

How much water is used in the production of plant-based products?

In response to Bev McArthur's question on the use of water for plant based foods I tender the following.

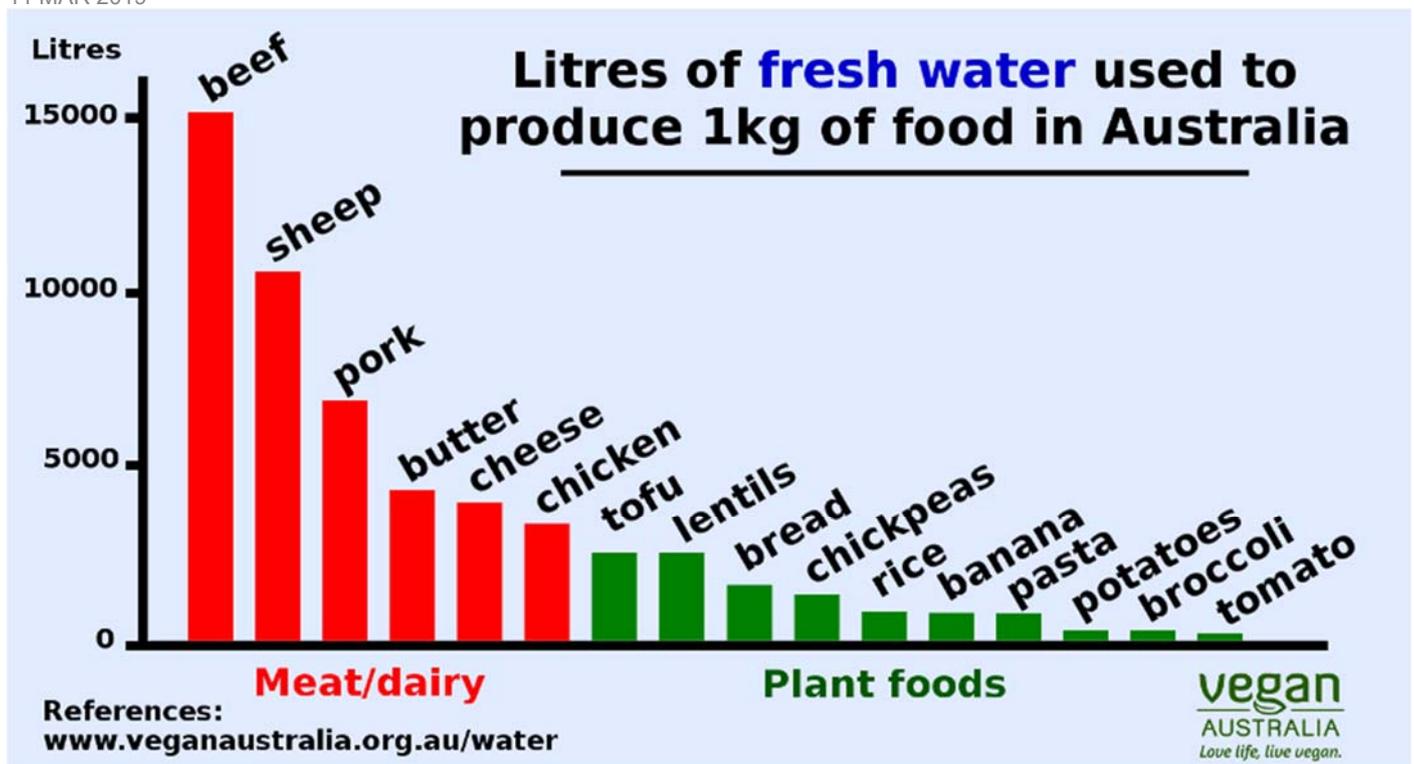
It is believed that Benjamin Franklin stated that "when the well is dry we know the worth of water". Living on the driest continent on earth, Australians are increasingly becoming aware of the precious resource water is- and indeed our "well" is starting to run dry. With agriculture accounting for our greatest use of water we need to look at its consumption in food production, and depending on which author you read various answers abound however the greatest consensus appears to be that the water consumption for beef (and animal products) is greater than that of grains.

In November of 2006 the Food and Agriculture Organization of the United Nations produced **Livestock's Long Shadow: Environmental issues and options**. This significant tome detailed the impacts of animal agriculture on climate change, air pollution, land, soil and water degradation along with reductions in biodiversity. Henning Steinfeld, Chief of FAO's Livestock Information and Policy Branch and senior author of this report states "Livestock are one of the most significant contributors to today's most serious environmental problems. Urgent action is required to remedy the situation." Chapter 4 is given over to livestock's role in water depletion and pollution. The report can be read here <http://www.fao.org/3/a-a0701e.pdf>

In order to provide a more complete answer I have turned to the following resources.

Live vegan, save how much water?!

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Compared to a vegan diet, eating meat, dairy and eggs uses a **lot** of water!

Studies carried out by researchers in Australia and overseas show that over 20 times more fresh water is required to produce animal products compared to the same weight of plant products. Animal agriculture puts a huge strain on our water resources and compromises our water security.

While directly saving water at home is a noble idea, most people don't realise that water used to produce our food makes up 90% of all water used by an average Australian household. So whether

saving water for drinking, or saving our mighty rivers and their wetlands, moving to a vegan diet will have a much more positive impact than having shorter showers or not watering the garden.

As the graph above shows for Australia, producing 1kg of beef, lamb, pork and other animal products takes many more litres of water than 1kg of vegan foods, like grains, beans, fruit and vegetables.

Did you know?

- It takes [over 20 times more water](#) to produce 1kg of beef compared to rice, grains, beans, fruit and vegetables in Australia.
- It takes [800 litres of water to produce one litre of cow's milk](#), four times as much as it takes to [make one litre of soy milk](#).
- [Vegan households use less than a third](#) of the water of the average Australian household.
- Agriculture is the number-one user of water, [accounting for 65% of total water](#) consumed in Australia and [70% worldwide](#).
- [Animal agriculture is responsible for up to one third](#) of all fresh water consumption in the world today.
- [43% of irrigation water](#) in Australia is used by the animal agriculture industry.
- [Only 24% of irrigation water](#) in Australia is used for fruit, vegetables and grains for human consumption.
- [The dairy industry uses 19%](#) of irrigated water in Australia and is responsible for [35 per cent of water consumption in the Murray-Darling basin](#), Australia's most important agricultural region.
- The [world will run out of fresh water by 2050](#) if we continue to consume animal products at the current rate, according to the Stockholm International Water Institute.

The research behind the numbers

The values used to create this graph come from a [2010 study by researchers at the UNESCO Institute for Water Education](#). The values for animal products are for Australia. Unfortunately the study does not show the values for plant products for Australia, so global average values are displayed. However, according to [earlier work \(2005\)](#) by the same researchers, water use for plant production in Australia is about the same as or less than the global averages.

The graph above was derived from research done by the UNESCO Institute for Water Education. Other researchers have found even greater discrepancy between animal and plant foods. [Earlier research by CSIRO](#) in Australia estimated that it takes 50,000 litres of water to produce 1kg of beef, but only 1,010 litres to produce 1kg of wheat, 2,200 for soybeans and 2,385 for rice.

All values discussed so far have been litres per kilogram. Because different foods have different energy densities, another useful measure is the number of litres of water used to produce one calorie or megajoule. This would account for the fact that there is more energy in a kilogram of tofu than in a kilogram of broccoli. However, even using this measure, animal products are still very water intensive, with beef using about 10 times more water than most fruits and vegetables. [Research by CSIRO](#) shows that fruits and vegetables generally require around 200 litres of water per megajoule, whereas beef requires 2,500 litres per megajoule. Similar figures are obtained when protein is measured rather than energy, with [research published in The American Journal of Clinical Nutrition](#) stating that "producing 1 kg of animal protein requires about 100 times more water than producing 1 kg of grain protein."

As shown above, there is some difference between the numbers found by various researchers, but, as [one researcher has noted](#), "All authors agree the water footprint of beef is [...] much larger than the water footprint of grains."

Values used for graph

Product	Litres/kg	Cooking factor
beef	15,182	
sheep	10,600	
pork	6,924	
butter	4,351	
cheese	3,968	
chicken	3,343	
tofu	2,523	
lentils	2,517	2.3
bread	1,608	
chickpeas	1,305	3.2
rice	832	3.0
banana	790	
pasta	764	2.4
potatoes	287	
broccoli	285	
tomato	214	

Sources for figures used: [Animals \(Table 4\)](#), [Crops \(Table 4\)](#)

The values used for lentils, chickpeas, rice and pasta have been adjusted by the factors given to take into account their increase in weight when cooked.

Links

- [Water Footprint Network](#)
- [The green, blue and grey water footprint of crops and derived crop products](#), M.M. Mekonnen, A.Y. Hoekstra
- [Water footprint of crop and animal products: a comparison](#), Water Footprint Network
- [The water in our food](#), Paul Mahony
- [Water footprints of nations: Water use by people as a function of their consumption pattern](#), A. Y. Hoekstra, A. K. Chapagain
- [Water for Food - the continuing debate](#), Wayne Meyer
- [Sustainability of meat-based and plant-based diets and the environment](#), David Pimentel, Marcia Pimentel
- [Comments on Meat & Livestock Australia's "myth busters" and other claims](#), Paul Mahony
- [Water Account, Australia](#), Australian Bureau of Statistics
- [Demand for Meat Is Driving Water Shortages Affecting 4 Billion People](#)

Source <https://www.veganaustralia.org.au/water>

For an Australian perspective on water in animal based products I cite "Water usage" from a submission paper prepared by Paul Mahony entitled Submission in Response to Department of Agriculture Fisheries and Forestry National Food Plan Green Paper. The full submission can be found here <https://terrastendo.files.wordpress.com/2016/02/mahony-paul.pdf>

Mahony writes more extensively on the consumption of water in animal products here <https://www.veganrising.org.au/the-environmental-destruction-of-eating-animals/>
Of particular note is the following section;

WATER USE

Professor Wayne Meyer is Professor of Natural Resource Science at the University of Adelaide and former Deputy Chief and Business Director for Commonwealth Scientific and Industrial Research Organisation (CSIRO) Land and Water. He has received the CSIRO Medal for Research Achievement for his research in irrigation water management.

Prof. Meyer has estimated that, to produce 1 kilogram of product, it takes between 50,000 and 100,000 litres of water for beef compared to between 715 and 750 litres for wheat and between 1,550 and 2,000 litres for rice. [25]

David and Marcia Pimentel of Cornell University have reported that producing 1 kilogram of animal protein requires about 100 times more water than producing 1 kilogram of grain protein. Their estimates for 1 kilogram of beef range from 100,000 litres (relating to grain and hay for production systems that include intensive feedlots) to more than 200,000 litres (relating to forage production on rangelands). [26]

Elsewhere, David Pimentel and co-authors have cited figures of 43,000 litres for intensive production including feedlots and 120,000 – 200,000 litres for open rangeland production. [27]

Professor Meyer's figures were originally derived for intensive production using irrigated pastures. Seemingly consistent with the findings of David and Marcia Pimentel, he has subsequently suggested that if the same exercise were conducted on rain fed, extensive meat production, there may be even more water involved. The reason is that feed conversion is likely to be lower, energy expended in gathering dry matter (including grass) would be greater and soil evaporation losses may even be higher than in a system involving irrigated pasture. [28]

It then becomes a question of the optimum use of the water, taking into account potential alternative uses.

Prof. Meyer has pointed out that water used for irrigation has many alternative uses, including keeping it in the river systems, keeping riverine and wetland ecosystems healthy and providing water for urban and industrial uses. He has noted that alternatives for rain fed areas are more restricted, but could include provision of run-off in catchment areas, growing native vegetation for conservation purposes and or for groundwater recharge. He has said:

"Using this logic there is little value in arguing that meat production does not embody a lot of water. More rationally the discussion can be about the value we place on the genuine alternatives for the use of this water."

In areas where crops for human consumption can be grown, there are high opportunity costs in meat production, with the water requirement of animal-based foods being many times that of non-animal options for any given level of nutritional output.

In non-cropping areas, the choice can be as simple as steak dinners versus natural ecosystems. Alternatives are available for steak dinners but not for natural ecosystems.

Prof. Arjen Hoekstra of the University of Twente in the Netherlands and Prof. Ashok Chapagain of the University of Free State, South Africa, have estimated that, in Australia, 17,112 litres of water are required to produce 1 kilogram of beef. [18] Although lower than other estimates referred to in this article, their estimate is still many times higher than estimates for vegetables and grains. [29]

Their figures for soy beans are 2,106 litres (Australia) and 1,789 (global average), and for paddy rice 1,022 litres (Australia) and 2,291 litres (global average).

Hoekstra and Chapagain are on the supervisory board of the Water Footprint Network, which is a non-profit foundation under Dutch law. The founding partners were: University of Twente, World

Wildlife Fund, UNESCO-IHE Institute for Water Education, the Water Neutral Foundation, the World Business Council for Sustainable Development, the International Finance Corporation (part of the World Bank Group) and the Netherlands Water Partnership. [30]

In responding to queries regarding the differences between his figures and those of Prof. Meyer and Dr Pimentel, Prof Hoekstra has noted: [31]

" . . . all authors agree the water footprint of beef is larger than the water footprint of pork or chicken and much larger than the water footprint of grains".

His global average figures for chicken meat and pig meat are more than double those of soy beans, while the multiple for beef is more than eight.

In personal correspondence from Paul Mahony he notes that " 70% of our beef is exported. That means the driest inhabited continent on earth is using its precious water to feed foreign customers when the price they pay fails to adequately allow for the enormous environmental cost (including water usage, greenhouse gas emissions, land clearing, habitat loss, species extinction, Great Barrier Reef coral loss, etc.)"

Further reading on water consumption in food production can be found here

<https://waterfootprint.org/media/downloads/Report-48-WaterFootprint-AnimalProducts-Vol1.pdf>