



Maxwell

The Concept of Virtual Water: Understanding Our Real Water Use

Over the past decade as the global challenges of water scarcity have become more visible and better understood, we've all begun to learn more about our water efficiency, how much we consume, and how we can become better at conserving this precious resource. With this better understanding—and concerted efforts to improve efficiency—certain regions of the country have made significant advances in water conservation. Many water districts have shown marked progress in recent years; in particular, many of the arid western cities such as Denver, Colo., Albuquerque, N.M., and Las Vegas, Nev., for example, have cut daily per capita consumption by as much as half. The hope is we are all getting better at monitoring the amount of water we consume for drinking, cooking, cleaning, and the numerous other things we use water for in our everyday lives.

What we often don't recognize is that we use far more water in terms of the various goods and products that we consume—the food, clothes, consumer goods, and so on—because they often take large amounts of water to produce. Currently most people think of their conservation or efficiency in terms of direct water use, not in terms of indirect water use—water that is needed to produce everything else we buy and consume. The water that is embedded or “hidden” in all these commodities and products is increasingly being referred to as “virtual water.” This more accurate measure of our total water consumption is coming to be called our “water footprint”—identical in concept to the much more widely discussed carbon footprint. By thinking about our total water footprint from this broader perspective, we can open up a whole new world of understanding and insight—as well as troubling new concerns.

GROWTH OF A WATER CONCEPT

This nascent field is becoming much more sophisticated with each passing year. The virtual water concept was first developed by British scientist Tony Allan, for which he won the Stockholm Water Prize in 2008. He reasoned that we should look at not only direct water use, but also indirect consumption—the total amount of freshwater used to produce anything that we consume, measured over its full supply chain. Arjen Hoekstra and his associates at the Water Footprint Network in the Netherlands have developed extensive water footprint data for all kinds of goods and products (Hoekstra, 2007).

More recently, Hoekstra has refined the concept of virtual water even further. Blue water is the consumption of freshwater—surface water and groundwater—in the production of a product. Green water refers to the amount of water—stored in the soil as rainfall—that it may take to grow the inputs for a given food or product. Finally, gray water refers to pollution of blue water—the amount of water that may be required to assimilate the pollutants produced in the process of making the product. Thus, the total water footprint is really a volumetric measure of water use and pollution.

These and other researchers have built a growing database that illustrates the total water use of almost everything in our daily lives—from all of our food and drinks, through all of our clothes, computers, automobiles, and the full array of other consumer goods. In addition to defining the water footprint represented by various commodities and products, researchers have also begun to summarize virtual water use in terms of different types of consumers, producers, and indeed even nations. This is an

increasingly complex field, and there is a wealth of information and insight to be gained from understanding and assessing the full water footprint of an individual or business.

BREAKDOWN OF A WATER FOOTPRINT

First, let's look at virtual water consumption in terms of individual commodities or products.

How much water for crops? In its April 2010 special issue, *Water: A Thirsty World*, *National Geographic* summarized current estimates as to the water footprint of various fruits and vegetables. A pound of bananas, for example, takes 103 gallons of water to produce, whereas a pound of apples takes 84 gallons, oranges 55 gallons, and just 33 gallons for a pound of strawberries. The science may not be exact, but all agricultural crops and commodities can fairly easily be assigned a virtual water component. At the same time, it's important to understand that virtual water content for a given commodity can vary depending on local climate, whether or not the crop has to be artificially irrigated, what type of irrigation system is used, the efficiency of farming techniques, and so on. In other words, a bushel of wheat may have one water footprint in the central United States and a different one in central Kazakhstan.

In reviewing the virtual water content of other agricultural commodities, it seems intuitive that some plants will need more water than others, but the breadth of the spectrum is quite unexpected. Rice and alfalfa, for example, turn out to be two of the most water-intensive commodities that humans grow anywhere on the planet. In fact, from a global perspective, it's estimated that rice cultivation takes up 21% of all the water consumed in agricultural production around the world. Wheat is next at 12% and corn (or maize) is third at 9%. When the locations where much of the planet's rice and alfalfa are grown are examined, the power of virtual water analysis becomes apparent: more water-intensive commodities often seem to be grown in areas that do not have particularly abundant water.

More water is required for animals. Not surprisingly, meat products generally have a much higher water footprint than crop products. A live animal not only consumes water, it also consumes some of those crops discussed previously in order to grow. Consider that typical beef cattle are fed for about three years before slaughter, during which time, according to Hoekstra, the individual animal may consume 1,300 kilograms of grain (wheat, oats, corn, barley, and so on), 7,200 kilograms of roughage (pasture grass, hay, silage, or alfalfa), and 24 cubic meters of water (about 6,300 gallons). One animal may produce about 400 pounds of beef, and after doing the math, it turns out that a pound of hamburger has a virtual water content of about 1,900 gallons. The water content of chicken or pork is lower, but still astonishingly high, relative to fruits and vegetables.

Nonfood items require even more water. Food turns out to be “water cheap” compared with most of the other products and things that we buy and consume. A pair of jeans requires 2,900 gallons of water, a cotton t-shirt 766 gallons, and so on. Think about it—cotton itself takes a lot of water to grow, but once grown (whether in Alabama or China) it is usually then shipped to the textile plants of Malaysia or India to be turned into a shirt, where it consumes more water, and then it's finally shipped back to buyers in the United States or Europe. Each step of that process—growing, harvesting, shipping, manufacturing, and shipping again—requires water.

When we begin to understand and evaluate water consumption from this full life cycle and sustainability perspective, many of our traditional assumptions fly out the window. In other words, we are each responsible for a whole lot more water consumption than the typical 100–200-gpd figure that we are all used to hearing about. In reality, we should be thinking about our total water consumption, not just our direct water consumption.

ADDING IT ALL UP

The issues and implications revealed by virtual water analysis become even more interesting—and potentially grave—when we look at actual water consumption on a national basis and in terms of international trade. The volume of virtual water flows between countries represents a substantial portion of total water withdrawals around the world. The *National Geographic* issue pointed out that the international flow of virtual water around the world is comparable to the annual volume of the Congo River—one of the world's largest river systems.

According to the theories of international trade and comparative advantage, countries should tend to specialize in the manufacture and export of goods produced with resources that are abundant within their borders. Countries rich in copper or oil tend to be exporters of copper products or oil to countries where those commodities are less abundant. Labor-intensive manufacturing processes have tended to move to those areas where more abundant and cheaper labor is available. Water has never really been thought of as a resource or a factor of production in this regard; it has generally been considered more of a free good. But as water becomes more scarce and consequently more and more expensive, it will obviously start to have more of an effect in these types of decisions. Eventually water-intensive commodities or products will logically be produced more in areas where water is abundant and less in areas where water is scarce. By importing virtual water in the form of products or commodities, water-scarce countries will be better able to relieve the pressure on their own internal water resources.

In calculating the actual water footprint of a country, both the internal and the external footprint must be

examined; i.e., not all the products we consume and buy are produced within our own country. The water consumption of an individual country may be far higher than what would be suggested by the traditional metric of water withdrawal, or even by the virtual water consumption of its domestic industries. Many of our consumer goods—for example, clothing and electronics—are now imported, and whether they come from China, Malaysia, or Bangladesh, they are using up water that may be increasingly needed for other uses in those countries. Australia used to be the world's largest rice exporter, but when a terrible drought struck that country early in this decade, water used to grow relatively low-value rice was quickly reallocated to other, more valuable products.

In terms of food, some countries are more self-sufficient and others are less so. This factor has always been a critical political strength of the United States. Other countries—typically those with less arable land—tend to import more food. For example Japan imports 15 times more virtual water than it exports—not so much because of its arid climate or poor agricultural situation but because of its large population relative to its area land mass. From a water perspective, this represents the biggest virtual water disparity of any major country in the world. Other countries—such as Saudi Arabia and other Middle Eastern countries—may have plenty of land, but it is so arid that they simply don't have the water to grow enough crops. Many of these countries are starting to strike deals with countries in more humid areas to provide their food.

A DIFFERENT WAY OF THINKING “GREEN”

There are many interesting and sometimes startling conclusions that result from virtual water analysis. In many ways, it makes our water challenges seem much more imminent and dire. For example, the combination of fixed planetary water supplies and a rapidly growing population are really the only two things that need to be understood in order to see that we are eventually going to have a water shortage. But it's not that simple. Not only are more people going to require more water, but as standards of living rise, more people want to eat more meat, and, in terms of water, we've just learned that meat production can be costly. In other words, the problems of water scarcity are likely to grow geometrically rather than arithmetically.

Virtual water analysis tells us that when there's really no longer enough water to go around, we are going to have to focus on using that scarce water to produce the goods and products that are the most valuable. Harkening back to alfalfa, one oft-cited example during the 1976 California water crisis posits that the amount of water that it took to grow \$100 worth of alfalfa could alternatively be used in a semiconductor plant to produce more than \$1 million worth of computer chips. Virtual water analysis tells us that it may make better

sense—and ultimately be more sustainable—for us to buy asparagus imported from Central America than to buy it from the local farmer's market. It helps us to better focus on ways we can actually affect the issue of water shortages. For example, virtual water analysis implies that eating one less hamburger saves more water than turning off the dribbling faucet while we're brushing our teeth every morning for 10 years.

But neither can we nor should we rely totally on this type of thinking. Water is one critical input, but there are many other factors that go into all the things that we produce—other resources such as human labor, energy, or mineral commodities—that are also in increasingly short supply. Although it's more and more critical, water isn't the only thing we must consider in making economic decisions, and critics have pointed out various drawbacks of relying too heavily on virtual water analysis. For example, the water used in rangeland beef production in a certain region could be reduced, but it might not end up being used for any other more economic or more water-efficient activity. Virtual water analysis is certainly not the only tool we should use in addressing water scarcity issues. Arguing that certain types of perverse virtual water flows are here to stay, Christopher Gasson stated: “You cannot tell peasant farmers in North Africa or India that they should give up their land and become advertising executives or bank clerks because those professions use less water” (Gasson, 2008).

Nonetheless, in the future we may see labels on food products and goods that indicate the total amount of water that went into producing them. In order to understand our water scarcity challenges and improve our overall water efficiency, a better grasp of our true individual water use and water footprint through virtual water analysis can be an invaluable tool.

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