Is the Future of Milk Plant-Based? Exploring Dairy's Decline in Australia in a Climate and Ethical Context

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Abstract The Australian dairy industry is shrinking, and more sustainable alternative drinks are growing in popularity in this time of climate chaos and growing ethical awareness. This review examines the production and consumption of plant-based milk in Australia, and reasons for the dairy's decline. Approximately 42% of Australian consumers buy plant-based milks, with soy and oat the most commonly purchased. Dairy production and consumption are in decline, although plant-based milk still has a smaller market share (9.5% in 2023). Public concerns that are driving the switch include animal welfare and the impact of dairy farming on the environment. Primary ethical and welfare concerns about dairy include the separation of calves from their mothers, the killing of 'surplus' calves, and the physical pain cows endure from lameness, mastitis, malnutrition and other diseases. Heat stress has been experienced by Australian dairy herds and is likely to get worse as the climate crisis continues. Farming cows produces more greenhouse gases than the farming of any other species, and the Australian dairy industry produces 3% of the country's climate emissions. It is linked to environmental degradation including deforestation, habitat loss, and water pollution. Dairy farming uses vast amounts more water than soy or oat milk production, a particular concern in a country afflicted by droughts. The outlook for Australian dairy farming is a transition into other farming methods to meet the consumer demand for

plant-based milk. Some growers and producers are diversifying into soy and oat crops and producing local plant-based milk and tofu that is retailed to the public. Is this the beginning of the end for dairy in Australia, and the emergence of an agricultural transition to bring a greener and more ethical future to all?

Keywords dairy, sustainability, ethics, plant-based milk, farming

Plant-based milk use is becoming widespread around the world. Milks made from nuts, beans, legumes, and grains are replacing dairy milk from cows in the home and in hospitality businesses (Good Food Institute). The drop in dairy consumption has occurred over several decades in developed nations such as the US (Stewart et al. 562) and the UK ('Family Food Datasets'). During this time span, there has been a steady rise in plant-based milk consumption in regions such as Western Europe (Mylan et al. 233). The plant-based milk market was valued at $21 billion globally in 2024 and is expected to reach $41 billion by 2034, with a compound annual growth rate of 6.6% (Global Market Insights).

The transition away from dairy comes in the context of increasing public awareness of the climate emergency, and lifestyle behaviour changes that can be taken to mitigate it. The Intergovernmental Panel on Climate Change encourages the uptake of diets rich in plant-based foods to mitigate the climate crisis (Intergovernmental Panel on Climate Change). The dairy industry has come under the spotlight as one of the largest emitters of greenhouse gas emissions in agriculture (Lazarus et al. 1). Impact assessments show that producing non-dairy drinks has a lower carbon footprint and uses less land and water than cow's milk (Poore and Nemecek 987). Today's environmentally conscious consumers are willing to pay a higher price for plant-based milks (Su).

This review article reports on the production, sale and consumption of plant-based milk in Australia. The drivers of consumer change are examined, with a focus on ethical, climate, and environmental factors. There is a growing awareness that routine practices in the dairy industry have adverse outcomes for animals, such as the killing of 'surplus' calves (Bolton et al.), and the emotional stress cows endure at calf separation (Green et al. 826). Australia has a long-established dairy industry, but it is facing mounting pressures as consumers move towards more ethical choices and seek eco-friendly options. The worsening climate emergency is impacting Australian farmland with wildfires, high temperatures and droughts (Van Oldenborgh et al. 1). As dairy farming faces an uncertain future, there are emerging opportunities for Australian farmers to transition into the plant-based milk sector.

The plant-based milk boom

The Australian non-dairy milk sector is growing. Retailers, from convenience stores to supermarkets, stock an array of soy, oat, almond and other plant-based milks in chilled and ambient formats (Harmer et al. 76). Rice, coconut, pea, hemp, macadamia and quinoa milks are also available. Vitasoy Australia's chief executive David Tyack said in 2023 that 40% of Australian households have plant-based milk in the fridge (Brown and Broom). This is supported by Dairy Australia's report, which states that 42% of households bought plant-based milks in 2022 (Dairy Australia 'How Does Milk Compare to Plant-Based Beverages?').

The non-dairy milk market in Australia expects a 10.34% compound annual growth rate between 2025 and 2030 (Mordor Intelligence). Soy milk is the most popular type, which is different from the US market, where oat milk is dominant in sales over soy and all other types (Ramsing et al. 291). Oat milk sales may catch up to soy milk purchases in Australia. IMARC Group predicts a 20% compound annual growth rate between 2025 and 2033 for oat milk sales in the country (IMARC Group).

Dairy milk production in Australia has declined over the last 20 years (Figure 1). This correlates with declining records of consumption: from 190 grams per day in the 2018-19 period, to 176 g/day in the 2022-23 period (Australian Bureau of Statistics 'Apparent Consumption of Selected Foodstuffs, Australia'). By contrast, the consumption of plant-based milks has increased from 13 g/day in 2018-19, to 17.6 g/day in 2022-23 (Australian Bureau of Statistics 'Apparent Consumption of Selected Foodstuffs, Australia').
Long-term plant-based milk consumption or production data from Australia is not available, but oat, almond and soy crop production could be used as a proxy for plant-based milks. The production of these crops has been stable to slowly increasing over the last two decades (Figure 1).

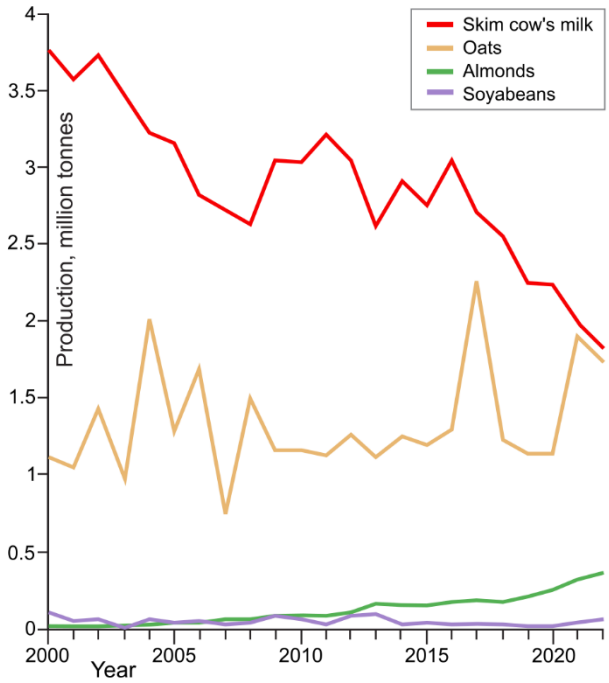

Figure 1. The production of skimmed cow's milk, oats, almonds and soyabeans in Australia from 2000 to 2022. Data sourced from the Food and Agriculture Organization of the United Nations. 'FAOSTAT' database.

Sales of drinks using plant-based milks are booming in Australian coffee shops. Soy, oat, almond and other non-dairy formats make up 25% of milk coffee sales (Mackintosh). Café market analyst Sean Edwards predicts that plant-based milk sales will account for half of coffee shop hot drink sales in Australia in the coming years (Mackintosh). Yet despite these high predictions, plant-based milk sales still have a long way to go to outcompete dairy milk. In 2022-23 the Australian plant-based market was valued at 465 million AUD (Australian dollars) (Harmer et al. 76). This is only 9.5% of the value of the dairy milk market of 4,873 million AUD in 2023 (Global Data). Plant-based milk brands in China, the US and Europe have the highest global sales (Good Food Institute). The US plant-based milk market share was reported as 15% of retail sales in 2021 (Ramsing et al. 291).

The companies producing plant-based milk in Australia range from small enterprises like Bonsoy and Milklab to multinational giants like Nestlé and The Coca-Cola Company. Even traditionally dairy-focused companies like Fonterra, Norco Co-operative and Bega Cheese have plant-based ranges or fund research into them.

Who is drinking non-dairy milks? It's not just vegans. A 2023 YouGov report stated that 6% of Australians are vegan, and a greater 19% are flexitarian (Tan). It's clear that the majority of the market is made up of 'flexitarians' – people who are actively reducing their consumption of animal-derived foods but are not fully vegan. A study of the consumption habits of over 3,000 Australians confirmed this, reporting that 39% of participants drank both dairy and plant-based milks, compared with 59% who exclusively drink cow's milk, and 3% exclusively plant-based milks (Tulysewski).

Flexitarians often choose to reduce animal product consumption for animal welfare reasons, in order to benefit the environment, or for reasons relating to health (Malek and Umberger). In an article exploring what is driving the boom in Australian plant-based milk sales, experts from the University of New South Wales Sydney state that ethics, health and taste are important factors (Knight). Professor Johannes le Coutre said, 'There is a movement of consumers who resent animal products – such as milk – because they are not necessarily associated with good animal welfare' (Knight).

Despite the growing consumer demand for plant-based milks, national government policy is still firmly behind dairy, offering trade links, promotion and funding (Australian Government 'Dairy in Australia'). Dairy lobbying groups such as the Australian Dairy Products Federation push for the industry to receive government funding and promotion, and for the Australian Nutritional Guidelines to retain their recommendation for people to consume dairy (Australian Dairy Products Federation 'Promote & Protect the Value of Dairy'). Not all countries around the world follow this. For example, advice to consume dairy is not part of the nutritional guidelines of Brazil (Ministry of Health of Brazil) or Canada (Health Canada).

Unethical dairy

Dairy farming is big business in Australia. The dairy industry reports that there are over 5,800 operating dairy farms (Dairy Australia 'Dairy Farm Facts and Regions'), keeping 2.1 million cows (Australian Bureau of Statistics 'Australian Agriculture: Livestock'). The number of dairy farms has reduced over time, from over 14,400 in 1990, to over 7200 in 2012 (Stott and Gourley, 101). The volume of milk taken from cows has increased dramatically over the last several decades, as farming methods have changed. In Australia the average milk production per cow was 2848 litres/year in 1980, increasing to 5731 litres/year in 2015 (Wales and Kolver, 1366).

The high milk production that is demanded of modern dairy cows is not natural, it is far more milk than is needed to feed a calf. Images used to promote sales of Holstein Friesians, the most common dairy cow breed in Australia, show extremely large udders as a selling point (Australia's Livestock Exporters). Extensive milk production puts an enormous strain on cow's bodies. Malnutrition and metabolic disorders, mastitis and lameness are common afflictions suffered by Australian dairy cows (PETA Australia; Shahinfar et al.). Osteoporosis and bone fractures have been reported in New Zealand dairy cows due to dietary deficiencies (Wehrle-Martinez et al. 88). Heat stress caused by wildfires, high summer temperatures, and droughts have also caused lower welfare conditions in cows (Osei-Amponsah; Windsor) and are likely to become worse as the climate crisis intensifies.

Cows are sensitive, inquisitive, gentle animals with their own needs, desires, and the will to live. Yet on Australia's dairy farms they are subject to emotional and physical pain. Calves would naturally suckle milk from their mother for nine months to a year, but on the majority of farms, babies are separated from their mothers days after birth. Mother cows call out to their calves after they've been separated, demonstrating the intense emotional stress they endure as a result (Green et al. 826). Female calves are kept to become the next generation of cows used for dairy, while males (and some females deemed 'surplus') are often shot or killed by other means a few days after birth (Bolton et al.; PETA Australia 'The Truth About Cows Used for Milk'). When females reach maturity, they will

be restrained and forcibly impregnated using an 18-inch syringe-like device. This can begin as young as 15 months old (Simões and Stilwell). Ovulation is often induced so that artificial insemination can be achieved en masse, by injecting individuals with hormones (Rheinberger). When born their calves are taken away, and the cycle of pregnancy and loss continues.

Mother cows are no longer deemed economically viable when they are still young, five or six years old, due to waning milk production. When the decision has been made to stop using the animal, she is forced onto a truck and driven to the abattoir. Many people are unaware of the suffering and death inherent in the dairy industry due to false marketing by the industry, which perpetuates a myth that dairy farms are kind or good places (Wicks 45). Yet there is a growing awareness of the cruelty to cows used for dairy, with animal advocacy groups publishing shocking investigations that reveal routine abuse (Farm Transparency Project; PETA Australia 'EXPOSED: Babies Bludgeoned and Mothers Shot Repeatedly for Australian Dairy'). The dairy industry is, in response, investing funds to 'build greater levels of trust' with consumers, with a goal of increasing profits (Australian Dairy Plan).

Dairy's climate crisis

Raising and killing animals for food is a major cause of planetary heating, responsible for between 14% and 20% of global greenhouse gas emissions (Gerber et al.; Xu et al. 724). The farming of cows produces more greenhouse gases than the farming of any other animal exploited for food. Cows are large ruminant animals whose digestion process of enteric fermentation causes them to belch methane. Enteric methane is the main source of greenhouse gas emissions from the Australasia dairy industry (Eckard and Clark 10). Other sources include ammonia (which converts to the greenhouse gas nitrous oxide) and methane emitted from cow's manure, nitrogen fertiliser used to grow crops, and carbon dioxide emitted from non-renewable energy sources that are commonly used to power farm and slaughter equipment.

While raising cows for their flesh (beef farming) in Australia has the highest carbon footprint of any farming type, dairy's impact is significant. According to Agriculture Victoria, the Australian dairy industry produces 3% of the country's greenhouse gas emissions (Agriculture Victoria). This figure could be an underestimate, as little scientific research has been published about greenhouse gas emissions from the Australian dairy sector, compared with the US and Europe (Ferraz et al. 1721). In a 2018 joint study by the Institute for Agriculture and Trade Policy and non-profit group GRAIN, researchers found that the five largest meat and dairy corporations – JBS, Tyson, Cargill, Dairy Farmers of America, and Fonterra – were already responsible for more annual greenhouse gas emissions than oil giants ExxonMobil, Shell, or BP and that the 'combined emissions of the top 20 meat and dairy companies surpass the emissions from entire nations, such as Germany, Canada, Australia or the United Kingdom' (Sharma). Since the report was published, the number of cows used for their milk worldwide has continued to grow (Food and Agriculture Organization of the United Nations).

Despite their clear negative climate impact, dairy operations continue to be financially supported by the Australian government (Parliament of Australia). The dairy industry encourages farmers to reduce climate heating emissions from their operations by employing measures like manure management, feed changes, and reducing fertiliser use (Garnett and Eckard). Other methane-reduction methods include feeding cows red seaweed (Lean et al.) and fitting individual animals with 'gas masks' (Obek 479) to address the emissions problem. Such initiatives are expensive (Garnett and Eckard) and have been called out as greenwashing (Donnison and Murphy-Bokern). Even if multiple climate abatement measures were undertaken at each farm, they can only address a fraction of the environmental costs of breeding, raising, feeding, transporting, killing, and processing billions of dairy cows globally every year.

Environmental damage

Animal agriculture causes deforestation, habitat loss, drought, species extinction, and pollution (Poore and Nemecek 987). Dairy production is an inefficient use of land and crops. It is estimated that cows must consume six calories in order to yield one calorie of dairy for human consumption (Eshel et al. 11996). Half of all land in Australia is used for agriculture (Australian Bureau of Statistics 'Agricultural Commodities, Australia'), and the majority of that land use is for grazing ruminant animals. Land use studies and non-governmental organisations report that a major cause of Australian deforestation is to create grazing land for cows and sheep (Evans 130; Heagney et al; WWF). The location of dairy farms is within regions that have experienced deforestation (Figure 2). However, no published data currently identifies which areas now used for dairy farming were previously subject to deforestation, as cow grazing for dairy, 'beef' and sheep grazing are usually reported as one category when it comes to changes in land use. Extensive land clearance has been attributed to areas used for grazing sheep and cows used for 'beef' (Henry et al. 191), with the national 'beef' herd over 27 million strong (Australian Bureau of Statistics 'Australian Agriculture: Livestock').

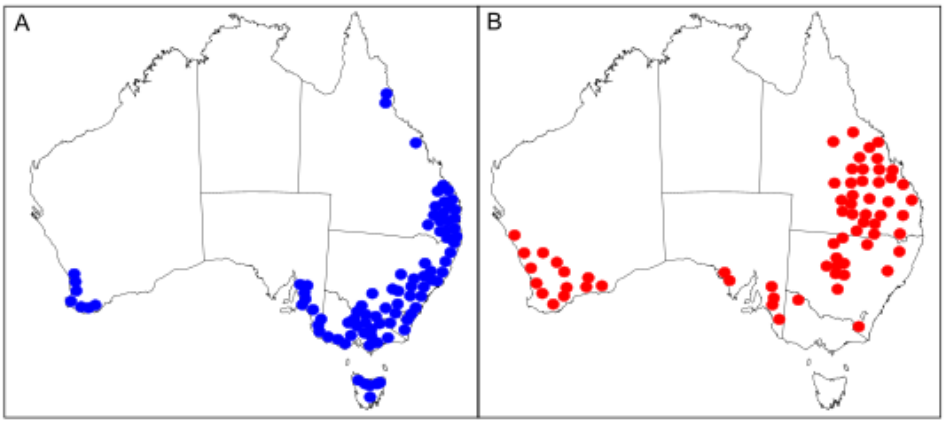

Figure 2. Australian dairy farming and deforestation hotspots. A: Dairy farming hotspots, map modified from Dairy Australia ('Dairy Farming Regions'). B: Deforestation hotspots, 1972-2014 deforestation. Map modified from Evans (130).

Habitat loss and the impacts of the climate crisis, including increased droughts, wildfires and high temperatures, are driving Australian terrestrial biodiversity loss to such an extent that 'ecosystems are collapsing' (Legge et al. 622). One study estimates that over 50 million wild birds, mammals and reptiles are killed annually due to deforestation in Queensland and New South Wales (Finn and Stephens 377). Flora and forests are under threat too, with one example being forest canopy dieback in southwestern Australia, caused by droughts, rising atmospheric temperatures and diminished rainfall (Hoffmann et al. 3). Dairy farming is known to have negative impacts on biodiversity due to the land used for grazing (Sizemore 145). The pressure on wild faunal species populations is likely to be exacerbated by land clearing for Australian dairy farming, although no research to date has directly examined this topic.

According to Dairy Australia, cows are fed a combination of pasture and grain or supplementary feed, with 2% of farms being zero grazing operations (Dairy Australia 'Are Australian Dairy Cows Completely Grass Fed?'). Concentrated feed use is the norm on US dairy farms and is common in the UK. Soy grown in Brazil as a product of deforestation is

fed to animals on farms, including dairy cows (Rezende et al. 23). The use of concentrated pulses like soyabean meal in dairy cow feed is becoming more popular in Australia, as it contributes to higher milk yields (Wales and Kolver 1366; Wilkinson and Lee 1735). It was estimated in 2015 that around 20% of dairy farms in Queensland, New South Wales and Western Australia used concentrated feed (Wales and Kolver 1366). This is likely to exacerbate ecological and environmental problems in Brazil caused by soyabean farming: deforestation and habitat loss (Song et al. 784), and wild species declines (Garber et al.).

Water pollution from Australian dairy farms comes from manure and urine run-off, the use of fertilisers, soil degradation, and other on-farm sources (McDowell et al. 1419). Nitrogen and phosphorus from these sources can cause algal blooms and water toxicity (McDowell et al. 1065). Australian dairy farms are responsible for degraded water quality in some coastal estuaries and embankments (Scarsbrook and Melland 856). The intensification of dairy farming in south-west Victoria, with increasing numbers of cows in a certain land area, is responsible for higher nitrogen and phosphorous loading into rivers (Smith et al. 1). Ammonia emissions from dairy farms are a major air and water pollutant, and when manure particles become airborne, they are a significant human health hazard. Little data is available on Australian dairy farm ammonia emissions, but animal agriculture is an important source of this pollutant gas (Zhang et al.).

Water use is high in the dairy industry, accounting for 19% of all water use in animal agriculture, while the beef industry is 33% (Mekonnen and Hoekstra 401). Water-intensive agriculture has come under scrutiny as the climate emergency worsens. Extreme climatic events such as bushfires are becoming more frequent in Australia and are linked to regions that experience drought conditions (Cui et al.). Farmers have been devastated by severe droughts – with one dairy farmer stating, 'Farmers are getting out left, right and centre. It's gotten to the point where it's cheaper to shoot your cows than it is to feed them' (Mao). Agricultural change towards plant production can have long-term positive environmental impacts. Producing soy milk drinks uses just 4% of the water used in dairy milk production (Poore and Nemecek 987).

Plant-based milks offer a sustainable solution. Impact assessments show that they have much lower greenhouse gas emissions (Figure 3) and lower land and water use (Poore and Nemecek 987; Ramsing et al. 291). Laboratory-produced plant-based dairy has even more impressive credentials: 90% fewer greenhouse gas emissions, 90% less water use, and 99% less land usage (George). Chemical synthesis can be used to convert carbon dioxide, oxygen and other gases into edible fats that are more sustainable even than plant fats from traditional agriculture (Davis).

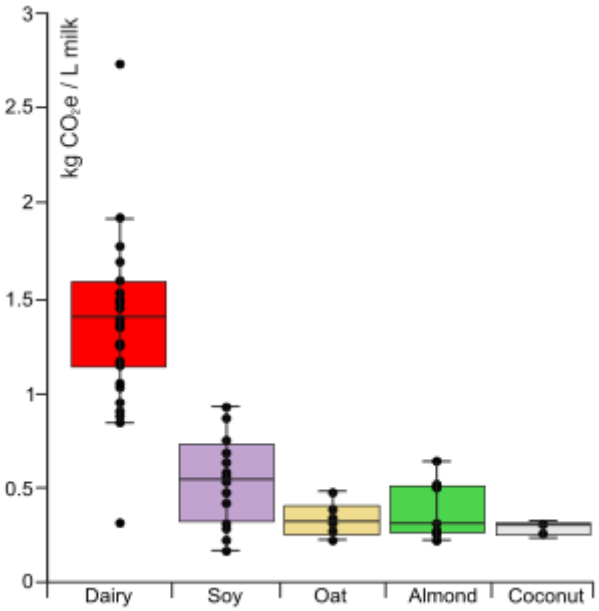

Figure 3. Box and whisker plot of greenhouse gas emissions of dairy and plant-based milks. Emissions data (kg CO_2e / L milk) is reproduced from global datasets published in a recent review study (Ramsing et al. 291). All data points are shown, with median values indicated by a horizontal line.

A new future for Australian farmers?

Australia is embracing the potential for more sustainable and ethical alternatives to dairy farming. In 2023 the ingredients manufacturer Wide Open Agriculture received an AUD$5 million grant from the Western Australian Government to fund a novel high-protein oat milk factory (Grain Central). The oats used will be grown in Western Australia, already known as a hub of oat farming. Australia's Commonwealth Scientific and Industrial Research Organisation is developing a plant-based dairy product called Eden Brew using precision fermentation technology (CSIRO).

Soy is often imported into Australia to feed animals who are raised for their flesh or milk, but Australian soy production for human consumption is growing (Wells). Australian grown soyabeans are used in soy milk, tofu, tempeh, flour and other products. Vitasoy is one of the most popular soy milk brands that use organic, Australian grown beans. Tofu brands using homegrown soy include Blue Lotus Foods, Earth Source Foods, Kingland and Soyoyoy.

Will dairy producers switch to plant-based production? The group Farm Transitions Australia stands ready to help. They offer bespoke support and resources to help dairy or beef farmers move into horticulture, sustainable businesses, or new career paths. In the group's survey of 147 dairy farmers, 36% of participants expressed willingness to transition away from the industry (Celik et al.).

Conclusions

Plant-based milk is experiencing a sales boom in Australian home and hospitality settings. Approximately 42% of consumers buy plant-based milk, and it has been predicted that half of all drink sales in coffee shops will soon use them. Dairy production and consumption have been declining for decades, and the number of Australian dairy farms is shrinking. One of the reasons people choose non-dairy milks is the growing awareness of the physical and mental suffering of cows and calves in the dairy industry. Lameness, mastitis, malnutrition

and osteoporosis are common diseases, and 'surplus' calves are often killed. Concerns over the carbon footprint of farming cows are also driving consumer change, as these large ruminants are high methane emitters. Dairy farming is responsible for 3% of Australia's greenhouse gas emissions. It causes multiple negative environmental impacts, including deforestation, pollution, and droughts. Heat stress has already been experienced by Australian dairy herds, and as the climate crisis continues, the longevity of dairy farming comes into question. With the boom in plant-based milk consumption, farmers have the opportunity to change with the times to embrace a new sustainable future. Oat and soyabean crop farming is gaining support, and the agricultural transformation towards crops for plant-based milks will benefit Australia's animals, climate, and environment.

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