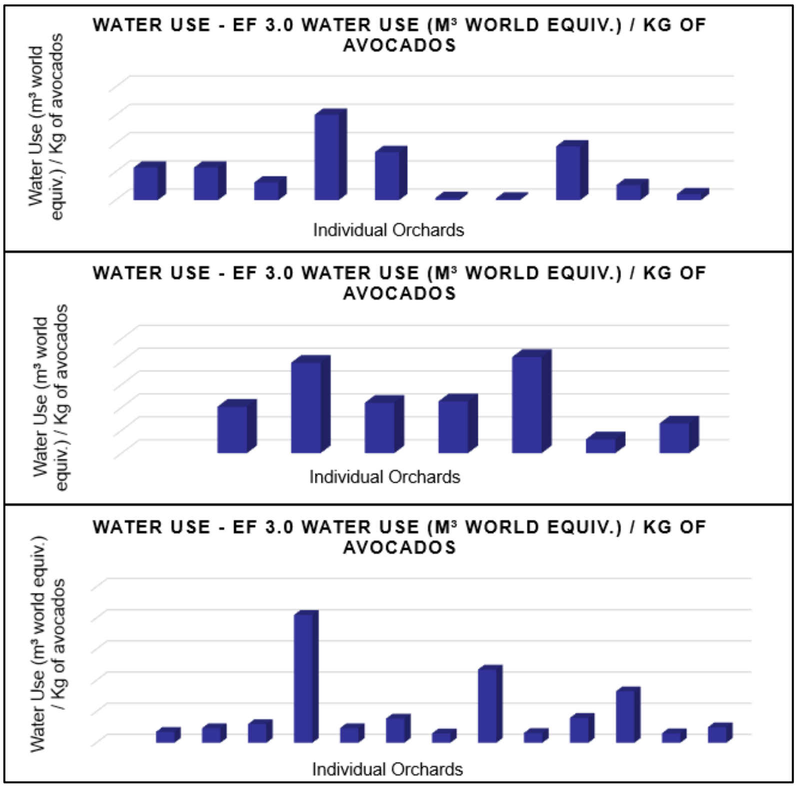

Figure 7 Variability in water use impact scores between selected orchards in the Far North, Mid-North/Rest of New Zealand and Bay of Plenty (top, middle and bottom graphs respectively)

Conclusion

The results of this environmental impact study showed that the environmental impact 'hotspots' for the two impact categories studied are:

- Climate change: fertiliser production and use; fuel use on orchard
- Water scarcity: water use on irrigated orchards.

The normalised climate change score for the Mid-North region was slightly higher than the other two regions. The normalised water use score for the heavily irrigated Far North was significantly higher than the other two regions, especially Bay of Plenty, where growers often use rainwater for most of their orchards' water needs.

In addition to quantifying the impacts of growing avocados in New Zealand and identifying hotspots in the production stages/activities, an additional point of interest emerged from the study – the high variability in impact scores between orchards in all three regions for both impact categories.

The results of this study are being used to develop a more extensive model that includes packhouse and coolstore activities, and distribution to domestic and overseas markets, to provide consumers with information on the environmental footprint of New Zealand avocados. This could potentially lead to the development of a sector-based environmental monitoring system and/or certification scheme. Such a scheme would not only support producers and other stakeholders in these supply chains to implement more environmentally sustainable activities in the country, but also help New Zealand producers to leverage their products based on environmentally sustainable credentials, differentiate such products in the export marketplace and potentially obtain price premiums for products with an enhanced environmental profile.

However, this research has shown that if such a certification/monitoring system is planned, it will be important to consider the reasons for the variability between orchards when establishing such a system in order to make sure it efficiently drives improvements across the sector (Poore & Nemecek, 2018).

Our recommendations for future research include: 1) a more in-depth understanding of the differences in results for different growers in each region; 2) improving data quality with respect to fertiliser datasets; and 3) investigation of additional environmental impacts (e.g., eutrophication, ecotoxicity, acidification and land use change).

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