Agricultural water management

Water footprints – the story of our fruit and vegetables

We get our water from taps and our fruit and vegetables from the green grocer, but few people realise the tight link between water and the food we eat. Despite the importance of food, most people are unaware of the many challenges to keep producing food for a growing population, especially in an arid country such as South Africa. Water footprinting is not just a new buzzword, it may be a very useful tool that can help us manage our water resources better.

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A citrus orchard on Patrysberg Farm in the Olifants -Doorn water management area.

Besides drinking it, producing food is perhaps the most important thing we do with our water. Producing the food we eat uses up to 15 times more water than what we physically use in our houses. In South Africa, irrigation uses about 60% of runoff, and approximately 90% of vegetable and fruit products are grown under irrigation in South Africa, representing a significant fraction of available water.

This dependence on irrigation is of concern due to the vulnerability of water supply in South Africa. While many irrigation schemes make use of groundwater which is an important resource, when more water is being used than recharged, this practice becomes unsustainable. It is very important, therefore, to learn how to increase our water use efficiency and to find ways to produce more 'crop per drop'.

According to the Department of Water and Sanitation, South Africa is facing a number of important challenges in the management of our water resources. In the future, water scarcity will become more of an issue as a result of the ever growing population and economy. Little additional water can be made available from conventional sources and developing alternative sources of water is expensive.

The deterioration of water quality is considered to be the most serious threat to water resources and agriculture is one of the major contributors to this problem. Apart from these uncertainties about future water availability for people, we are also legally required to allow for water required by natural ecosystems, and to be mindful of the potential water impacts associated with climate change.

To address these challenges the Water Research Commission (WRC) is currently funding several water footprint projects, including for important horticultural and field crops, and assessing the usefulness of this information. Research by the University of Pretoria in collaboration with the CSIR is now underway on fruit and vegetable crops in two very interesting regions in South Africa from a water resources perspective.

Citrus in the Olifants-Doorn Water Management Area (WMA)

Economically, after deciduous fruit and vegetables, citrus is the third most important agricultural crop in South Africa, covering approximately 58 000 ha. Citrus is grown in winter and summer rainfall regions of the country, and is the sector that exports the greatest amount of fruit from South Africa, with more than 1.35 million tonnes shipped annually.

The winter rainfall Citrusdal and Clanwilliam area of the Olifants-Doorn Water Management Area (WMA) is no exception as it exports more citrus than any other growing area in South Africa. The WMA is situated north of Cape Town along the West coast. It is a dry, water stressed region, where mean annual rainfall is less than 200 mm, and competition for water is continually increasing.

Due to water scarcity, the area is largely unsuitable for rainfed agriculture, but it has approximately 500 km^2 of irrigated agricultural land. Consequently, agriculture accounts for 87% of the total water use of this WMA.

Irrigation water for citrus and grapes is sourced primarily from the Olifants River, while water for deciduous fruits comes from smaller rivers and farm dams in the higher lying Koue Bokkeveld area. Potatoes grown in the low-lying Sandveld region depend on groundwater for irrigation.

A water footprint assessment estimated that it requires approximately 126 ℓ of water to produce one kilogram of navel oranges. Of this, over 99% was

Grading oranges at a citrus packhouse.

After washing, oranges are automatically size-sorted at a citrus packhouse.

attributed to crop evapotranspiration in the orchard, while water used for other purposes like washing the fruit in the pack-house and agrochemical spraying in the orchard made up the balance.

Given the limited water resources in the Olifants-Doorn WMA, such water use is significant and requires careful management. Theoretically, when crops are exported, the water that was used to produce these crops is also exported. This water has been termed 'virtual water'.

We seldom use products that were produced in our backyards, and virtual water is therefore a useful way of remembering the possible impacts our activities have on water resources elsewhere. Virtual water can also be useful on a national level where decisions are being made about where we import our products from and export them to.

"Increasing water scarcity means that water footprinting may become a valuable tool to enable us to manage our water resources better."

In some cases it might be better to import crops from regions with good soils and high rainfall rather than using local scarce water supplies for irrigation. The virtual water concept highlights the importance of balancing the sustainability of local water use to produce the crops against socio-economic benefits gained from exports.

Carrots and broccoli on the Steenkoppies Aquifer

The Steenkoppies Aquifer is located just west of Johannesburg. For thousands of years this water has flowed through a natural outlet called Maloney's Eye and into the Magalies River. Once the water enters the Magalies River, it gives life to vibrant ecosystems and provides irrigation water to a number of downstream farms.

Following the late 1980s, farming began above the Steenkoppies Aquifer itself, irrigating with water from boreholes tapping directly into the aquifer. Water flowing from Maloney's Eye was drastically reduced as a result. This would go on to cause conflict between farmers on the aquifer and downstream users, especially during years of drought.

There's a really good chance that the carrots in your fridge were grown with groundwater pumped from the Steenkoppies Aquifer, as this region is the largest carrot producer in Africa. Again it isn't just the physical water in the carrots that we need to be concerned about. Up to 230 ℓ of water is used to grow a 750 g bag of carrots. That is almost three times the volume of water you would use in the average bath. Additional water is used in cleaning, packaging and distributing the carrots.

On top of that, some of the carrots produced are wasted. Wasting food is like wasting water. Vegetables are being wasted along the entire supply chain from the farmer to the consumer. Most wastage occurs in the hot summer months.

Data from the Tshwane Fresh Produce Market for the year 2012/2013 indicated that an average of about 100 000 kg of carrots from the Steenkoppies Aquifer were wasted at the Market. This represents about 1.5% of all carrots received from the Steenkoppies Aquifer and is expected to be only a small fraction of the total wastage. More perishable crops such as lettuce and strawberries are expected to have even larger losses. One way to reduce impacts on water resources is to prevent food from being wasted unnecessarily.

We often also throw away a big part of the plant, like the leaves that cannot be eaten. If the farmer uses these parts of the plants for making compost or feeding animals, then he gets more productivity out of the water that he used for irrigation. Broccoli is a good example, because it has a significantly high water footprint relative to many other vegetables.

To get one kilogram of broccoli heads a farmer uses up to 1 300 ℓ of water. This is because the broccoli head is very small compared to the rest of the plant. However, farmers on the Steenkoppies Aquifer often use the rest of the plant to make compost for use on future crops, effectively recycling the water used to produce them, so these water savings should ideally be off-set against the water footprint.

So what is water footprinting exactly?

The water footprinting concept originated in response to challenges in water resource management. The Water Footprint Network (WFN) has led the way regarding the methodology of calculating water footprints, originally coming up with the concepts behind blue, green and grey water footprints.

Blue water is the water in dams and rivers and groundwater that anyone can use for any purpose. Green water is rainwater that has infiltrated into the soil and can only be used by plants. Grey water is the volume of clean water needed to dilute the harmful pollutants we put into water.

A total water footprint is the sum of the three colours reported as a volume of water and can be calculated for an entity, region or to produce a product. This network has ensured that the term 'water footprint' has become more mainstream, and a key contribution has been to show global virtual water flows, indicating which countries are net exporters of virtual water and which rely on water used and polluted elsewhere to produce the products they consume.

But some scientists feel that it is irresponsible to report a water footprint

simply as a volume of blue, green and grey water. Whereas greenhouse gas emissions are considered to have the same global impact regardless of where these emissions take place, this is not true for water. The impact of using or polluting a certain volume of water will differ depending on the local conditions where the water is used. Because of this local nature of water, there are so many different scenarios within which a water use must be interpreted before you can understand its full impact.

This makes standardisation for comparative purposes very difficult as, for example, you need to consider the spatial and temporal availability and demand for water. For example, even though 230 ℓ of water for a 750 g bag of carrots seems like a lot, it of course doesn't mean that growing carrots is a bad thing.

However, finding a standard way to calculate a water footprint has not been an easy task, and the international scientific community remains divided on the issue. One reason for this is that different people need different information. A water footprint must help a farmer to reduce the amount of water he uses, a consumer to choose the most environmentally sustainable product and a politician to make sensible water policy decisions.

As a result, ISO Standards for water footprints (ISO 14046:2014) were developed and released in August 2014, aiming to standardise the ways in which people conduct water footprint assessments. The Standard gives very broad and flexible guidelines and includes a few important principles. Water footprints, according to the Standard, must consider the full lifecycle of a product, must include an environmental impact assessment and must preferably be based on scientific evidences. The Standard also has specifications on how water footprints are reported, in order to ensure transparency.

However, the scope of the ISO standard does not include a way to report the results as product labels. Rather than a volume, it is suggested that results be reported as 'water equivalents' (H_2O-e) which gives an indication of the product or activities' impact on water resources. Rather than the utilisation of the grey water footprint concept to estimate impact on water quality, this Standard proposes the use of other mid-point indicators firmly established in Life Cycle Assessment methodology, such as estimating eutrophication potential in 'phosphate-equivalents' in the case of nitrogen and phosphorus pollution from agriculture.

Further complexities in water footprinting in agriculture

Apart from standardising water footprinting for various purposes to reflect local conditions, there are also other complexities. For example, the same crop grown in different seasons will have different water footprints due to variances in growth rates and atmospheric evaporative demand. Crops grown predominantly during the rainy season may also have

Carrots are mechanically harvested on the Steenkoppies Aquifer – representing the largest carrot producing region in Africa.

Following harvest the carrots are washed at the pack-house. This represents a very small fraction of the water use compared to in-field crop evapotranspiration.

high ratios of green to blue water consumption due to higher rainfall during this season.

The importance of doing local studies on water use and yield measurements therefore also becomes clear, as opposed to utilising international, easily available crop factors, for example, from FAO56. Accurate water footprint calculations are dependent on accurate measurements of crop water use/requirements.

However, published crop coefficients used for estimating crop water use in South Africa are still often taken from research studies conducted overseas, and may not be representative for local conditions.

Furthermore, the coefficients are crude estimates in that they only have initial season, mid-season and end-season values, linked by straight lines representing growth stage periods. This is not entirely realistic compared to the curved and fluctuating crop coefficient curves for most crops, when derived from observed data. To get the best water footprint estimates, crop water use information should be based on field observations.

Then of course equally important is the impact on water quality, arising through the cultivation of land and the use of agrochemicals such as pesticides and nitrogen fertilisers. This is even more difficult to quantify than water use, and the scientific community are currently devising approaches to quantify this using different levels of complexity depending on what data are available.

Potential of water footprinting

Despite all these challenges in standardising and refining water footprinting methodologies, the concept has the potential to really improve water resource management. Water footprint accounting intends to address environmental as well as socio-economic issues. Analogous to carbon footprinting, it aims to provide a metric on the impact of our products or activities on our water resources, especially when calculated impact along the entire production chain.

Many studies in the past have focussed on improving water use efficiency at the farm level, but water footprinting also aims to inform consumers, water resource managers and policy makers. Water resource managers have found themselves overwhelmed by complex questions about when and where water is available, when and where it is needed and how the use of water impacts our societies and ecosystems. Water footprint accounting aims to simplify the complexity of catchment hydrological cycles and water use dynamics.

And water footprinting can also contribute to improved water resource management on a farm level. More often than not farmers over irrigate their lands to reduce any risk of the crop being water-stressed, and water footprinting can potentially play an important role to prevent this. Water footprints are currently being calculated for a range of fruit, vegetable and field crops in South Africa, and these footprints can serve as benchmarks for farmers, potentially revealing inefficient use of water. This, in turn, allows savings in electricity due to reduced pumping, and fertiliser due to reduced leaching losses. It will also have longer term sustainability benefits for the environment and society.

So what does this mean for South African farmers

Increasing water scarcity means that water footprinting may become a valuable tool to enable us to manage our water resources better. Consumers are also demanding more information on the products they consume. If the WRC projects to estimate the water footprint of common fruit, vegetable and field crops and the growing interest in water footprints leads to an emphasis on refining water use estimates and reducing impact on water resources, then this will be a positive development.

Even though a farmer cannot change the amount of water his carrots or citrus need, he can reduce the impacts of growing crops with good management. Water footprinting can provide the necessary information to do that. Maximising the use of rainfall during the growing season reduces the need to use blue water from dams, rivers and aquifers, making it available to other users. For example, in the Steenkoppies aquifer, in contrast to Olifants-Doorn, there is greater opportunity to make use of green water by not over-irrigating. Reducing the volumes of water we irrigate has multiple benefits for the environment. A farmer can also ensure that water distribution and irrigation infrastructure is in good condition so as to minimise transmission losses.

Once water footprint accounting has developed to a point where we can label food, we as consumers will be able to make more informed decisions. Until that day we as consumers can already have a positive influence by reducing the food we throw away. This can be done through better planning and preserving food, but also through buying food that is grown locally.

The further we are from the farm, the more food is wasted on its way to us. And of course our backyards are the ultimate local source of vegetables which can be watered with water from the bathtub or a rainwater harvesting tank. But most importantly, we must try to become more aware of the stories of the food we eat. As consumers who vote with our money, we are one of the most powerful role players that can drive changes from poor use of water resources and prevent the associated impacts.