16. Modelling Challenges

Qiang Jiang

Introduction

This chapter discusses the controversy surrounding the modelling work that has been undertaken in the Murray–Darling Basin Authority's *Guide to the proposed Basin Plan*. Furthermore, the future modelling challenges of the social and economic impacts of the sustainable diversion limits (SDLs)—such as data availability, and the methods and objectives of modelling—will be identified, together with a review of existing modelling work within the Basin. To meet these challenges, the Australian Government should systematically facilitate researchers to accumulate the relevant basin data, or allow them access to their current basin data.

In October 2010, the *Guide to the proposed Basin Plan* was released by the Murray–Darling Basin Authority (MDBA). The calculation of SDLs is specified within the Guide. The Authority proposed that the amount of additional surface water needed for environmental flows is between 3000 gigalitres a year and 4000 GL/yr, which represents a cut of between 27 per cent and 37 per cent in watercourse diversions (MDBA 2010a). As the majority of water-use reductions are in irrigated industries, the Australian Bureau of Agricultural and Resource Economics–Bureau of Rural Sciences (ABARE–BRS 2010a) have predicted that these water-use reduction scenarios might result in losses of between $800 million and $1.1 billion a year for irrigated agricultural production (ABARE–BRS 2010a). Furthermore, if a 3000 GL/yr additional environmental flow target is adopted, 800 jobs will be lost in the long term (ABARE–BRS 2010a).

The irrigators in the Basin reacted angrily to the proposed water-use cuts in the Guide, and disagreed with the MDBA's social and economic impact findings for these additional scenarios. For many farmers in the Basin, the Authority underestimated the social and economic losses of additional environmental flows.

Although most of the ABARE–BRS results are similar to those from previous studies of the Basin (Adamson et al. 2007; Jiang 2010), there are rising concerns about the report's findings and the modelling that underpins the Guide. These have led to a parliamentary inquiry that is set to examine the social and economic impacts of SDLs on regional communities. This inquiry might have a strong focus on understanding the human impact of any proposed changes. The MDBA has also commissioned a future study to deliver a better understanding of the social and economic impacts of the SDLs. The modelling of social and economic impacts will be a major issue in these two future studies.

ABARE–BRS Modelling

In this section, we examine the details of ABARE–BRS modelling including the method, models, implementation, limitations and results. The general findings from ABARE–BRS are similar to the conclusions from previous studies in the Basin (Adamson et al. 2007; Jiang 2010). Not all models in the ABARE–BRS modelling are, however, designed to simulate the 19 Basin Plan regions in the Guide. Therefore, this modelling can reveal only an overall picture of the impacts and predictions of SDLs in some regions, which might not necessarily be accurate. ABARE–BRS stated their model limitations: 'While large-scale economic models are suitable for analysis at broad regional (for example, catchment) levels, they are limited in their ability to provide accurate estimates at smaller geographical scales' (ABARE–BRS 2010a, p.15). Despite the limitations, the models used in the ABARE–BRS study are the best available at this time. Future research might reduce these limitations.

In the method of the ABARE–BRS study, a two-stage approach has been applied (Figure 16.1). The first stage involves using ABARE–BRS's Water Trade Model to estimate the direct effects of changes in SDLs on the gross value of irrigated agricultural production (GVIAP) by the CSIRO's Sustainable Yield regions. In the second stage, these GVIAP estimates have been imported into a computable general equilibrium (CGE) model of the Australian economy, AusRegion, to estimate flow-on effects to regional, State and national economies.

In the first stage, the ABARE–BRS Water Trade Model consists of two parts: hydrologic modelling based on the CSIRO's Sustainable Yields project, and social and economic modelling based on Australian Bureau of Statistics (ABS) data. The hydrologic study modelled the water availability and environmental demands of the Basin. The various simulated water usages under proposed additional environmental-water scenarios in the hydrologic study have been used as the inputs for the social and economic study. This approach has been widely used in previous integrated hydrologic and economic modelling.

In the second stage of the study, these gross value loss estimates from the Water Trade Model have been exported into the AusRegion model. The flow-on effects of SDLs, and the long-term employment change, have been simulated by the AusRegion model.

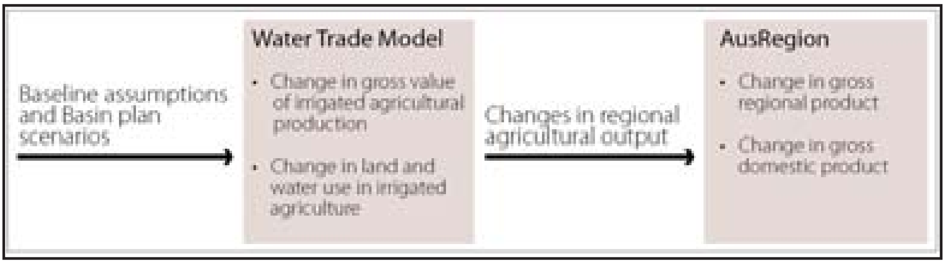

Figure 16.1 Two-stage approach in the ABARE–BRS study

Source: ABARE–BRS (2010a).

In the baseline scenario of the ABARE–BRS Water Trade Model, the 10 375 GL reported in 2000–01 is 2000 GL less than the 12 300 GL of water use under the long-term condition reported by the MDBA. Although this water-use difference was between simulated baseline water use and historical water use, the 2000–01 data are the best available at the moment, and were therefore used by ABARE–BRS to simulate the 3000 GL, 3500 GL and 4000 GL additional environmental flow scenarios. One important assumption in the ABARE–BRS study is that the water market in the Basin is efficient, and allows water to be traded away from relatively lower-value crops to relatively higher-value horticultural crops.

According to the simulated results of the ABARE–BRS study, it is estimated that the gross value of irrigated agricultural production would decline by about 13 per cent under a 3000 GL/yr scenario, 15 per cent under a 3500 GL/yr scenario and 17 per cent under a 4000 GL/yr scenario. As stated earlier, basin-wide employment would fall by approximately 800 full-time jobs, or about 0.1 per cent of current employment levels. These forecasted job loss figures are for the long run and mitigated by the government investment in water saving infrastructure. Without these assumptions, the job loss number could be higher. In a following study by ABARE–BRS, if without the government investment in water saving infrastructure, the short term job loss number could be around 5000 (ABARE–BRS 2011).

Irrigators are suspicious of the modelled social and economic impacts put forward by ABARE–BRS. They have been viewed as inadequate, and the estimated economic and employment losses described as optimistic. In general, the findings from ABARE–BRS are consistent with those from the literature (Adamson et al. 2007; Jiang 2010). In addition, ABARE–BRS state the assumptions and limitations in their report. These statements and results have, however, been largely ignored and misunderstood by the public.

Despite some limitations in the ABARE–BRS modelling, the used models are appropriate. More research is required, however, to improve them. This could include the following.

1. Developing a better regional boundary design in models, consistent with the Basin Plan regions in the MDBA's Guide. Neither the 22 regions in the ABARE–BRS Water Trade Model nor the seven regions in the AusRegion model can fully match the 19 Basin Plan regions in the Guide. Therefore, the prediction qualities in some regions are not as good as the overall results.
2. Continuing to accumulate the relevant basin data in a way that is consistent with the Basin Plan's regions. The best available data for the Basin are currently 10 years out of date, relating to 2000–01.
3. Water saving from irrigation infrastructure has not been examined in the ABARE–BRS Water Trade Model. Irrigators claim it is very important in Australia's water reforms.
4. Some findings, such as employment losses, are focused on the long term. Some short-term impact studies are also required.
5. Water used in the baseline of the ABARE–BRS modelling is 2000 GL less than the MDBA's long-term water-use data. This is the equivalent of an additional 2000 GL water buyback.
6. Water-use data for some regions—for example, 79 GL in eastern Mt Lofty Ranges—are 10 times greater than the water-use data from the CSIRO.

Other Water-Management Modelling in the Murray–Darling Basin

A large amount of literature exists on the subject of water management in the MDB. The Risk and Sustainable Management Group developed their model (RSMG) at the University of Queensland (Adamson et al. 2007). Two similar models were developed with different regional boundaries: the Integrated Irrigated Agriculture Water Model (IIAWM) was developed by the Centre for Water Economics, Environment and Policy at The Australian National University (Jiang 2010), and the ABARE–BRS Water Trade Model was developed by ABARE–BRS (Hafi et al. 2009).

The common approach in modelling water management is to combine hydrologic and economic models. The hydrologic studies examine water availability, water movement and barriers of the MDB under various scenarios such as climate change and water buybacks. In contrast, the economic studies simulate and optimise water use to maximise economic returns. These often use the hydrologic model data as the inputs or constraints. The output data of the existing economic models are limited in direct economic impacts such as gross value and profit. The broad economic impacts, such as indirect economic effects and employment changes, are not examined in the existing economic models.

As a typical example of these kinds of integrated hydrologic and economic models, Adamson et al. (2009) have assessed the effects of irrigated agriculture under different climate scenarios and states of nature using the RSMG model. They used inflow projections by Jones et al. (2007) for 2030, and found under their global solution (optimal adaptation to reduced water availability) that the social value in the Basin declines by at least $178 million a year, and up to $444 million a year (Adamson et al. 2009). The losses occur because of reduced revenues from lower yields due to deficit irrigation, smaller areas under irrigation and because of increased costs from accessing water. A recent SDL impact study using the RSMG model estimated water use fell by 3746 GL, or 35.5 per cent, and the resulting reduction in GVIAP was $1.445 billion, or 16 per cent (relative to the baseline). In the number of economic loss, the result from the RSMG model is 50 per cent higher than the ABARE–BRS Water Trade Model.

The Centre for Water Economics, Environment and Policy at The Australian National University, on behalf of the Wentworth Group of Concerned Scientists, recently developed a combined hydrologic and economic model (IIAWM) to study the economic implications of SDLs in the Basin. IIAWM assumed unrestricted water trade in the Basin and used the CSIRO's regional boundaries. One important feature of IIAWM is that an employment-change forecast function has been developed within simulated land use.

In IIAWM, under a basin-wide diversion of 30 per cent, agricultural diversions were estimated to require a reduction of 65 per cent in the Murrumbidgee River and 39 per cent in the Murray River, while other regions were relatively unaffected. For a 40 per cent basin-wide reduction, the regional reductions were more evenly spread, with the Campaspe and Loddon–Avoca rivers requiring reductions in agricultural diversions of 98 per cent and 84 per cent, respectively. The resulting reduction in annual net returns, averaged across the Basin, was 9.5 per cent for a diversion of 30 per cent and 16.3 per cent for a 40 per cent reduction.

The general findings from these models show that foregone profits resulting from additional environmental flows can be modest with a free water market. Particular regions, however—the Murrumbidgee, for example—might suffer substantial reductions in profits with water trade.

The Challenges of Existing Models

The findings and results from existing models should be treated with caution and considered in the context of model assumptions. Social and economic impacts in these studies, such as flow-on impacts and employment change, are insufficient. In the future social and economic study commissioned by the MDBA, it demands that the wider social and cultural implications of the proposed Plan should be scrutinised. The existing models are, however, limited in these broader impact studies, and the relevant science and social data are insufficient or not available to researchers.

The first challenge is from the free water market assumption. In most models, it is assumed there is a free water market at the Basin scale, and that water can be transferred between regions without barriers. The purpose of this water market is to transfer water from low economic value crops to those with higher economic value. Although some regions might suffer greater economic losses than others, with a free water market, the losses can be minimised at a basin-wide level. Under this free water market assumption, it is inevitable that transaction costs—such as water-purchase costs between farmers—and the uncertainty of the farmers' water-purchase mechanism might diminish the contribution of water trade. Therefore, economic returns from existing models represent long-term results of a best-outcome scenario. In the short term, the economic loss will be higher than the simulated results found in the literature. To overcome this problem, we need to measure and simulate water-trade costs and agricultural production under some water market failure scenarios. As there are no consolidated and consistent water-trade records for the Basin, these issues cannot, however, be fully examined.

The second challenge arises from inadequate employment-change data for irrigation industries—another controversial issue in terms of employment data availability. In 2006, the MDB accounted for approximately 10 per cent of total national employment—about 920 000 people, with about 96 000 engaged in agriculture. We do not, however, have any records for the farmers who worked only in the irrigated industries in the Basin. This poses a further data availability problem for modellers. Similarly, no historical data or models can estimate how many workers will find jobs in other industries.

The third challenge is the assumption in predicting employment change caused by water-use reductions. Using the SDL scenarios, relatively small reductions in employment have been reported by the AusRegion model, with a 0.1 per cent loss of employment across the MDB as a result of the Basin Plan, relative to the baseline. This figure was, however, based on two important assumptions.

1. Employment-change simulations focus on the long term and job losses in irrigated industries can be absorbed by new employment opportunities generated by other industries, such as dryland agriculture and mining. In the short term, the employment losses will be greater than the results for the long term.

2. The AusRegion model assumed Australia is close to full employment and able to adjust and send displaced agricultural labour to other industries. The flexibility and efficiency of transferring irrigators to other industries in the future Australian labour market are uncertain. For instance, the current skills of farmers might not be sufficient for them to find new jobs.

The fourth challenge is how to simulate employment change caused by water reductions. In current employment-change studies, the number of farmers in work is linked with GVIAP; however, commodity prices might change in the future, and employment change forecasted by GVIAP change is unable to consider this. Recently, IIAWM developed a new employment-change forecast function by considering land use and the average farm-worker numbers by crop.

The final challenge is data availability. In 2010, during the design of the *Guide to the proposed Basin Plan*, the Australian Government provided ABARE–BRS with a range of assumptions on irrigation water for the future, including projected total regional expenditures, volumes of water recovered and the distribution of these expenditures and water recovery over time, for both water-entitlement purchases and infrastructure investment. The infrastructure data are not, however, available to the public. Without the water-saving data from infrastructure investment, water-saving studies are not sufficient in the existing models.

A further example involves the Basin Plan's regional boundary data, which were not released by the MDBA. The regional boundaries play a vital role in our model development, yet some models cover only some parts of the Basin (Dixon et al. 2009). These models fail to take a holistic approach to simulate the Basin's water management and are therefore not suitable to model the whole Basin as required.

There are different ways to divide the Basin into regions, but adopting different regional boundaries results in a data-sharing problem between different government agencies. The first way to divide the Basin is based on the catchment management authority areas. Under these rules, the Basin has been divided into

The second way to divide the Basin has been developed in the CSIRO Sustainable Yield report (Figure 16.3). In hydrologic modelling, this method involves linking 24 existing water models from New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory to construct an integrated model with surface and groundwater intersections. This project modelled the water availability in the Basin for the past 100 years, and under several climate-change scenarios. A third way to adapt for the specific needs of the Basin Plan has seen the MDBA update the methods and tools underpinning the CSIRO study with new regional boundaries and hydrologic features (Figure 16.4).

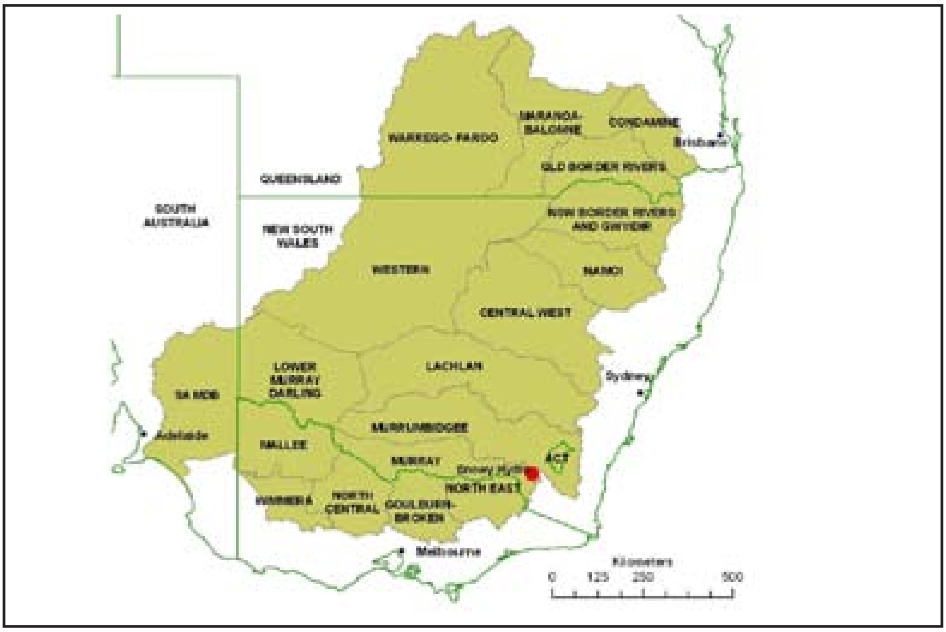

Figure 16.2 Catchment management authority areas

Source: Quiggin et al. (2008).

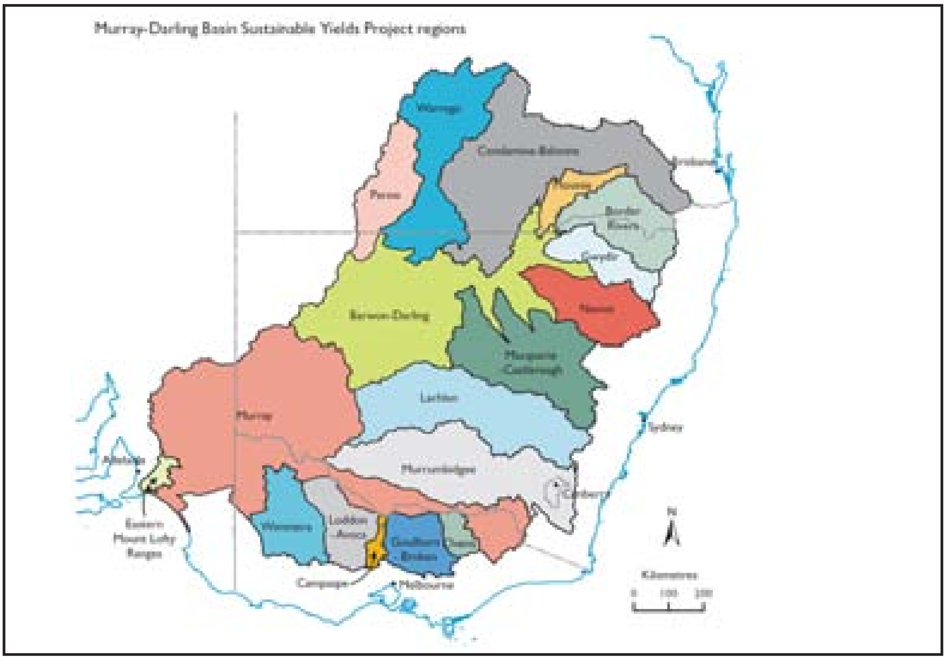

Figure 16.3 CSIRO Sustainable Yield regions

Source: CSIRO (2008a).

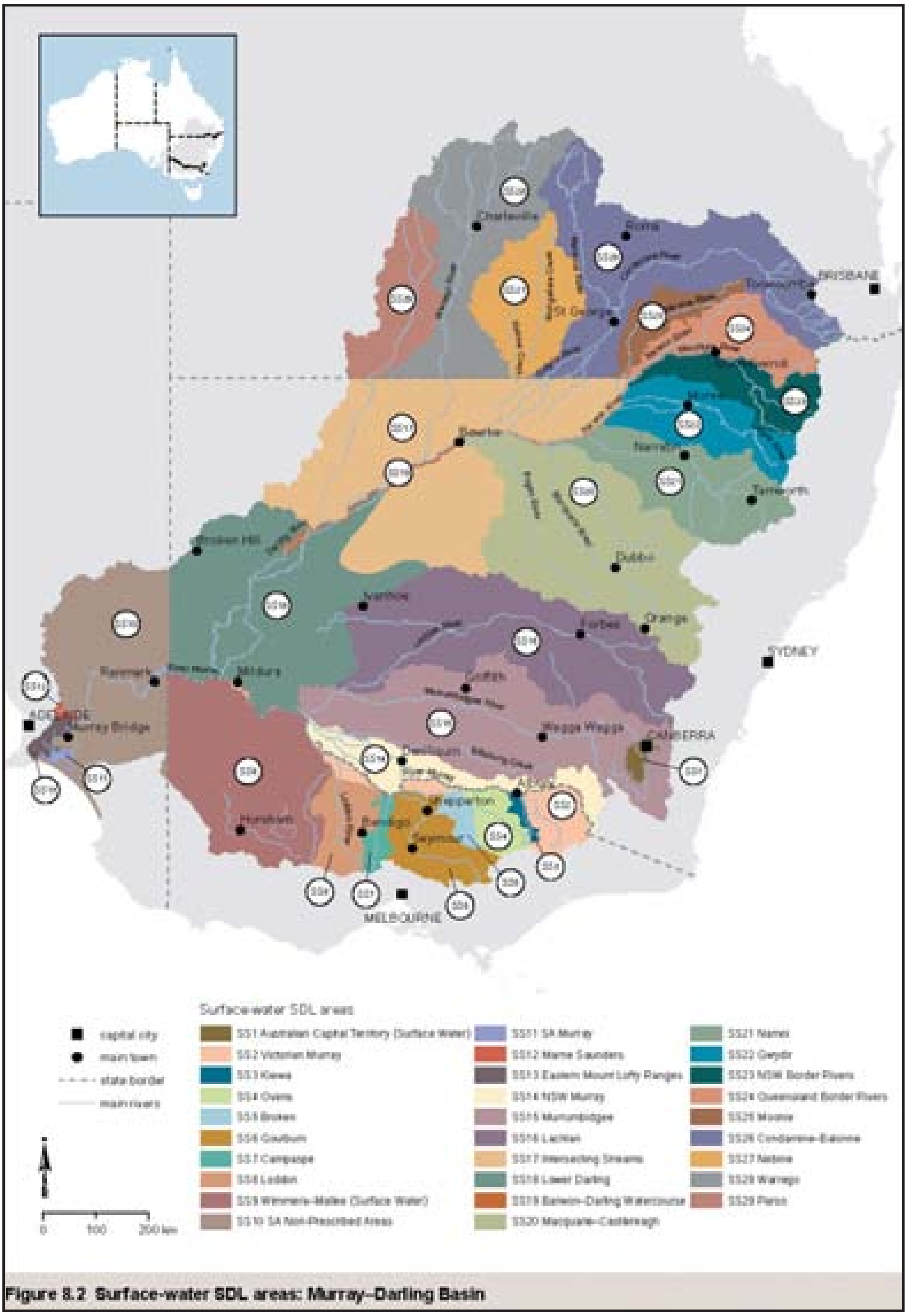

Figure 16.4 Basin Plan regions

Source: MDBA (2010a).

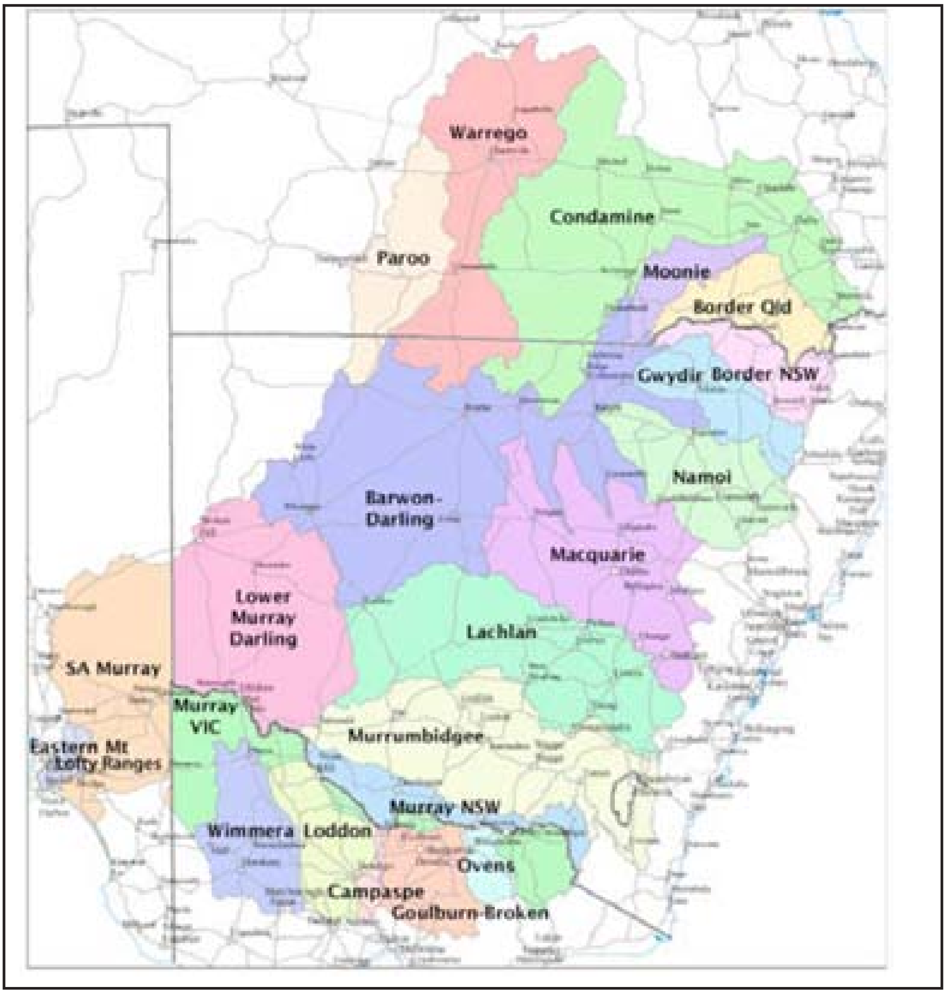

Figure 16.5 Regions in the ABARE–BRS Water Trade Model

Source: ABARE–BRS (2010a).

The regions in the ABARE–BRS Water Trade Model are similar to the Basin Plan regions (Figure 16.5). Some regions, however, such as the Barwon–Darling in the ABARE–BRS Water Trade Model (Figure 16.6), are totally different from their equivalent region in the Basin Plan (Figure 16.7). Without relevant spatial data made publicly available, researchers cannot modify existing models to match the Basin Plan regions.

Clearly, the new Basin Plan regions are different from previous regional definitions in the Basin. Therefore, much of the existing regional data or economic models are spatially incompatible with the new Basin Plan regions, and require significant effort in manipulating and scaling for a comprehensive economic analysis to be possible.

Figure 16.6 Barwon–Darling region in the ABARE–BRS Water Trade Model

Source: CSIRO (2008b).

Conclusions

In 2010, ABARE–BRS modelled the social and economic impacts of the SDLs and predicted that the impacts of additional environmental water are modest. Although the results from ABARE–BRS are similar to previous studies, the Basin communities have challenged their reliability.

With the different regional boundaries and model assumptions between the ABARE–BRS models and the Basin Plan, these SDL impact findings are the results of the first stage of analysis. We need a new model that can fully match the Basin Plan's regions and simulate the impacts under model assumptions.

Furthermore, new methods to analyse employment change need to be investigated, and some simulation scenarios, such as possible water-market failure, should be examined.

After the release of the *Guide to the proposed Basin Plan*, we need to improve our social and economic models of the regions of the Basin. As a substantial amount of data are not available to the public, however, researchers are unable to develop a full model using the Basin Plan's regions. To address this problem, the Australian Government should provide more resources relating to basin data, and allow researchers to access and share them.

Figure 16.7 Barwon–Darling region in the proposed Basin Plan

Source: MDBA (2010b)

References

Adamson, D., Mallawaarachchi, T. and Quiggin, J. 2007, 'Water use and salinity in the Murray–Darling Basin: a state-contingent model', *Australian Journal of Agricultural and Resource Economics*, vol. 51, no. 3, pp. 263–81.

Adamson, D., Mallawaarachchi, T. and Quiggin, J. 2009, 'Declining inflows and more frequent droughts in the Murray–Darling Basin: climate change, impacts and adaptation', *Australian Journal of Agricultural and Resource Economics*, vol. 53, no. 3, pp. 345–66.

Australian Bureau of Agricultural and Resource Economics (ABARE) and Bureau of Rural Sciences (BRS) 2010a, *Environmentally Sustainable Diversion Limits in the Murray–Darling Basin: Socioeconomic analysis*, Australian Bureau of Agricultural and Resource Economics and Bureau of Rural Sciences, Canberra.

Australian Bureau of Agricultural and Resource Economics (ABARE) and Bureau of Rural Sciences (BRS) 2010b, *Assessing the Regional Impact of the Murray–Darling Basin Plan and the Australian Government's Water for the Future Program in the Murray–Darling Basin*, Australian Bureau of Agricultural and Resource Economics and Bureau of Rural Sciences, Canberra.

Australian Bureau of Agricultural and Resource Economics (ABARE) and Bureau of Rural Sciences (BRS) 2011, *The economic and social effects of the Murray–Darling Basin Plan: recent research and next steps*. ABARE Conference Paper 11.12, March, Presented at the 41st Outlook Conference.

Commonwealth Scientific and Industrial Research Organisation (CSIRO) 2008a, *Water availability in the Murray–Darling Basin*, A report to the Australian Government from the CSIRO Murray–Darling Basin Sustainable Yields Project, CSIRO, Canberra.

Commonwealth Scientific and Industrial Research Organisation (CSIRO) 2008b, *Water availability in the Barwon–Darling*, A report to the Australian Government from the CSIRO Murray–Darling Basin Sustainable Yields Project, CSIRO, Canberra.

Dixon, P. B., Rimmer, M. T. and Wittwer, G. 2009, *Modelling the Australian Government's Buyback Scheme with a Dynamic Multi-Regional CGE Model*, Monash University, Clayton, Vic.

Hafi, A., Thorpe, S. and Foster, C. 2009, *The impact of climate change on the irrigated agricultural industries in the Murray–Darling Basin*, ABARE Conference Paper 09.3, February, Presented at the Australian Agricultural and Resource Economics Society (AARES).

Jiang, Q. 2010, *An overview of the Integrated Irrigated Agriculture Water Model (IIAWM) of the Murray–Darling Basin*, CWEEP Research Paper 10-03, Centre for Water Economics, Environment and Policy, The Australian National University, Canberra.

Jones, R., Preston, B., Brooke, C., Aryal, S., Benyon, R., Blackmore, J., Chiew, F., Kirby, M., Maheepala, S., Oliver, R., Polglase, P., Prosser, I., Walker, G., Young, B. and Young, M. 2007, *Climate Change and Australian Water Resources: First risk assessment and gap analysis*, Australian Greenhouse Office and the National Water Commission, Canberra.

Murray–Darling Basin Authority (MDBA) 2010a, *Guide to the proposed Basin Plan. Volume 1: Overview*, Murray–Darling Basin Authority, Canberra.

Murray–Darling Basin Authority (MDBA) 2010b, 'Summary of Barwon–Darling region', in *Guide to the proposed Basin Plan*, Murray–Darling Basin Authority, Canberra.

Quiggin, J., Adamson, D., Schrobback, P. and Chambers, S. 2008, *Garnaut Climate Change Review: The implications for irrigation in the Murray–Darling Basin*, University of Queensland, St Lucia.