City people eat rivers: estimating the virtual water consumed by people in a large Australian city

Ian Rutherfurd[1], Amelia Tsang[2] and Siao Khee Tan[2]

1 School of Social and Environmental Enquiry, University of Melbourne, 221 Bouverie Street, Carlton, 3010. Web: http://www.sages.unimelb.edu.au/, Email: idruth@unimelb.edu.au
2 Department of Civil and Environmental Engineering, University of Melbourne, 221 Bouverie Street, Carlton, 3010.

Abstract

It is self evident that the majority of stream length in Australia flows through rural rather than urban areas. The result is that stream condition is seen to be a rural issue. In fact, the condition of rural streams in Australia is determined, to a large degree, by food choices made by people in cities. Using Melbourne as a case-study, we show that for every litre of water consumed directly in the average Melbourne household, nine more litres are consumed indirectly through the water used to produce food. This is called 'embodied' or 'virtual' water'. Thus, product choices made by city people ultimately drive how much water is removed from rural streams. We suggest four ways that consumers can dramatically reduce their indirect water consumption: waste less food; select *comparable products* that use less water; *substitute types* of food that use more water for types that use less; and become a vegetarian. It is also clear that changing food choices will not automatically lead to environmental benefits. In some cases it could lead to unintended disbenefits. Nevertheless, each mouthful of food links urban people to the nation's rivers, and food choices can potentially empower them in improving the condition of those rivers.

Keywords

Virtual water, embodied water, urban food choices, water use

Introduction

In Australia, water is taken from rural streams to produce food to feed people in cities. Eighty five percent of the divertible water from the Murray-Darling system is now diverted, and only 7 of Victoria's 29 major catchments are not fully allocated for water (DNRE, 2004). In Victoria, 75% of that diverted water is being used for agriculture, and about 12% for urban domestic purposes. The great bulk of water used in agriculture goes toward irrigation, and mostly irrigation of pasture for dairy and beef cows. It is well known that Australia is amongst the most urbanised countries on Earth, with 75% of the population living in the 15 cities that have populations above 100,000 (ABS, 1999). The great bulk of streams are in rural areas. There are over 330,000 kilometres of streams in Victoria (the blue line length on the 1:25,000 scale mapsheets, Mike Stewardson, pers comm.) compared with the 5,000 or so kilometres of stream in the built-up areas of Melbourne (1.5% of the State's stream length).

In this paper we make the simple point that, as consumers of agricultural products produced in rural areas, urban people are, in large part, responsible for the consequences of that production. Urban consumers very much drive the condition of rural streams through their food choices. It has become common-place for the media to report how much water is used in producing particular foods. This is known as 'virtual' or 'embodied' water (see the major review in Chapagain & Hoekstra, 2003). Meyer (1997) estimated that 1Kg of Australian beef requires an astonishing 100,000L of water to produce, and 1Kg of butter, requires 18,000L of water. The Water Education Foundation (1991) produced a water-use table for foods in a sample daily menu. Examples of water used in the menu were toast and butter (213L), chicken (435L), cheese (636L) and ground beef (312L). Whilst these figures are interesting, it is important to express them in relation to other water uses – in particular the daily 'direct' water used in a household, such as for washing, gardening etc.. Thus, in this paper we estimate the proportion of water that is consumed 'directly' by households in Melbourne, in comparison with the volume that is consumed indirectly in the foods that these households consume.

Methods

We needed three pieces of information: how much water do Melbourne households use directly, how much and, what sort, of food is eaten in Melbourne homes, and finally, how much water is required to provide that food? We estimated the amount of water used in three types of Melbourne household: the average household, the household with no garden, and the household that eats out for 5 days of the week. Each household is assumed to contain 2.6 people. For each of the three household types we allocated nine different diets, producing 27 different combinations of households and diets (e.g. one combination would be "*a household of males with an Asian diet living in a house with no garden*"). In this paper we only report on the average and vegetarian diets for men and women.

The most complete survey of food consumed by people in Australia is the National Nutrition Survey (NNS), conducted in 1995/6 (ABS, 1999). The survey does not have specific data on Melbourne or Victoria, so we have assumed that the average values in the survey apply to households in Melbourne. The NNS provided sufficient information to reconstruct the food consumed annually by the nine diet types. We only discuss a few of these combinations here. We made the following assumptions:

- The only 'virtual water' used in a household is in food (so we have not included water used, for example, in manufacturing).
- The weight of food consumed is a reflection of its nutritional value.
- All foods consumed are locally grown rather than imported.
- Alcoholic and non-alcoholic beverages and oils are not included.
- Food wastage is not taken into account.

Several methods have been developed to estimate the amount of water used in the production of different foods (Hoekstra & Hung, 2002; Zimmer & Renault, 2003; and Oki & Kanae, 2004). For this exercise we simply compiled water use values, from the literature, for each food type. We took an average value for Australian estimates, or an appropriate average from countries with a similar climate to Australia. Total water usage figures are calculated for the age groups of 2-11, 12-18 and over 19yo. To find the average consumption, age demographics of Melbourne (ABS statistics) were used to calculate the weighting of the amount consumed so it is representative of the total proportion of the population.

Results

Household water consumption

An independent commission report comparing three retail water companies reported average water use in Melbourne of 212 kilolitres/household/year, and a typical owner-occupied household using 230 kilolitres per annum (ignoring the 4% of un-metered losses) (The Melbourne's Retail Water & Sewerage Companies — Performance Report, 2001-2002). Other estimates of use are between 360 Litres/person/day (DNRE, 2004) and 380 Litres/person/day, adjusted figure for climatic conditions (Water Resources Strategy Final Report, 2002). By assuming a household size of 2.6 people, each household consumes about 936 litres per day (Figure 1).

Food consumption

From interrogating the NNS, we determined the nine diet types. For example, the 'average' Melburnian is considered to eat the following foods, in the following amounts.

- *Cereals* (30% rice, 70% wheat products)
- *Fruits* (35% pome, 40% tropical and 25% citrus)
- *Vegetables* (65% potatoes and 35% stalked vegetables)
- *Milk* (90% Milk, 5%cheese and 5%butter)
- *Meat* (35% beef, 35% pork and 30% chicken)

Indirect and direct water consumption

The average Melbourne household directly uses 936 litres per day, whilst through food consumption; 9,276 litres per day per household. Thus, on average, water use through food consumption is 90% of a household's water use (Figure 2). Regardless of how scenarios are combined, much more water is consumed through foods than through direct water use. The percentage of direct water use to total water use ranges from 6%,

for an all male household with a garden (scenario 1), who consume 3,928 Litres per capita per day, to 26% for a vegetarian household with no garden (Scenario 27) who consume just 1,345 Litres per capita per day. Thus, the water used to feed one average person can feed three vegetarians.

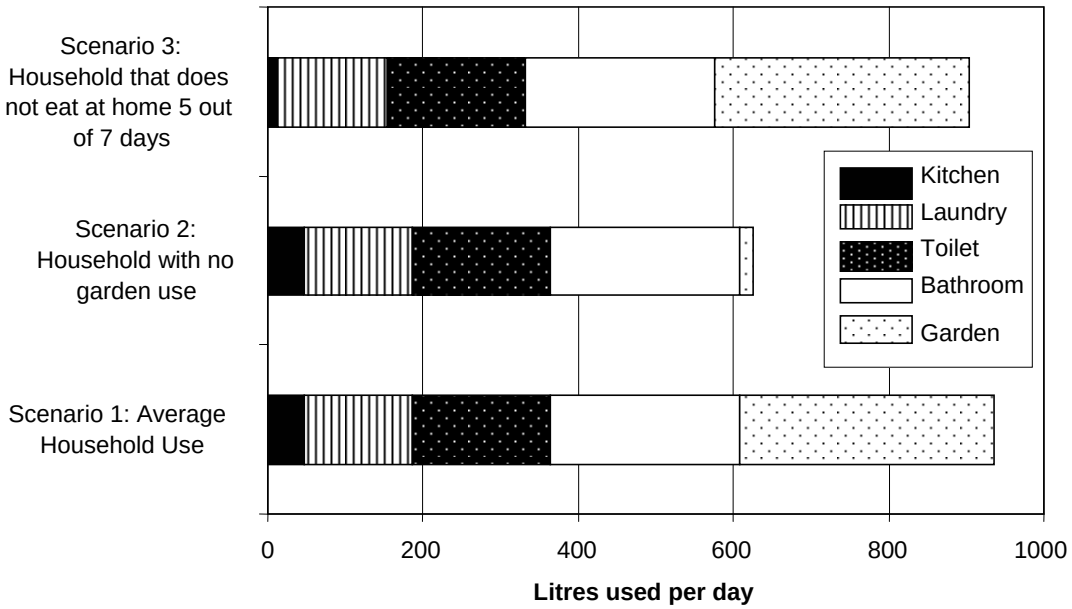

Figure 1. Three Scenarios showing variation in direct daily water consumption of Melbourne households.

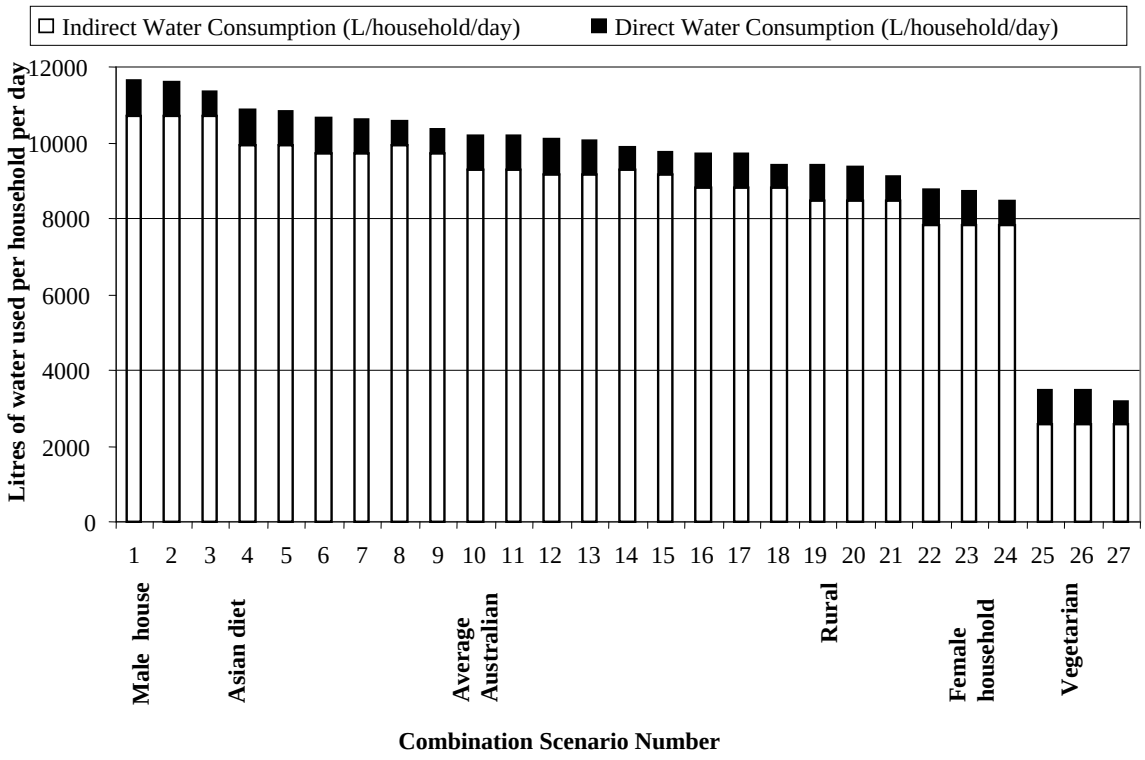

Figure 2. Total daily water consumption (Direct and Indirect) of 27 scenario combinations.

Discussion

For every litre of direct water consumed by a Melbourne household, they will consume another eight to nine litres 'embodied' in the food that they eat. Total direct and indirect water consumption per head for Melbourne (3,928 Litres per capita per day) is similar to figures found in the USA (3,384L/capita/day) (Water Education Foundation,1991), although other estimates are higher (5,400 L/c/d for the USA, and 4,000 L/c/d for developed countries (Renault, 2003). The amount of indirect water consumption would be slightly higher if we included the water used in manufacturing the food (which generally adds between one and nine litres of water per kilo of food (AFGC, 2003), and if we included manufactured agricultural products (e.g. the cotton in a bed-sheet uses 10,000L of water to produce (Chapagain *et al.*, 2005).

The results of the study assume that all virtual water was consumed in primary food production. Large volumes of water are also used in making manufactured goods in the home, however, less than 10% of all water is used in manufacturing. The other major assumption in these figures is that the water used by agricultural plants comes from irrigation. For example, most beef does not come from irrigated pastures. Much of the water used by plants comes directly from natural precipitation that would not have reached a river anyway. This means that the link between food and rivers is not simple, but we cannot escape the fact that three-quarters of all irrigation water use is for food production.

In gross terms, these results mean that changing one's diets could save much more water than changing ones water-use behaviour in the home. For households that love meat, eating poultry instead of beef and pork will half their total water usage (from 3568L to 1603L per day). This is a saving of three times the total amount of water used directly in the home.
Urban consumers can dramatically reduce their total water consumption with the following actions:

1. consume less food (and hence less water) by wasting less food (or by eating less food altogether!);
2. select *comparable products* that use less water;
3. substitute *types* of food that use more water for types that use less;
4. become a vegetarian.

Waste less food
Reducing the wastage of food will also increase efficiency of food transported and reduce the amount of virtual water use (Waste management and Environment, 2004). The rate of waste generation increases towards the consumer end of the food supply. On a national level, we consume 11.5 million tones of food each year and throw out 2.2 million tones (20%) (Waste Management and Environment, 2004).

Select the more water-efficient product
Dramatic improvements are already being made in water use efficiency in Australia. With best irrigation practices, only 430 litres of water is required to produce 1 litre of milk, while worst practices will use 1,150 litres (Reid, 1981). As an example, consider milk. The consumer can select between two brands at the supermarket shelf – one produced in NE Victoria, and one produced in East Gippsland.

Table 1. Water use from dairy and milk consumption.

	Irrigation water applied per cow (ML/cow)	Annual milk production per cow by dairy region	Water applied per litre of milk
Murray Irrigation region	2.6	4700	553
East Gippsland sub-region	1.2	4500	267

In the year 1998-99, each Australian consumed an average of 102 L of milk. Thus, choosing milk from the Murray irrigation area would consume 56,600 embodied litres of water per year, compared with 27,340 litres of water embodied in milk produced in Gippsland (Table 1). This is a reduction in water use of nearly 30,000L per year or 80 L/day. Compare this with the 17 litres per day per person that has been saved in Melbourne under Stage 3 water restrictions between 2005 and 2006 (Media release by Minister for the Environment, John Thwaites, 1/12/06).

Food substitution
Consumers can 'substitute' entire groups of foods in their diet that use different amounts of water in their production. For example, in general, the greater the protein content of foods, the more water is used in their production per kg (Tan, 2006). However, by choosing soybeans and lentils instead of cheese, you would be eating roughly the same amounts of protein, but saving more than 2,000 litres of water per kilogram of food (Figure 3). Note that the actual amount of irrigation water saved depends on where the products are grown. Numerous other comparisons, based on food groups, are provided in Tan (2006).

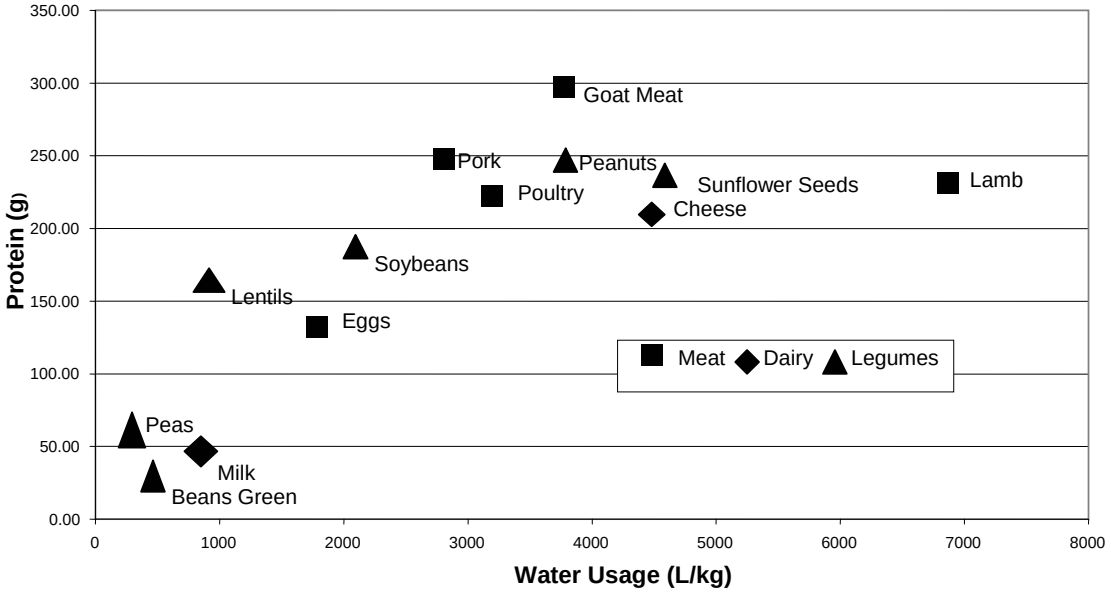

Figure 3. Protein vs. water use for various food groups – dairy, meat and legumes (without beef & butter) (from Tan, 2006).

Become a vegetarian
A vegetarian diet can save households up to 35% of their total water usage. That is 13 times the volume of water that would be saved by not watering the garden. The environmental benefits of vegetarianism have been made for many years, and Renault (2003) suggests that an animal product based diet may need 10 times more water than a vegetarian diet. Certainly the water efficiency of vegetable production is startling.

Problems with the argument
It is empowering to think that urban consumers could save more water by altering their purchasing than they could by altering their behaviour in the shower. However, the two types of water are not entirely comparable. Irrigation water is of lower quality, lower value, and the water often comes from different river systems than the potable supply. If the people of Melbourne are saving water in order to ensure the security of the city's supply (which motivates many people), then there is little relationship between their water decisions and embodied water use. This is because little of Melbourne's potential water stock competes with irrigation use (the Thomson Reservoir in Gippsland is an exception). However, much of the concern over water relates to some, often vaguely expressed, concern for the environment. But is it true that the 'environment' will benefit from reducing our embodied water consumption? The premise is that using less water in food production, and choosing products that use less water, will result in less water being extracted from streams. Imagine, for example that all the consumers of Melbourne suddenly selected milk from Gippsland over milk from the Murray Basin. Would the water that was going to go to dairy irrigation simply continue to flow down the Murray and its tributaries? Probably not. First, the dairy industry might simply sell the milk to a different, less environmentally sensitive market interstate or overseas. Dairy products are already the major export product from Victoria. The change in food choice would lead to no benefit to rivers, and increased carbon production with the increased transport distances.
Second, the water that would have gone to irrigated dairy could be left in the reservoir, to increase the security of supply. Unless there were clear environmental flow rules in place, most water wholesalers would chose this option. Third, the water would be traded to another user under the water trading rules. Depending on where the trade was to, and what product the water would be used on, the consequence of the trade could

be better or worse for the environment. For example, the water that would have gone to the Kerang irrigation area for irrigating dairy pasture could be traded downstream to the almond growers in the Sunraysia area near Mildura. It would require a larger study to determine if this would be a cost or benefit to the environment.

Conclusion

The drought of the last decade has galvanised concern in Australian society about water use. As a result direct water consumption in urban homes has been reducing for the last decade. Although this is commendable, this study demonstrates that, on average, 90% of the water consumed in households in Melbourne is embodied in the production of the food that comes into the house. In one sense, urban food consumers are also consuming rivers. Small changes in food choices could potentially lead to water savings that dwarf the savings that can come from changes in direct water consumption. Thus, river condition is, to some extent, a consequence of decisions made in urban supermarkets. We believe that this is an empowering observation. Urban people, far from being isolated from the environment, make critical decisions about rivers, every day, in their consumption choices. We suggest four ways that consumers can dramatically reduce their indirect water consumption: waste less food; select *comparable products* that use less water; *substitute types* of food that use more water for types that use less; and become a vegetarian. It is also clear that changing food choices will not automatically lead to environmental benefits. In some cases it could lead to unintended disbenefits. Nevertheless, each mouthful of food links urban people to the nation's river, and food choices can potentially empower them in improving the condition of those rivers.

Acknowledgments

Amelia Tsang, Siao Khee Tan contributed to this research as part of 4th year Environmental Engineering projects. Their full reports can be found at the University of Melbourne. Thanks to Professor Wayne Meyer, for providing information concerning studies of virtual water content in Australia. Goulburn Murray Water provided data on water use. Lizzie Pope collected some more recent data, for which we are grateful.

References

AFGC (2003). *Environment report 2003*: Australian Food and Grocery Council, ACT.

ABS (1999). *National Nutrition Survey, Foods Eaten, Australia*, Australian Bureau of Statistics, Canberra.

Chapagain, A.K., & Hoekstra, A.Y. (2003). *Virtual water flows between nations in relation to trade in livestock and livestock products.* Value of Water Research Report Series No. 13 UNESCO-IHE, Delft.

Chapagain, A.K., Hoekstra, A.Y., & Savenjie, H. (2005). *The water footprint of cotton consumption* Value of Water Research Report Series No. 18 UNESCO-IHE, Delft.

DNRE (2004). *Parliamentary White Paper – Our Water Our Future*, Department of Sustainability and Environment, Victoria.

Hoekstra, A.Y., & Hung, P.Q. (2002). *Virtual water trade: A quantification of virtual water flows between nations in relation to international crop trade.*

Meyer, W.S. (1997). *Water for food: The continuing debate*. Draft paper for 1997 Irrigation Conference. CSIRO Land and Water, Griffith Laboratory, NSW

Oki, T., & Kanae, S. (2004). *Virtual Water Trade and World Water Resources.* Water Science and Technology, 49(7): 203-209

Reid, R.L. (1981). *A Manual of Australian Agriculture*, Heinemann, Melbourne.

Renault, D. (2003), "Virtual water value in food supply management." Houille Blanche-Revue Internationale De L Eau(1): 80-85.

Tan, S.K. (2006). *Is a Healthier Diet also more Environmentally Sustainable? The case of water use in food production*, Fourth Year Research Project, Department of Civil and Environmental Engineering, University of Melbourne.

Waste Management and Environment (2004). *Greening the Food Cycle*, <http://www.wme.com.au/categories/special_reports/sept1_04.php> [Accessed: 1 November 2004].

Water Resources Strategy Final Report (2002). '21st Century Melbourne: a WaterSmart City' <http://www.watersmart.vic.gov.au> [Accessed on 9th September 2004].

Zimmer, D., & Renault, D. (2003). *Virtual Water in Food Production and Global Trade.* World Water Council, FAO-AGLW.