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TE APĀRANGI

# VIRTUAL WATER

## Emerging Issues

New Zealand is a major exporter of virtual water – water tied up in the production of agricultural products. Our resources of freshwater are finite and inefficient use will limit the wealth that can be created from this resource. In addition, international sustainability standards for water use are being developed and our farmers will increasingly need to show that their use of water is sustainable.

The sustainability of water use depends upon the impact of that water use. However, as the impact varies greatly across nations, it is difficult to use water use to compare sustainability at that level. At a regional and catchment level, water use becomes more clearly connected with measures of sustainability.

Measuring the virtual water content of our products is a necessary first step to improving and demonstrating our efficiency and performance. Monitoring, auditing, and predicting both water availability and use will be needed to create the maximum economic benefit from finite water resources. However, this optimisation must not take place at the cost of environmental, social, and cultural water services, which are not currently informed by the virtual water concept.

### Virtual water is a measure of the water use required to produce a product or service

Virtual water is a measure of the total amount of water required to deliver a product or supply a service. Two commonly quoted examples are that a single cup of coffee can require 140 litres of water (mostly to irrigate the coffee plant),[1] and one kilogram of beef can require 16,000 litres of water to produce (mostly to produce feed for the animal).[2]

The virtual water concept takes a bottom-up, life cycle analysis approach to measuring the water embodied in a product. A similar concept, water footprinting, looks at the overall water required to meet a specific demand, whether national or personal. Water footprinting is used to compare and describe the flows of virtual water among nations as they trade water-intensive products.

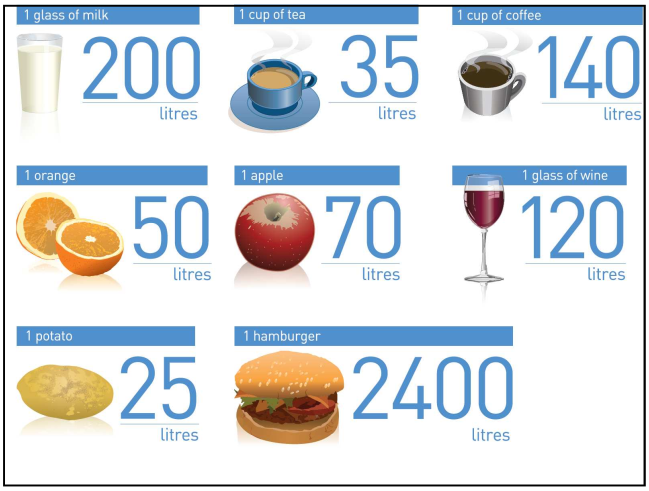

Figure 1: Global average figures for the virtual water content of foods and beverages[2]

Virtual water is typically measured as litres of water per kilogram of production. However, it can also be stated as litres per dollar of production, which allows the economic value of water uses to be considered. This can be extended to litres per dollar of profit, or litres per job created by the use of that water. The CSIRO *Balancing Act* report provides an example of this approach to measuring the productivity of natural capital, showing "how much energy, water, land, employment (and so on) is embodied in every dollar in the Australian economy".[3] For New Zealand at present, the database for this kind of knowledge is weak and modelling of these connections is very limited.

### Freshwater will become as important a global issue as greenhouse gas emissions

Our freshwater resource is precious and finite. It underpins the biological basis of the New Zealand economy and provides a competitive advantage for our exporting industries.

Irrigation for agriculture comprises three-quarters of the consumptive water use in New Zealand.[4] Hence this analysis only focuses on virtual water in agricultural

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[1] Chapagain, A.K., Hoekstra, A.Y. "The water footprint of coffee and tea consumption in the Netherlands", Ecological Economics 64 (1): 109-118, 2007

[2] Hoekstra, A.Y. and Chapagain, A.K. "Water footprints of nations: water use by people as a function of their consumption pattern", Water Resources Management, 21(1): 35-48. 2007

[3] CSIRO, "Balancing Act: A triple-bottom-line analysis of the Australian economy", 2005

[4] "Environment New Zealand", Ministry for the Environment, 2007

products. New Zealand is an importer of water through crop products, but exports over five times that amount as livestock products, primarily dairy.[5] The growth of irrigated agriculture in New Zealand has enabled the expansion in dairying over the past few decades. This growth has been dependent upon supplies of freshwater, but those supplies are now over allocated in some regions. There is great potential to use the water we have more efficiently as well as further land that could profitably be irrigated if water were more available.

New Zealand is in the top three exporters of virtual water, per capita.[5] In that context, our agricultural water use may be a major trade advantage or a possible trade risk, if virtual water becomes a useful measure of sustainability or not.

The sustainability of freshwater use is rapidly becoming a topic of global concern. Wal-Mart recently introduced plans requiring its suppliers to report their water use and plans for reducing that use;[6] JP Morgan have stated that freshwater presents companies with risks that are increasing and hard to assess.[7] Recent reports by the World Wide Fund for Nature (WWF) have flagged the overseas water footprint of the UK and other European nations as an issue of concern.[8]

The international debate around water sustainability is lagging around five to ten years behind the carbon footprinting debate, but this debate will become unavoidable. Several of New Zealand's major producers are planning to be ready as requests for water footprint information begin from consumers, retailers, and governments. The International Organization for Standardization (ISO) is scoping out what an international standard on water footprinting could involve.

### The water required to create a product is an incomplete guide to that product's sustainability

Carbon footprinting is useful to show the climate change impact of products and services. There is a direct relationship between the emissions of greenhouse gases created by products and the resulting anthropogenic contribution to climate change. This can be used to construct an emissions cost which is valid across all nations and from year to year. The impact of water use is very different. The economic and environmental impacts of water vary from region to region and from season to season, as do water supply and demand.

This variability in the impacts of water use raises difficulties for the concepts of virtual water and water footprinting as measures of sustainability at an international level. For the three components of water use,[9] there are problems in defining or measuring actual use, and the impacts of that use. For rainwater and surface water, the limits on use depend upon minimum ecological flow requirements for river and groundwater ecosystems. For groundwater, the limits on use depend upon both aquifer recharge rates and requirements for the natural outflow that feeds lowland streams. For polluted water, limits are set by downstream and groundwater quality requirements. The science around each of these factors is complex; setting the limits based on this complex science is contentious.

The concept of virtual water was originally developed as an indicator for trade comparisons (and as a measure of corporate risk). Trade among water-rich and water-poor nations allows each to specialise in water-intensive or non-intensive goods. However, measuring water use and trade by volume alone is a poor guide to environmental impact. The value of water is so variable that many comparisons are invalid. For example, New Zealand's net virtual water exports are similar to Sudan's.[5] Clearly, the impact of that water export will be very different between pluvial New Zealand and highly water-stressed Sudan, thus using virtual water as an indicator for sustainability is imprecise and potentially misleading.

For international comparisons to be valid, they will need to take into account the impacts of water uses. Nevertheless, these comparisons will continue to be made, regardless of the quality or quantity of data available. Food retailers are pushing for omni-standards that demonstrate the sustainability of products. Water footprint will be an inevitable part of these standards, as businesses seek to "communicate water scarcity… encourage scrutiny of supply chain practises… and enable people … to choose products that cause less harm or greater benefit".[10]

### Virtual water does not cover all dimensions of freshwater management

Beyond the economic sphere, many policy questions around freshwater involve trading-off among economic, environmental, social and cultural values. These values are not well described by economic terms and are often incommensurable with purely economic approaches. A conceptual tool such as virtual water is less useful in informing these trade-offs between fundamentally non-economic values.

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[5] "Water footprints of nations", A.K. Chapagain and A.Y. Hoekstra, November 2004

[6] Walmart, "Sustainability Product Index: 15 Questions for Suppliers", June 2009

[7] JP Morgan, "Watching water: A guide to evaluating corporate risks in a thirsty world", March 2008

[8] Chapagain, A.K., Orr, S., "UK Water Footprint: the impact of the UK's food and fibre consumption on global water resources", WWF-UK, 2008

[9] Virtual water can be broken down into three types - green, blue, and grey:
Green water is the amount evaporated and transpired from plants that comes from rainwater;
Blue water is the amount evaporated and transpired from plants that comes from surface and groundwater reservoirs; and
Grey water is the water that is polluted during production, or the additional water required to dilute pollutants to acceptable quality standards.

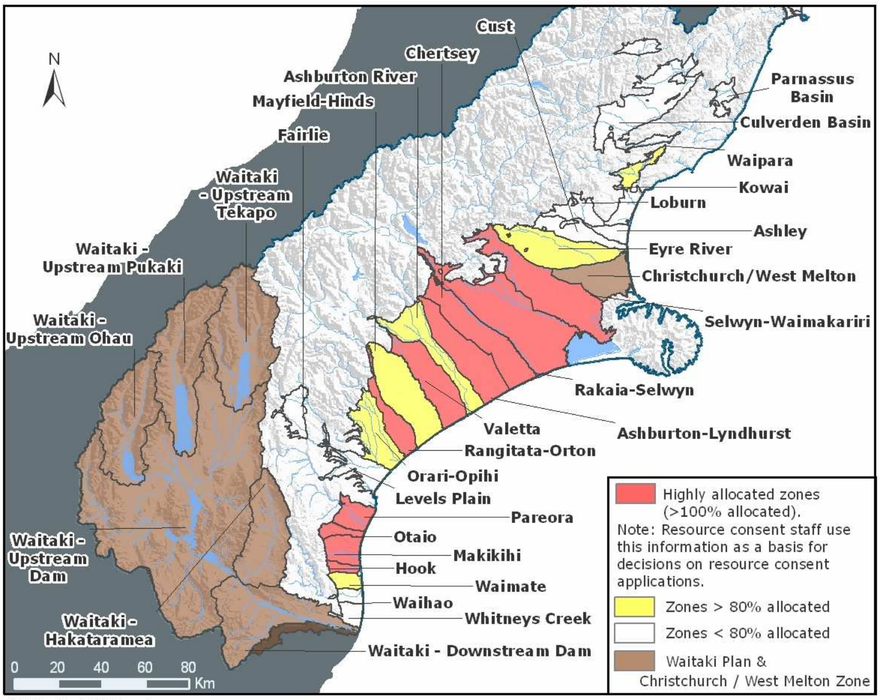

Figure 2: Groundwater allocation zones for Canterbury[15]

**New Zealand data on water use is poor, as it is globally, and data on the virtual water content of products is worse**

While water allocations are known, actual data on water use and availability is patchy. Some district councils, such as Tasman District Council, have required water metering of all abstractions in many of their catchments and have long-term records describing average and extreme water use; most others do not.[11]

Our virtual water performance reflects both the nature of our farms, which use modern irrigation technology and so are relatively efficient, and of our maritime climate. Using rough figures, the virtual water content of apples grown in New Zealand matches that of those grown in the Netherlands and is greatly less than those grown in Cyprus. Similarly, the virtual water content of New Zealand kiwifruit is around a fifth of Australian kiwifruit.[5]

However, accurate data about the virtual water content of our agricultural products is very slim, as it is globally.

At a farm level, Plant & Food Research and Landcare Research, amongst others, are developing techniques for improved, real-time monitoring of water use by plants. An example of this research includes a project to investigate the increased water-efficiency achieved by using dwarf rootstock for fruit trees.

At a supply chain level some companies, such as Zespri, are using information gathered as part of carbon footprinting work to inform water footprinting . At a regional level, NIWA and Aqualinc are working with Environment Canterbury to inform water resource management.

The methodologies for virtual water measurements and water footprinting differ for each of these levels and international agreements on methodologies have yet to develop. This lack of clear methodologies is limiting industry work on virtual water measurement. The recent opening of the Life Cycle Assessment Centre at Massey University should improve New Zealand's capability in environmental footprinting, including water footprinting. The aims of the centre are to develop specific methodologies for footprinting and to pool expertise from Massey University, Plant & Food Research, Landcare Research, AgResearch and Scion.

**Research can enable water users to demonstrate and improve their virtual water performance**

New Zealand's copious supplies of freshwater are already a source of our comparative advantage in agriculture. However, our virtual water performance will only become a source of trade advantage if farmers or their industry organisations can demonstrate and certify that water use has a low environmental impact and that they meet overseas standards of environmental stewardship. Justifiable, verifiable, full life cycle water footprinting may become a requirement for market access. However, our farmers are far from being able to certifiably report on the social and environmental impacts of their water use.

An improved measure of the virtual water content of a product may be useful for meeting the information demands of a retailer. However, improving water performance requires two kinds of data:

- A breakdown of water use during production, processing, and delivery stages, to show where savings can usefully be made;
- Data connecting virtual water performance with changes to production such as irrigation schedules, new varieties, etc to show what savings can be made at what cost.

At a farm level, decision support tools will be needed to

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[10] Segal, R., & MacMillan, T., "Water labels on food: Issues and recommendations", Food Ethics Council, 2009

[11] Energy use by water pumps has been used as a proxy to measure water use, but this is only weakly connected to actual water use, depending upon irrigation type, farm layout, depth of groundwater, and other factors. The proposed National Environmental Standard for Measurement on Water Takes should eventually provide a much better evidence base on water use.

**The potential irrigation gains from existing knowledge**

Farmers face existing costs for water, mainly through the energy costs of pumping, but these costs have not delivered best practice in irrigation efficiency. The irrigation industry has recognised this and has responded with an Irrigation Code of Practice and Irrigation Design Standards. The industry aims to use best practice for 80% of water use by 2016. Training courses are underway or in development for irrigation auditors, operators, and system designers so that skilled people will be available to implement best practice on farms.[12] Improving irrigation practices will improve efficiency, for example, through basing irrigation on active monitoring of soil and crop needs.[13] Lower application rates also result in less water loss through percolation and evaporation, and will have knock-on effects upon water quality through reduced runoff of pollution or leakage to groundwater.

Water scarcity already limits the growth of irrigation schemes, despite the economic potential of irrigable land. Canterbury includes 450,000 ha of extra land that could be irrigated, if water was available (in comparison, 560,000 ha is currently consented for irrigation).[14] Best practice in irrigation efficiency could allow the expansion of irrigation to all of the suitable Canterbury land with only a small increase in water use. The expected economic returns to this expansion of irrigation are in the order of $200-300 million.[15] Further increases in agricultural incomes could be achieved by land use choices that minimise the virtual water content of crops, changing varieties or crops, and focus on the most economically productive uses of water, within existing water constraints.

provide both water use reporting and to inform farmers' water use decisions. The information included in these tools would include soil moisture profiles, rainfall and weather conditions and predictions, and the response of crops to additional water. For some crop and farm types, such as arable crops and some fruits and vegetables, this information is available and decision support tools have been launched. For others, whole farm irrigation models are in development. However, the information base is insufficient to support such tools for many farm types. These decision support tools will need comparison and validation if they are to provide farmers with high quality recommendations.

### Research on inventory, prediction, and modelling of water use and supply will enable the informed management of virtual water

Improved, fine-scale measurement and monitoring of both water supply and water use would ensure that local conditions are better understood. Enhanced inventory capability, such as more detailed understanding of groundwater stocks and flows, and ecosystem stress would inform the freshwater management role of local government. Fine-scale prediction of weather, climate, and the risks of extreme events could support more responsive, resilient, and flexible water allocation systems.

In Canterbury, the limited water supply limits production. Efficient water use is the key to further growth in irrigated agriculture. To achieve this efficient use different crops and varieties can be substituted and land use can change to reflect water availability. Virtual water provides one perspective to inform these questions of resource productivity. For example, to create the same value of production in Canterbury, vineyards can require one quarter the volume of water than dairy farms. However, wine value is volume sensitive, so increased wine production will itself change the value created, complicating this simple sum.

Understanding the options depends upon a good knowledge of the interactions between water use and farm outputs. Resource managers would benefit from tools that make useful this knowledge, for "simulating the broad effects of alternative policies and alternative scenarios";[16] these tools do not exist yet. Even at the simplest level, of computable general equilibrium economic models,[17] work is only just beginning.

## Further reading

Jenkins, B., "Water allocation in Canterbury", Environment Canterbury, presented at the New Zealand Planning Institute Conference, 27th-30th March, 2007
Chapagain, A.K., Orr, S., "UK Water Footprint: the impact of the UK's food and fibre consumption on global water resources", WWF-UK, 2008

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[12] Primary Sector Water Partnership Leadership Document
[13] NIWA, "Forecasting Irrigation Potential: a case study in the Waimakiira River catchment"
[14] Environment Canterbury, "Canterbury Strategic Water Study"
[15] Jenkins, B., "Water Allocation in Canterbury", Plenary address, NZ Planning Institute Conference, Palmerston North, March 2007
[16] "Old Problems, New Solutions: Integrating economic, bio-physical, social and legal perspectives to support regional management and governance of natural resources", FRST-funded research programme lead by the University of Otago and Landcare Research
[17] Lennox, J., & Diukanova, O., "Modelling regional general equilibrium effects and irrigation in Canterbury", Landcare Research, 2008