World Running Dry: An examination of the concept of "virtual water" in relation to the impending global water crisis.

Introduction

The lectures during the A3 module showed how water is becoming scarcer even in maritime climates such as the UK. Examples were given on how to adapt both buildings and our own habits to reduce the 148 litres per day (OFWAT 2007) that each person uses. However as important as conservation of domestic supplies is, in actual fact the vast majority of our personal "water footprint" comes from the water used to grow the food we eat. (Waterwise 2007)

Globally one billion people lack a basic supply of clean drinking water and by 2025 two-thirds of the planet will be living in water scarce areas (Waterwise 2007). In developing countries, as people migrate to urban environments, diets are becoming more meat based which places even more stress on domestic and agricultural water demands. Given that a growing population is using the same finite water supplies, it is possible that we will be unable to produce enough food to feed everyone.

As virtual water is a way of quantifying the water used to produce a given product, I am going to look the origins of this method, how trading in this commodity might work and examine how changing diets can affect the consumption of water.

What is virtual water?

There is nothing virtual about the water content of "virtual water". Tony Allen originally coined the term in 1993 as a replacement for the less hard-hitting "embedded water", a term which he also invented (Allen 2003). Put simply, "virtual water is the water needed to produce agricultural commodities" (Allen 2003).

Since it takes around 1,300 litres of water to produce a kilogram of wheat, the virtual water content of wheat is 1,300 litres per kilogram (Van Hofwegen). However I will discuss later how this figure could be different depending on where in the world the wheat is produced.

Although the concept may seem slightly simplistic, Allan wanted to get the idea into the community rather than spending years in an office calculating virtual water contents. Therefore there are disagreements about the specifics. The table below shows some average virtual water contents.

Virtual water content for selected products [m3/ton]	
Wheat	1,300
Rice	1,400
Sorghum	2,800
Millet	5,000

Table 1 – Source: http://www.waterfootprint.org/

It is not just basic crops that can be calculated, others have shown that products from coffee to cars use water during their production which can be quantified.

The water content can be further split up into green and blue water. Green water is the volume of evaporated rainwater and blue is water from sources such as groundwater and irrigation. This is something that becomes more important when you consider the differences in why and how certain types of products have been produced.

There has been some criticism of the term in the scientific community. Merrett (2003a) criticises the term saying "in everyday English we use the word 'virtual' (as in virtual reality) to mean something parallel to or imitative of a real-life entity or process. But Allan's virtual water does not do this. This is because virtual water is real water." Merrett prefers the crop water requirements of food, but personally this doesn't really conceptualise the idea greatly enough. It is true that there aren't cargo ships full of water moving around the globe but I think Allen has come up with a good concept that is easy to grasp in the same way as food miles.

Water, Agriculture and Population

We live on the "Blue Planet", yet only 2.5% of the 1.383 billion km^3 of the water on earth is fresh water and of this only a tiny amount ($12{,}500km^3$) is distributed near to where humans live (Constance 2004). This is still a vast amount of water, and as an average there should be enough for everyone. However as Rijsbermen (2006) argues, water is physically scare in densely populated areas where the majority of the world's population now lives. This means 1 billion people lack safe domestic water (Constance 2004). At the same time, world population is increasing by 80 million per year and per capita use of water is rising.

The greatest consumer of water by far is the agricultural sector, using nearly two thirds of the water available to produce the crops we need to live (Constance 2004). During the 20^{th} century, the "green revolution" allowed food supply to keep up demand with growing populations through high-yielding crops, pesticides, fertilisers and increased water use (Gleick 2000). Irrigation is used heavily to grow crops and despite only 18% of cropland being irrigated, producing 40% of food grown, it uses an astonishing 85% of all water consumed (Gleick 2000). Now crop levels are struggling to keep up with demand. The amount of grain produced in the world peaked in 1984 and has been reducing ever since (Constance 2004). This is acerbated by land degradation and a shift in water from agriculture to cities (Gleick 2000).

Demand for water in light of local scarcity is causing depletion of underground stocks of water globally. In Beijing the water table is dropping 2 metres a year and in India the pumping of underground water is now estimated to be double the rate of aquifer recharge from rainfall (Constance 2004).

Whether or not there will be a new green revolution in the form of GM or transgenic crops is beyond the scope of this essay. What is obvious is that localised water shortages through increased food demand has created a global food trade or what could be called the "virtual water trade".

The Trade in Water

Unlike other commodities, it is extremely expensive and difficult to trade in physical water due to its weight. Pipelines have been built in some countries such as water piped in from the Owens valley to supply the water deficient area of Los Angeles. China is constructing canals to move water from the south to the north (Ma et al) and attempts were made to construct a pipeline from Turkey to the Middle East (Qadir 2007) but this failed due to political reasons. Small trials in fabric bags filled with freshwater and tugged to their destination have been used to transport water to some Greek islands (Qadir 2007) but this is a small scale solution. Physical trading in water between nations is as unlikely to happen due to cost as politics.

Trade in virtual water has taken place ever since people and nations started trading commodities. But it was in the 1980's that the Israelis explicitly realised the benefit of importing water-intensive goods rather than producing them themselves (World Water Council) and in effect "saving" the water for other uses. As a comparison during this period, Saudi Arabia attempted to become self-sufficient in wheat despite being one of the driest places on earth lacking much freshwater. It invested vast amounts of its oil wealth into the production but ultimately the cost of this wheat was 4 times that of the price on the world market (Postel 1992). Nowadays, most of the Middle Eastern nations import a proportion of their basic food crops.

Today about 1,000 km^3 of the 5,400 km^3 of water used for agriculture is transported in virtual form (Chapagain 2006). Rain abundant areas of the world are able to produce goods using less water (and also perhaps using green rather than blue water) than water scarce regions bringing an estimated 455 km^3 of global water "saved" (Chapagain 2006).

This trade may make some sense if we disregard factors such as the energy costs of transportation. Trade is more that just agronomic, it is economic and political. Scarcity is forcing governments to think about their internal use of water. A water scarce country could import crops to feed their population but they may consider it more important to produce these crops internally. Governments may not want to acknowledge the term virtual water for feat of admitting they have food security issues (Wichelns 2000).

A Changing Diet

Globalisation and falling transportation costs have meant European consumers demanding salads in winter and countries like Spain have the climate to produce these crops. In the region of Andalusia, a water-deficient area, agriculture uses 80% of water resources. Despite this it has specialised in crops whose water consumption level is high (Velázquez 2007). This seems incomprehensible as they are producing water intensive products for export whilst needing to import low water products such as cereals and arable crops (Velázquez 2007). The reasons for choosing these crops may have been political, economical or historical but in light of the droughts and partial desertification on the Iberian Peninsula it would seem unsustainable to continue "losing" water in such amounts.

It is not only crops grown for human consumption where recent water demand has been increasing. Urbanisation has meant less subsistence farming and a greater consumption of animal based products. Animals are being fed grain that could feed human beings.

> "Those who consume livestock products and fish are competing directly with those who need grain for food". *Lester Brown, past president of WorldWatch institute, USA.*

Livestock consumption in the developing world is increasing by 3% a year and 40% of food grain goes into feeding livestock (Gleick 2000). The greatest changes are happening in countries such as China where beef consumption increased by 20% annually between 1990 and 1997 (Constance 2004).

The chart below shows the different amounts of water required for some crops and meat products.

Virtual water content for selected products [m3/ton]	
Rice	1,400
Beef Pork Poultry	13,500 4,600 4,100

Table 2 - Source: Van Hofwegen

These figures show the combined water content of feed and volumes of drinking and service water consumed during lifetime. There are disagreements in the industry about the quantities of grain required; the US National Cattlemen's Beef Association says it takes 4.5kg to produce 1kg beef whereas the US Department of Agricultural Economic Research Service says its 16kg of grain. (Less meat p. 22) However nobody is arguing against the fact that rearing animals reduces land for human crops. An acre of cereal can produce 5 times more protein than an acre devoted to meat, and legumes can produce 10 times as much (animal aid). A vast 5.3m^3/day is required to sustain a United States meat based diet whereas it is only 2.6m^3/day for a vegetarian diet.

The global trade in animal feed shows that water is being traded to keep the meat industry running. Egypt used to be self-sufficient in wheat and 10% of this was fed to livestock – now it's 36% and has to import 8 million tonnes (p. 28 less meat). If people want to choose to eat meat, that should be their choice but as most meat industries are subsidised by Government, there needs to be a level playing field so the cost of meat reflects the actual cost of producing the animal; including the cost of the water used.

There are of course some cases when animals are beneficial in converting unusable pasture to meat for instance on areas where animals on grazing land and no crops will grow. In some ways the hill farming areas of Wales are a good example of this. But on a larger scale this is not going to be possible.

A useful measure?

Despite some media attention about water issues, water scarcity has yet to be a front page topic. But is "virtual water" a sufficiently robust measure that could be adopted as a mainstream term? All products, not just crops and meat contain water. Products like wine, beer and coffee all use huge amounts of water during their production. People are unlikely to stop consuming products they enjoy and governments are unlikely to legislate specifically for this. However one of the flash points of the 21st century is going to be the redistribution of incomes from the west to the east. People are already demanding a more "western lifestyle" and market forces are going to play out.

There are several reasons why it will not be possible to label every product with the amount of water used in its production. Firstly it is hard to quantify. The same crop grown in different climates, types of soils and even the season will have a different water usage. As Qadir (2007) says "Quantifying and comparing the exact volumes of water needed to produce food items in different agro-ecological zones is difficult". Who is going to work out these figures and guarantee their authenticity? Neighbouring farms could be different. Crops would need to be broken down into blue and green water, each area could be different; some may use rainwater most of the time with blue water during droughts. Even if governmental agencies agreed on averages, I don't think this is something that is going to happen.

In terms of trade, countries importing products risk not being self sufficient and the produce also requires foreign exchange to purchase. For the domestic economy, the importing of products may remove employment in the local agriculture sector and therefore people move into cities, putting increasing environmental stresses on the water supply and also demand for food. This is why governments need to start examining how they use their water and making sure they are getting the best usage out of it. The problems are for those countries that lack local water but have seen increasing populations, meaning that trade is inevitable.

The dietary issue is starker. With enormous amounts of water used to produce animal products, there needs to be some debate about the direction in which the trade is going. Market forces would say the food should be produced for those who need it, but this would mean satisfying middle class palates while the poor starve. This happens already but as populations grow it could be disastrous. Even a small shift in the numbers consuming a western diet could have serious hydrological consequences.

The discussion of virtual water contents in this domain is something that is much more valuable to the debate. It shows explicitly and relatively simply the enormous variations between products. Through efforts to reduce meat eating in the west, developing nations may reconsider the benefits of the "livestock revolution" promoted by vested interests in the industry.

Conclusion

Nobody can predict the future water needs of the planet, but I have tried to show that the planet may struggle to feed itself in the future due to increasing and migrating populations and food demands. A method of viewing the amount of water embedded in crops, meat or ultimately everything that is produced is the virtual water content. The growing demand for animal products needs to be viewed through its associated virtual water demands. As the amount of trade increases faster than crop production we need a measure of viewing the water containing in products. Despite the protestations of some people I think the term is useful.

This essay has some limitations which I discovered as I was writing. The main one was lack of time and space to go more into the economic arguments regarding water cost that is the issue of privatisation and the cost of water. Despite being able to view the quantities of water, it would be interesting to put a price on water in the same way carbon may be priced. Water is given away too cheaply in most of the world due to fixed prices for water or subsidies to farmers. Governments may be frightening to make any changes in the short-term but ultimately change needs to take place.

Although I think it is think this is unlikely due that there will ever be a standard reference point for units of virtual water, I think more research would be useful in the split between blue and green water. Discovering the actual sort of water used to grow a product may actually be more important than how much. Rice grown in paddy fields may appear to use more water than the rice grown in the United States, but the types of water may be more sustainable.

The implications are for policy makers to decide how they are going to use the water on their land in the best possible way. There are decisions to be made about food security and self-sufficiency. Do they aspire to rid the world of poverty or allow the burgeoning middle classes to have their steak and eat it? Wars may be fought over oil but it will be over water where the conflicts are in the 21st century.

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