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Impact of water scarcity in Australia on global food security in an era of climate change

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ABSTRACT

Australia is a major food exporting country. Recent droughts reduced dryland farming production and the volume of water allocated to irrigated agriculture, with a resulting decline in aggregate agricultural production and exports. This paper analyses the possible impact of increased water scarcity on Australian agricultural production and the magnitude of subsequent impacts on global food security. Using the Australian Bureau of Statistics (ABS) data on land and water use coupled with a hydro-economic stochastic modelling approach, the impacts of reduced agricultural production in the southern Murray–Darling Basin, and more generally for Australia, are analysed. Changes in agricultural activity, reduction in agricultural exports and altered composition of products exported attributed to the severe 2000–2009 drought are also analysed to highlight the implications for global food security. The impact of climate change on food production is examined. The analysis shows that climate change, when modelled as the extreme case, along with other factors such as land use, will impact Australian food exports. Despite its relatively small contribution to total global food supply, Australia's contribution to international trade in wheat, meat and dairy products is substantial and could affect global food prices. Furthermore, Australia's agricultural exports are of disproportionate importance within the South- and South–East Asian and Oceania region, both in terms of volume and for strategic reasons. Adaptation along with investment in agriculture production is needed to maintain Australian agricultural production and enhance global food security.

Introduction

One of the dimensions that Australia serves global humanity is by enhancing global food security. Like many other arid countries and regions in the world, Australia's agricultural production has been threatened by water shortages, with potentially serious economic and environmental consequences (Cooley et al., 2009; Pigram, 2007). Australia is a major food producer, but recent drought has reduced its agricultural and food production (Goesch et al., 2007). Increased water scarcity and greater demand for water by non-agricultural uses, including restoration of environmental flows, will have major implications for Australian agricultural production (Quiggin and Chambers, 2004). Observed declines in the irrigated area in the Murray–Darling Basin, which is one of Australia's major food producing areas (accounting for about 40% of Australia's gross value of agricultural production), from 2001 to 2006 (ABS, 2001, 2006) is attributed to drought. Consequently irrigated production declined in the Murray–Darling Basin, especially rice production which fell from 1643 kilotonnes in 2000–2001 to 1003 kilotonnes in 2005–2006 and 18 kilotonnes in 2007–2008 (ABS, 2008). Furthermore, there are concerns that climate change will reduce or alter seasonal rainfall patterns (Chiew et al., 2009). The combined effects are likely to manifest as declining food production as water allocations for irrigation and crop effective rainfall are reduced.

Adapting cropping systems to new conditions to avoid reduction of agricultural production (for example drought responsive land use change and growing drought tolerant varieties) are medium to long term measures associated with high adaptation costs

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and subsequent higher total costs of food production. Reduced rainfall also means that dry-land and rain-fed agricultural production will likely decline in the current geographic distribution, further decreasing total agricultural production. The resulting shortfalls in production would reduce aggregate Australian contributions to international food supplies, potentially exacerbating food security threats given the global increase in food demand, changing global rainfall patterns and reduced availability of water for irrigation (Molden et al., 2010). Climate change is expected to reduce production of the major Australian agriculture commodities including wheat, beef, dairy and sugar production by 9–10% by 2030 and 13–19% by 2050 and would have significant implications for international agricultural trade (Gunasekera et al., 2007). According to Cline (2007) global warming caused by climate change will cut Australia's farm productivity by 27%.

The impact of climate change such as drought and water scarcity on agriculture in Australia and particularly in the Murray–Darling Basin has been examined in various studies (ABARE–BRS, 2010; Adamson et al., 2009; Grafton and Jiang, 2011; Kirby et al., 2012; Mallawaarachchi et al., 2010; Wittwer and Griffith, 2011). However, these studies mainly estimated the economic impact in terms of gross value and/or agricultural profitability rather than estimating the impact on total production (i.e. tonnage) of individual agricultural commodities. For example, ABARE–BRS (2010) found that 29% reduction in total water use will reduce average annual gross value of irrigated agricultural product (GVIAP) in the Basin by around 15% relative to the baseline scenario while Adamson et al. (2009) in their global solution scenario found that about 40% reduction in water use will reduce the social value of the basin by about 50%. However, there is evidence that farmers adapted in their land and water use practices when they faced restrictions in their irrigation water allocations. Consequently, these adaptations along with the institutional reforms in the form of water markets helped them in mitigating these impacts (Mallawaarachchi and Foster, 2009; Oliver et al., 2009). Kirby et al. (2012) found that in 2008–2009, water use in irrigation in the MDB fell by 33% while the gross value of irrigated agricultural production in 2008–2009 fell by about 20%. The key factor which helped in reducing the losses was increase in commodity prices, especially cereal prices which increased by more than 50% in 2007–2008 compared to 2005–2006. Thus, while the overall economic value of production did not fall very much, the volume of production fell a lot due to water scarcity and this fall in tonnage and changes in commodity mix have implications for food security, both nationally and in export destinations.

In the Murray–Darling Basin (for example), during the recent drought, water markets and trading have re-allocated some water away from low value agricultural activities (such as cereals, rice and other broadacre staple crops) to high value perennial horticultural activities (such as grapevines, citrus and almond) (Mallawaarachchi and Foster, 2009). Further reliance on water markets and trading (Qureshi et al., 2009) along with the greater recognition of environmental flows (CSIRO, 2008; Qureshi et al., 2010) could increase the transfer of water away from the low value staple food crops production to high value horticultural activities and/or environment or urban uses, with the potential to reduce staple food exports.

Simultaneously, major population increase in Australia's geographic neighborhood (Asia), particularly strong growth in India and China, an increased calorie intake in China and India associated with increasing wealth, as well as surging demand for fresh food, meat and live animal exports from the Middle Eastern countries (ABARE, 2008) is expected to increase the demand for Australian agriculture and food production. Despite Australia being one of the world's major food exporting countries, there is currently no analytical framework to estimate the impact of increasing water scarcity on agricultural and food production in Australia, future food exports and ultimately on global food security.

This paper builds on previous work (Hanjra and Qureshi, 2010) that focussed on the relationship between the global water crisis and future food security, using an analytical framework that examines the impact of water scarcity in Australia on food production, food exports, and the potential implications for world food security. Focusing on Australia, the Australian Bureau of Statistics (ABS) land use data was examined to appraise the impact of drought on Australian agricultural production. The analysis evaluated the vulnerability to water scarcity of the major crops produced in Australia, the relative importance in food production and traced the destinations of Australian food exports. The paper discusses findings of a recent study (Qureshi et al., 2012a) which examined the impact of climate change on agricultural and food production under various rainfall and water allocation scenarios, and alternate states of nature in the southern Murray–Darling Basin of Australia. The discussion emphasises the changes in agricultural activity from low value staple food production to high value agricultural commodities in the Basin. Assuming a similar trend across Australia, the implications for global food security are examined by linking with the Australian Bureau of Statistics domestic use and export data for wheat and rice production (ABARE, 2008) and identifying plausible linkages between water scarcity in Australia and potential impacts on global food security.

The next section provides a brief overview of Australian agricultural production, exports, and major destination countries for those exports. A discussion on the recent droughts and impact on water allocations in the Murray–Darling Basin, Australia follows. The impact of increasing water scarcity in Australia and implications for global food security in terms of exports is presented in the next section. Relationships between Australian food production, export and global food prices are explored in the next section. The paper concludes with a discussion of potential policy implications.

Australia's agricultural production and exports

Australian exports and destinations

Australia is a substantial exporter of agricultural commodities such as wheat, rice and other cereals, as well as livestock and dairy products and thus contributes significantly to world food supply. Fig. 1 illustrates the major Australian agricultural exports in 2007. Beef contributed approximately $4.5 billion of 2007 export revenue, followed by wine ($3.0 billion), dairy products ($2.5 billion) and wheat ($2.0 billion) (DFAT, 2008) [Note all monetary values are in 2007 Australian dollars]. As shown in Fig. 2, Australia is the world's sixth largest exporter of aggregated food production and as one of the five major wheat exporting countries, exports the majority of Australian annual wheat production.

The volumes and ranking of the countries importing Australian wheat vary from year to year depending on a number of factors including their local production, demand and global market price. In 2009–2010, Australia exported 12.9 million tonnes of wheat (with a value of $3.2 billion) (Australian Government, 2010). Australian wheat export destinations include countries in Africa, Asia, Middle East and Oceania (ABARE, 2008). Fig. 3 shows the top 10 major importing countries of Australian wheat. These countries accounted for 79% of Australian wheat exports while Indonesia, Japan, South Korea, Yemen and Vietnam imported 6.6 million tonnes (54%) in 2009–2010. Many of these countries are dependent on food imports to meet nationally designated conditions of food security. Overall, Asian countries are the major importers of Australian produced food. Japan is currently the largest importer of