Cotton and Virtual Water in the Murray-Darling Basin

Introduction

The Murray-Darling Basin (MDB) is a vast and complex system spanning 1.1 million km^2 covering 14% of Australia's total land-mass including four states and one territory (Friends of the Earth, 2012). In addition, three of Australia's longest rivers are contained in the MDB, the Darling, the Murray and the Murrumbidgee. In 2010, the Murray-Darling Basin just barely escaped ecological collapse and is still today very much at risk. Today, the decline in river health has resulted in a 90% decline in native fish species and an 80% decline in waterbird populations (Friends of the Earth, 2012). In addition, 75% of the River Red Gum population in the MDB is either experiencing stress or has died due to severe ecological stress caused by the mismanagement of water resources (Friends of the Earth, 2012). The basin not only serves as a source of drinking water for approximately 3.4 million people, but also provides many economic, social, cultural and environmental benefits to the surrounding communities and ecosystems.

Irrigated agriculture is the largest consumer of water in the MDB, drawing an average 43% of the flows (Friends of the Earth, 2012). In 2010-11, the agricultural land irrigated in the MDB increased to 1.2 million hectares, up 22% from the previous period, 2009-10 (Australian Bureau of Statistics, 2012). Further, there was a 26% increase on the volume of water applied to agricultural land in the MDB from the period 2009-10 to 2010-11 (Australian Bureau of Statistics, 2012). Although irrigated agriculture has brought much economic growth to the region, the simple fact is that not enough water is being left in for the system to work the way it was meant to work. The frequent low flows in the MDB do not allow for the connection of the wetlands and the floodplains and further do not allow for the flushing of salts, nutrients and sediments through the lakes, estuaries and the Murray mouth (Connell and Grafton, 2011). These are all vital processes of a healthy basin, which so many humans and other living organisms depend on for survival and livelihood.

Cotton, a highly water intensive crop, accounted for the highest proportion of irrigation water use in the MDB during both the periods of 2009-10 and 2010-11. This amounted to 1,789 gigalitres or 40% of the total water extracted for irrigation from the MDB for the period 2010-11 alone (Australian Bureau of Statistics, 2011 and 2012). For the period 2010-11, cotton accounted for the largest area of irrigated land (28% of total irrigated land in the MDB) amounting to 332,000 hectares (Australian Bureau of Statistics, 2012). This comes as no surprise as the majority (on average greater than 90%) of cotton grown in Australia comes from the MDB. Australia's average annual cotton production has increased dramatically, from 9,000 bales in the 1960's to an average 1.5 million bales (Cotton Australia, 2012). Cotton is regarded as a high value crop and therefore brings many economic gains to regional communities. The industry in Australia employs approximately 10,000 Australians and supports 4,000 businesses. In NSW, it has been estimated that one full time job is generated on an irrigation farm for every 270 megalitres (ML) of water used (Cotton Australia, 2012).

'Virtual water' is a term used to refer to the water used in the production of a product or service. When a country exports a product, in essence it also exports water in virtual form (Chapagain and Hoekstra, 2006). The concept of virtual water was first introduced in the early nineties by Tony Allan as a useful means of relieving pressure on scarce water resources in dry climates. The concept helps us realise how much water is needed for the production of different goods and services, which in turn, can be very useful in determining how best to use the scarce water resources available (Chapagain and Hoekstra, 2006). Nations with scarce water resources can decide to produce less water-intensive goods and instead import these water-intensive goods from nations with greater amounts of available water resources. Another practical use of the virtual water concept is that it provides information and awareness of the environmental impacts regarding the consumption of a product (Hoekstra, 2003). Awareness of virtual water contents of various products can allow us to decipher which products have the greatest impact on the water system and where water savings could potentially be achieved (Hoekstra, 2003). The term 'water footprint', introduced by Hoekstra and Hung, refers to the "cumulative virtual water content of all goods and services consumed by one individual or by the individuals of one country" (Hoekstra, 2003). The calculation of a particular nation's water footprint takes into consideration both the production and consumption that takes place in that nation, thus considering both the nation's exports and imports. The virtual water concept, in essence, is only one half of the water footprint concept as it only refers to the water footprint of a commodity in the place of production and does not take into consideration the water footprint of a commodity in the place of consumption.

The intent of this study is to quantify the virtual water content of cotton in the Murray-Darling Basin (MDB) and specifically the virtual water content of cotton exports from the MDB. For the purpose of this study, imports of cotton into Australia have not been included. In addition, impacts to water quality in the MDB, although most presumably present, have also been excluded from this study.

Methodology

The virtual water content of cotton in the Murray-Darling Basin (MDB) can be defined as the total volume of water used during the full period of crop growth to produce the total yield of cotton for that same period. The general method for calculating virtual water contents of crops takes into consideration the green water and blue water components. Green water refers to the rainwater used for plant growth, whereas blue water refers to the use of ground and surface water for irrigation. More recent virtual water and water-footprint studies have also taken into consideration the impacts of pollution (i.e. fertilisers and pesticides) rather than only the quantification of resource use. The term 'grey water' is used to refer to the water polluted as a result of the production of the product (Karunananthan and Barlow, 2011). One such study quantified the impact on water quality in comparable terms to the impacts of water use by representing the volumes of emitted chemicals instead by the dilution volume necessary to assimilate the pollution (Chapagain et al., 2005). For the purposes of this study we have only analysed the amount of blue water used to produce the cotton crop in the MDB.

The cotton production and water use data were collected and retrieved online from the Australian Bureau of Statistics (ABS). The water use data (catalogue 4618) was available specifically for the Murray-Darling Basin (MDB) and was derived by ABS from a concordance of NRM regions falling mostly within the MDB region. This data was collected by ABS using either an Agricultural Resource Management Survey (ARMS) or an Agricultural Survey/Census. The ARMS, which was run with a reduced set of commodities compared to the Agricultural Survey/Census, was a combination of a reduced Agricultural Survey and a benchmark survey of land management practices undertaken by agricultural businesses. The ARMS also included a survey of management responses to adverse seasonal conditions experienced by affected agricultural businesses. The ARMS method was used for only the periods of 2007-08 and 2009-10, whereas for all other periods, the Agricultural Survey/Census was used. For additional information on the collection of the ABS data, please see the 'Explanatory Notes' section of the publication for each period.

The cotton production data (catalogue 7121 and 7125) was available by NRM region for all periods (except 2010-11) and the following NRM regions (only NSW and QLD for cotton production) were considered as part of the MDB: Border Rivers-Gwydir, Central West, Lachlan, Lower Murray Darling, Murray, Murrumbidgee, Namoi, Western, Border Rivers-Maranoa, Condamine and South West QLD. Furthermore, this data was separated into seed cotton production and cotton lint production as well as irrigated and non-irrigated production for all periods except for 2007-08 and 2009-10. For these two periods, only a total production for cotton lint was given. Please refer to Table 1.

In order to break out the irrigated production of cotton lint (item e. in Table 1) for these two periods, the Gross Value of Irrigated Agricultural Production (GVIAP) as a percentage of the Gross Value of Agricultural Production (GVAP), item f. in Table 1, was applied to the total production of cotton lint. Please note, that the GVIAP% is not the same as total irrigated production as a percentage of total production however, it should still give a reasonable estimate of the actual irrigated cotton production quantities.

Using the three periods (2005-06, 2006-07 and 2008-09) where production quantities for both seed cotton and cotton lint were provided, an estimate was derived for both the total irrigated seed cotton production and total irrigated cotton

lint production as a percentage of the total irrigated production. The estimated average percentage of total irrigated seed cotton production and total irrigated lint cotton production were calculated as 72% and 28%, respectively (items i. and j. in Table 1). Using these estimated percentages, estimates of the total (seed & lint) irrigated production and the total seed irrigated production were calculated for the periods 2007-08 and 2009-10 (items g. and h. in Table 1).
Cotton production data for the period 2010-11 was only provided for Australia as a whole and not further broken out by NRM region. The cotton production for the MDB for this period was calculated using a conservative estimate of 90% of the total Australian production. On average, more than 90% of the total Australian cotton production comes from the MDB.

All cotton lint produced in Australia is exported overseas after the ginning process, which is the separation of the lint and the seeds (Cotton Australia, ABARES). Furthermore, as estimated by the oilseeds analyst at ABARES, on average approximately 22% of the seed cotton was exported for the period 2005-06 to 2010-11, except for the periods 2007-08 and 2008-09, where the exports of seed cotton was only 9%. The amounts of irrigated seed cotton and cotton lint exported have been calculated using these percentages as summarized in item k. and l. of Table 1. The volume of water used to produce the number of these exports based on mass has been calculated using these estimated percentages of exports along with the estimated production of seed cotton and cotton lint as a percentage of the total irrigated cotton crop (items i. and j. in Table 1). The total volume of water used to produce the number of exports was calculated as 2,543,120.48 megalitres (ML), which amounts to 42% of the total water used in the production of cotton for the periods 2005-06 to 2010-11. This total water volume attributed to the exports was calculated using the following equation: ((item a.) x (item i.) x (item k.) + (item a.) x (item j.) x (item l.)).

The volume of water used to produce the exports of cotton from the MDB as calculated above takes into consideration the proportions of seed cotton and cotton lint produced from the cotton crop based on mass but fails to take into consideration the value of the two components of the cotton crop, the seed cotton and cotton lint. According to Cotton Australia, the value of seed cotton for the period 2010-11 was $217 million, whereas the value of cotton lint for the same period was $2.66 billion. The value of the cotton lint represents 92.5% of the total value of the Australian cotton crop. In Table 2, the volume of water used to produce the exports of cotton from the MDB is calculated using the value of seed cotton and cotton lint rather than the mass proportions produced. The values for seed cotton and cotton lint provided by Cotton Australia for the period 2010-11 were used for each of the other periods 2005-06 to 2009-10 as data for previous periods were not provided and based on the assumption that values would not be significantly different in the five previous periods.

The volume of water used to produce the number of exports based on the value of cotton lint and seed cotton is 5,657,664.10 megalitres (ML), which represents an astonishing 94% of the total water used for the total production of the cotton crop for the six periods. The total volume of water used has been calculated using the export estimates provided by ABARES and Cotton Australia along with the value of each of the components (seed and lint) of the cotton crop (items p. and q. in Table 2). This total water volume attributed to the exports based on the value of the cotton crop was calculated using the following equation: ((item a.) x (item p.) x (item k.) + (item a.) x (item q.) x (item l.)).

Results & Discussion

As per the data collected by ABS, a total of 6,022,533 megalitres (ML) of water has been used for the production of cotton in the MDB for the period 2005-06 to 2010-11. Of this total, an astounding 94% of the total water used, 5,657,664.10 ML, was used for the production of cotton exports for the same period. This volume of water (5,658 gigalitres) is equivalent to approximately 11 Sydney Harbours and 2.26 million Olympic size swimming pools. As an average per period, the volume of water used to produce cotton exports in the MDB is approximately 943 GL per year, which is 24% of the minimum reductions in diversions required to restore the basin to health (3,856 GL) as reported by the Murray-Darling Basin Authority using a 2009 baseline (Murray-Darling Basin Authority, 2012).

As reported by Mekonnen and Hoekstra (2011), Australia is one of the largest gross virtual water exporters in the world. And according to data from the U.S. Department of Agriculture, Australia was the 3rd largest exporter of cotton for the period 2010-2011 (ending July 31) behind the U.S. and India. The question that should be asked is if we can afford to export such a large quantity of this water intensive crop and thus such a high volume of water when our own water resources, The Murray-Darling Basin, is at such great risk. It is critical for us to come together as a nation and work collaboratively and effectively to address this very serious issue, especially at a time when water shortages and unsustainable water consumption are threatening economies all around the world. A report released earlier this year by Frontier Economics and HSBC finds predicted global growth areas to be in river basins expected to be severely affected by water shortages, thus having a detrimental impact on the world's economic growth (Bawden, 2012). In response to the report, David Tickner, head of freshwater at WWF-UK, stated: "This is an extremely serious issue for economies around the world. Improving the way we manage and allocate water is among the great challenges facing the world in the 21st century" (Bawden, 2012). The future of river basins is critical for economic growth and it is imperative that we all work together efficiently and effectively to improve water management in our river basins (Bawden, 2012). The Murray-Darling Basin provides many economic and environmental benefits and a fair compromise must be attained in order for these benefits to continue to be available for future generations. One suggestion could be the reduction in the export of virtual

blue water from the basin that could instead be used for producing higher value added but lower water intensive goods such as various vegetables, fruit and nuts.
It should be noted that imports were not taken into consideration for the purposes of this study and analysis. Although 100% of cotton lint is exported, some of this does come back to Australia as yarn, fabrics and clothing. The manufacture of garments is conducted in Australia but it is from imported yarn and fabric and not necessarily from Australian cotton.

Conclusion

The virtual water concept was designed as an instrument to help achieve water security through providing a framework by which water-scarce nations can conserve domestic water resources by importing water intensive products from water-rich nations. However, unfortunately, in much of the world, a particular nation's virtual water trade is not determined by its water situation, but instead by the size of land it holds (Karunananthan and Barlow, 2011). There is significantly greater risk of environmental impact in exporting countries, especially if they are not a country abundant in water resources (Karunananthan and Barlow, 2011). Australia is one such country, especially in the Murray-Darling Basin region. We are putting our future at risk by producing large volumes of water intensive crops for export. The water used to produce these crops could instead be used for the environment, which is very much needed today in the MDB. Domestic water resources in Australia and the Murray-Darling Basin should be used to produce more water productive and less water intensive crops. Further, as reported by Karunananthan and Barlow (2011), water used to produce commodities for export is considered a consumptive water use, which will never be returned to its original source. Water is being removed from domestic watersheds and thus from the local hydrological cycle, which can result in more extreme weather occurrences including more extreme floods and droughts. It is crucial that water trade policy in the Murray-Darling basin be examined and water saving initiatives in this area be more thoroughly analysed and effectively implemented. Agriculture is by far the largest user of water world-wide. However, putting our domestic water resources and our Murray-Darling Basin at risk for the export of agricultural commodities should not be an option. The economic, social, cultural and environmental gain in the long run of protecting our domestic water resources will surely outweigh the short term economic gain of virtual water trade in the Murray-Darling Basin.

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