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Water allocation in Australia's Murray–Darling Basin: managing change under heightened uncertainty[*]

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Abstract

Historically, water resource policy in the Murray–Darling Basin (Basin) has taken a pro-farmer orientation leaving the environment to become the residual claimant. Around 1990, the attention was focused on minimizing overuse that led to on-farm productivity losses and developing a market for water to help define opportunity costs of water in irrigation. More recently, the scope has been extended to include explicit allocations for the environment. However, the failure to agree on policies for recovering water for the environment in the implementation of the Basin Plan has extended avenues for rent seeking and cost shifting, thereby raising the total costs of reform. A focus on water use *per se*, rather than system productivity, and sidelining of market-based approaches in preference for government investment in water recovery and water use efficiency has complicated risk assignment amongst different users. Recurring droughts and resultant scarcity of water has made negotiations further complicated and controversial, broadening the gulf between environmentalists seeking public good outcomes and irrigators seeking private profit. Despite these, the MDB system as a whole, including dryland and irrigated farming, environmental uses and other industries, has adjusted to changing conditions, drawing on

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new knowledge and technology and emerging market opportunities. Irrigators have shown an ability to diversify into new commodities with better prospects for managing risks. However, declining farm numbers, a changing demography and accelerating climate change point to general failure risks if the reform process were to halt and governments disregarded the gains through a rebalancing of consumption possibilities from the full complement of Basin's resources – not just irrigation. This paper, examines the sources of social costs in water resource allocation, including pros and cons of water trading with respect to agricultural production and externalities. The aim is to canvass possible reform alternatives which might help governments to become a catalyst in fostering collaboration for efficient adaptation.

Key words: water management; irrigation; social cost; risk and uncertainty; public policy: adaptation

1 Introduction

1.1 Background

For more than a century, since the River Murray Waters Agreement of 1915, water resource policy in the Murray–Darling Basin (Basin) has focused on irrigation. The natural environment was initially ignored, before becoming a residual claimant. Coordinated government reform since 1994 (COAG 1994) has attempted to refocus the Australian water industry towards efficient and sustainable resource use, helping to arrest some social costs of irrigation. Concerns over excess extraction was recognised with the imposition of the Cap in 1994, aimed at halting future growth in extractive water uses.

Successive reforms helped modernise the water economy, setting full-cost recovery charges for water, clarifying property rights, capping Basin water allocations for irrigation and facilitating the trading of water rights. Consequently, the economic value of water is now better reflected in decisions, particularly in irrigated production, and as a result, irrigation entitlements have become highly valued assets.

Despite these gains, the reform process remains inadequate to meet the needs of the environment (Quiggin, Mallawaarachchi and Chambers 2012, McKay 2005). Progress towards more sustainable water use has often been reversed under political pressure, creating instability and greater uncertainty, affecting all users.

The *Water Act 2007*, and the Murray–Darling Basin Plan as the most recent embodiment of Australian Government water reform, gave explicit recognition to environmental and social outcomes, providing the legislative basis for government investment and institutional reform. The stated aim was to better manage Australia's water resources in the national interest (Commonwealth of Australia 2007). Program elements included investment in enabling mechanisms to reallocate water for environmental and extractive uses, thus contributing to flexibility and adaptive capacity in general (Marshall 2013, Crase, O'Keefe and Kinoshita 2012).

The market-based approach to natural resource allocation, subsumed in progressive reform, has been more widely adopted to deal with environmental problems such as in fisheries management and climate change. However, political manoeuvring has allowed for beneficiaries of the status quo to continue to oppose reform, despite mounting social costs.

Such manoeuvring led to repealing the centre piece of climate change reform introduced in 2011, the emissions trading scheme (Talberg, Hui and Loynes 2016), and has similarly undermined water reform.

At the time of writing, Australia is experiencing a prolonged drought, the second such episode in the 21st century. Although attribution of such extreme events remains contentious, the view that drying across southern Australia cannot be explained by natural variability alone is now widely accepted (Australian Government 2019a). Moreover, higher temperatures associated with climate change exacerbate the impacts of droughts such as elevating bushfire risks.

Drought increases costs to irrigators and the risk of increased crop failure, while also curtailing benefits from holding natural assets. The result is increased conflict between production and environmental benefits derived from an unreliable water system (Chambers 2009). In particular, communities dealing with this conflict often support the status quo, as uncertainty complicates rational evaluations.

Hence, much of the difficulty in water reform revolves around the understanding of risk and uncertainty. If the aim of the *Water Act* and the Basin Plan that followed were to maximise Australia's social well-being from effective water management, then the matters fall largely in the economic domain and concern decision-making under uncertainty. Hence, clarifying the nature of opportunity costs could offer a way to ease conflicts. In this context, the effectiveness of reforms may be viewed in their capacity to reduce vulnerabilities and enhance security to better cope with contingencies (Chambers 2009, Mallawaarachchi et al. 2011).

Water policy determinations in the Murray–Darling Basin are complex and prone to error because of uncertainty and difficulties in negotiating policy agreements. In particular, significant stakes for private benefits make the negotiations vulnerable to rent seeking, potentially exposing tax payers to significant costs and public losses in environmental and heritage values. Climate change compounds the social problem and exposes taxpayers to future costs, placing in jeopardy the well-being of all parties (Pittock, Williams and Grafton 2015). In this context of information asymmetry, the market mechanism may fail to deliver optimal outcomes. Hence, complementary institutional mechanisms to guide necessary coordination becomes crucial. The purpose of this analysis is to contribute to the public debate in the hope of supporting better decision processes, improving transparency, and containing the public costs of future interventions.

The paper is arranged in five parts. Section 2 presents an overview of the Basin and its evolving land use to put different drivers of change in perspective. Section 3 briefly explores economic issues in water resource governance. The focus is on the interplay of issues of externality, public goods and uncertainty in determining economic efficiency, which complicates the analytical treatment (Quiggin 2001). Section 4 discusses key sources of risks faced by irrigators, environmental managers and taxpayers and consider the merits of the risk assignment framework in the *Water Act*. Some ways to reducing the costs of government engagement and creating a more transparent, adaptable and publicly accountable approach are then canvassed, noting the challenges in decision-making under increasing uncertainty. Section 5 concludes the paper with a discussion on some directions and issues for further research, notably the lack of reliable data and modelling tools that protracts the information asymmetry problem, and perpetuates the risk of inefficiency in government interventions.

2 The evolving Murray–Darling Basin

2.1.1 Significance of the Basin

The economic significance of the Basin is drawn from the value of production derived from both irrigated and dryland agriculture. For the year ending 30 June 2018, the gross value of agricultural output of the Basin was estimated at $23.7 billion, of which irrigation contributed $8.6 billion (36%) and consumed an estimated 7,065 gigalitres of water. Four commodities, cotton, dairy, fruit and nuts (including grapes) and vegetables accounted for 78 per cent of the gross value from irrigation in the Basin (ABS 2019).

Since early settlement, the region's economy has diversified, drawing on its agricultural base and natural assets. The heightened awareness of environmental implications of intensive agriculture, coupled with growing relative scarcity of water for both production-oriented consumptive uses (extractive uses), and conservation-focused non-consumptive uses (natural uses) indicate significant economic costs attached to current water use. Of particular interest is the impact of expanding irrigation on environmental assets (including assets of national significance, such as Ramsar listed wetlands), river corridors and associated cultural and heritage assets of the Aboriginal people.

2.2 The geography and natural setting

Diversity offer challenges and opportunities

The Murray-Darling Basin is exceptionally large and diverse, making it a complex entity to manage. The region is defined by the drainage areas of the Murray and Darling rivers and their many tributaries that cut across a number of Australian jurisdictions. The Basin covers 14 per cent of mainland Australia and includes 75 per cent of New South Wales, more than 50 per cent of Victoria, the southern section of Queensland, a portion of South Australia, and all of the Australian Capital Territory (ACT). Although similar in extent to the combined area of Spain and France, the Basin is essentially rural and sparsely populated with around 2 million people across its 110 million ha area. This sparse population and high level of remoteness means that some communities could face significant social disadvantage, creating greater conflicts when weighing up critical human needs and environmental services. Amongst the Basin's sub catchments, the Murrumbidgee, which includes the ACT could be considered the most affluent, and the Barwon-Darling, Warrego and Paroo regions would be the most remote (ABS/ABARE/BRS 2009 p.8). This diversity can provide fertile grounds for rent seeking activities, and confronting such inefficiencies with appropriate public policy requires a greater emphasis on accurate data, communication and information sharing.

2.3 A growing North–South divide

Irrigation development since colonial settlement has impacted on river flows and land use in the Basin, making it an important focus for cooperative federalism in Australia. Sharing the costs of transboundary water management for multiple use is an ongoing source of uncertainty in governance. In understanding the evolving patterns of the Murray-Darling Basin, variability in natural resource condition is an important aspect. As with historical developments, the resource condition determines the initial productive capacity, which can then be harnessed to better advantage with management options that draw on knowledge and technology. Along with the cost of capital and broader social policy, such as property rights systems, the variability in local conditions has a strong bearing on opportunity costs, in particular those relating to irreplaceable environmental assets and heritage values.

2.3.1 The Northern Valleys

The Darling River and rivers and tributaries that drain to it forms the Northern Valleys of the Murray–Darling Basin. It commences near Bourke at the confluence of the Culgoa and Barwon Rivers and then traces through south-western NSW to the Menindee Lakes and its confluence with the Murray River at Wentworth (Figure 1). Taken from its uppermost natural source, the Condamine River in south–east Queensland, to its confluence of the Murray at Wentworth, the natural movement of water through its 2,739 km passage could take several months. Many of the rivers and tributaries that drain to the Darling —and support opportunistic overland flow harvesting— flow only during flood events. Other times, the evaporation and seepage exceed total runoff, leaving these waterways run dry. Similar are the Warrego and Paroo rivers, which periodically join the Darling downstream of Bourke, and also run through more arid land.

The Northern Valleys are naturally more variable

Consequently, although the Darling River catchment accounts for 11 per cent of the Basin's area, it contributes less than 0.5 per cent of annual runoff into the Murray-Darling system. Moreover, because of the uncertain flow, relatively flat landscape, very high evaporation rates and predominantly summer-dominant rainfall, the Northern Valleys have not been a favoured area for public storage development. Much of the irrigation development has been privately funded. As dryness intensifies the reliability of these storages and the effectiveness of irrigation investment could suffer, exacerbating the risks to investors who follow a 'use it or lose it approach'. Recognising this variability, the cropping system has evolved around opportunistic irrigation of extensive annual crops such as cotton and cereal cropping for grain supported by irregular overland flow harvesting. Thus, pulses and dryland crops such as chickpeas, lentils and sorghum are grown under rainfed conditions.

Source: Murray–Darling Basin Authority

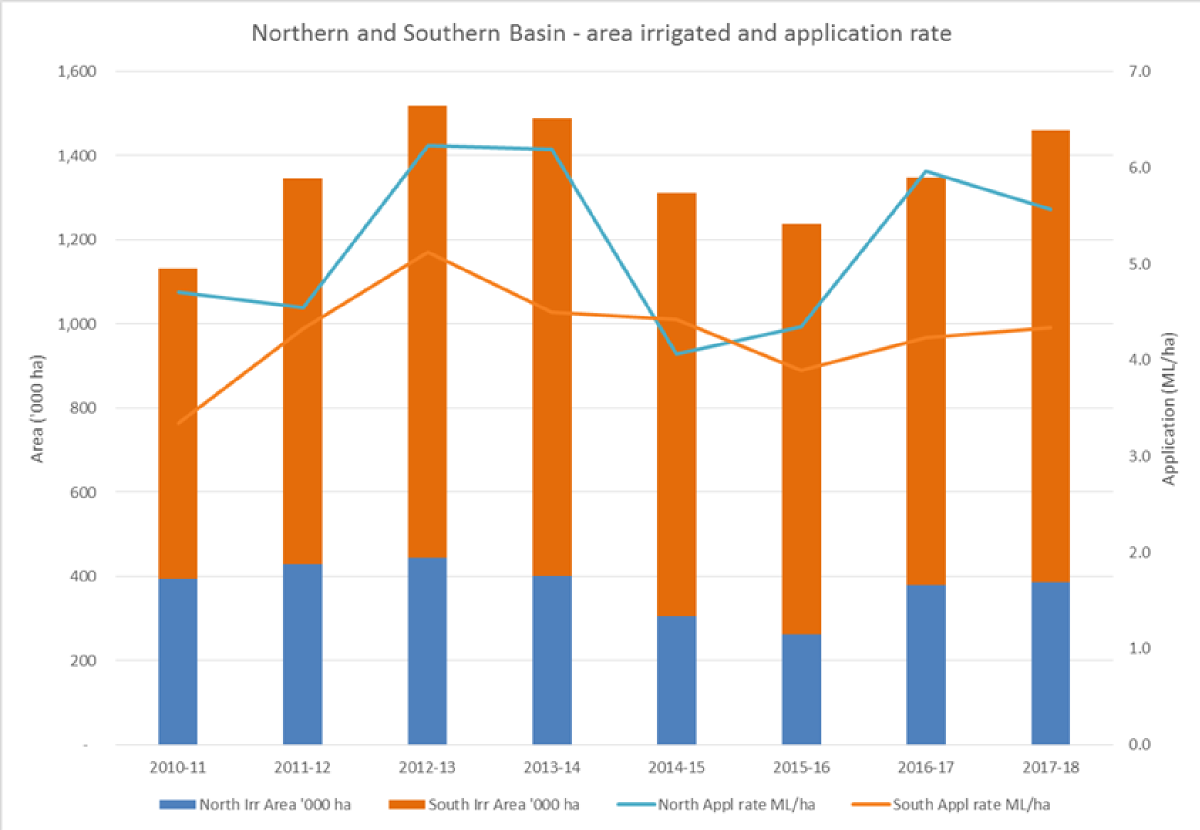
Figure 1: Map of the Murray–Darling Basin

The highland and slopes near headwaters have typically been used for limited perennial crops and pastures, along with other broadacre crops, taking advantage of relatively more favourable conditions. However, some of the vast plains have given way to larger farming operations with more extensive farm layouts and larger paddocks relative to the southern valleys. Labour saving is a key determinant of choice of technique in irrigation. Hence, although the area farmed as a proportion of landscape is similar to other parts of the Basin, the extensive nature of farming operations can lead to a wider environmental footprint during development as well as within the annual cycles of farming. The Queensland MDB Basin, for example, has some of the largest irrigation farms in the country. The proximity to subtropics also means a longer growing season, relatively higher rates of evaporation and hence higher rates of irrigation when in-season rainfall is low (Figure 2). The volume of water used in the Northern Valley since 2010-11 has varied from 22 to 43 per cent of the total annual water use in the Basin.

The relative scarcity of surface water also makes groundwater harvesting an important tool in water management, particularly on low alluvial plains, which include important habitat and hence environmental assets of national importance. Therefore, over time, as the aridity becomes more widespread with increased variability in rainfall, the Northern Valleys are more likely to experience greater competition for available water supplies between agricultural and environmental uses.

On the other hand, if those extensive land use operations were to diminish, it may lead to substantial capital losses, stranded assets and poorer communities whose income is essentially farming-related. The relatively high-input high-output intensive irrigation is highly valued by local communities that benefit from forward and upward linkages for employment and income. Therefore, under prevailing political pressure, prospects for maintaining environmental assets would naturally involve substantial income transfers from cities to regions, involving social trade-offs. Determining the nature of such transfers and how they could be used to uplift rural communities remains a more complex problem that may require considering opportunities outside agriculture[§], if risk to availability of water were to increase further.

[§] Such as largescale solar farming and expansion of tourism.



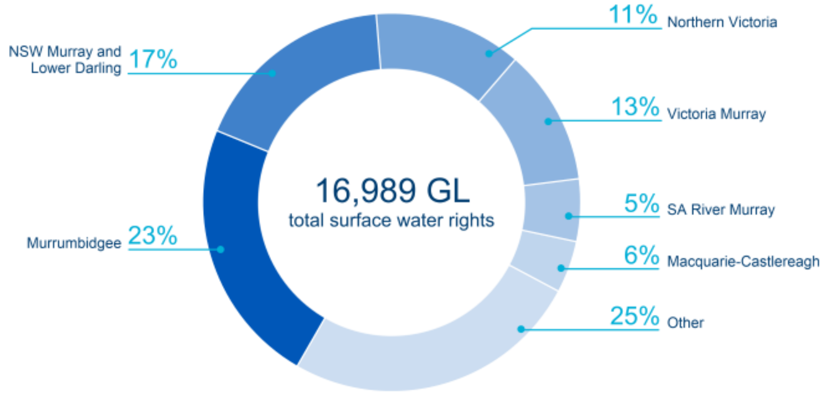
Source: Authors, based on Australian Bureau of Statistics

Figure 2: Water use in two parts of the Murray–Darling Basin, 2010-11 to 2017-18

2.3.2 The Southern Valleys

The Murray River, which runs through the southern valleys of the Basin, is much less variable due to its more even rainfall in the headwaters, including snowmelt, and a network of large storages, tunnels and dams that are designed to harvest above average precipitation during winter and autumn for use during the low water-availability season; the dry summers on the plains. Along its full-length of 2,520 kilometres, the Murray passes through a number of rural towns and cities in New South Wales, Victoria and South Australia providing an invaluable resource for agriculture, commerce, recreation and tourism. Therefore, much of the economic activity in the Basin is founded on the natural endowment of the river system, which has provided a source of habitation for many indigenous communities for over 45,000 years. This connectivity also raises significant private and public transaction costs in transboundary resource allocation negotiations.

The strong hydrological connectivity through its network of storages, channels and supporting infrastructure has meant that the bulk of the 16,989 GL surface water entitlements in the Basin are within the Southern Valleys, most of which can be reallocated through trade as supply and demand vary across seasons (Figure 3). The attendant low risk in irrigation supply means that the majority of the Basin's perennial irrigated crops and other intensive water use commodities are found in this part of the Basin. Moreover, extensive water trading has well-informed the financial opportunity costs of water, and an advanced knowledge in irrigation practices have helped avoid some on-farm externality implications, due mainly to more efficient on-farm water use owing to the high cost of water.



Source: Bureau of Meteorology (2019)

Figure 3: Surface water entitlements in the Basin

Hence, greater connectivity and a wider diversity of farm enterprises means that this portion of the Basin is relatively more resilient to unfavourable conditions. While it is not devoid of environmental concerns, with the availability of a more sophisticated infrastructure, ecological water flows can also be physically controlled to a large degree to manage such concerns. This relative high resilience may also provide greater flexibility to devise management regimes for environmental externalities, which are largely related to the much contested ongoing overallocation of the water resource. The realised high financial value of water means the opportunity costs of any reallocation would be equally high, posing greater risks for taxpayers.

2.4 Irrigation technology

Towards the turn of this century as irrigation expanded, irrigation technology and management has played a greater role in addressing issues of both supply and demand. A particular emphasis was on increasing labour productivity, and improving water use efficiency in the irrigation sector through better management systems for water conveyance, allocation and distribution (Ashton and Oliver 2012). Technologies adopted involved potential for both substitution and complementarity among activities allowing for a range of possibilities across enterprises. For example, laser levelling of irrigation paddocks allowed greater precision in flood irrigation and enhanced efficiency through controlled traffic technologies in later years, which helped gain economies of size and cost savings.

Technological change provides greater flexibility

In the pioneering days of irrigation, the location of fields and choice of crops were largely determined by the location of land adjacent to water supplies and the availability of labour. Whereas, today the technology and infrastructure has been refined to a point that irrigation systems could be installed quickly and efficiently across very large areas, with virtually no regard to contours or topography, and could be operated, monitored and maintained with minimum labour requirements.

Invariably, these changes occurred in an environment of shifting demand for farm produce, with attendant changes to farm revenue. Droughts during the past two decades have further highlighted the value to irrigators of efforts to maintain business profitability and mitigate productivity risks (Mallawaarachchi and Foster 2009, Mallawaarachchi et al. 2017). While decisions to respond to change and thereby adapting to minimize risks are made at the farm and household level, the collective impacts of such changes ultimately manifest through land use change at the Basin and catchment scale.

2.5 Land use and land use change

Agricultural income comes from both irrigation and dryland farming

Agriculture, involving both extensive dryland farming and intensive irrigated pastures and cropping, is the key primary economic activity in the Basin. In 2016–17, an estimated 88,100 commercial farm businesses operated an area of 394 million ha in Australia (ABS 2018). The Basin farm holdings were 90 million ha, operated by around 36,000 farm businesses. Out of this, 1.4 million ha (1.5%), involving one in four farm businesses (9,197) in the Basin practised irrigation. In 2016–17, these water intensive irrigated farms contributed $7.2 billion (29%) to the Basin's total gross value of agricultural output of $25 billion; whereas the land intensive dryland operations contributed $16 billion (71%). ABS data also indicate that Basin irrigation thus accounted for only 12% per cent of the total Australian agricultural production ($60.8 billion) in 2016–17. The total agricultural exports in 2016-17 were around $49 billion, and even with the high export orientation of Basin irrigation commodities such as cotton, dairy, wheat and wool, the Basin's share of national agricultural exports could not exceed 15-20 percent. While the Basin remains important for its agricultural economic activity, the public policy focus on the production value of irrigated farming has downplayed the significance of its dryland farming operations and the public good environmental impacts of irrigation.

Basin Plan introduced targets for environmental water withdrawals

A key feature of the Basin Plan introduced in 2012 by the Australian Government was to set targets for the recovery of water entitlements to restore the balance between consumptive water uses and the environment. The basin-wide water recovery target was set initially at 2,750 gigalitres but was subsequently reduced to 2,680 gigalitres in June 2018 as part of the adjustment to sustainable diversion limits.

The Australian Government has allocated $13 billion to implement the Basin Plan and associated activities, including $7.49 billion for environmental water recovery (Adamson and Loch 2018). As at 31 March 2019, 2,100 gigalitres of surface water per year has been recovered (Australian Government 2019b) at a cost of $2.36 billion on direct water entitlement purchases and over $4 billion on infrastructure projects to improve water use efficiency and partial withdrawal of entitlements in exchange (Infrastructure Australia 2019). This aspect of Basin Plan implementation has received the widest level of public criticism, raising doubts about the prospects of meeting the overall recovery target.

Basin farm numbers have fallen as the economy diversifies

In 2005–06, irrigated agriculture in the Basin accounted for 2 per cent of agricultural land use, and contributed $5.5 billion (37%) to the region's $15 billion gross value of agricultural production (GVAP). Then, the gross value of irrigated agricultural production in the Basin represented around 45 per cent of the value of Australian irrigated agricultural production and around 14 per cent of the value of total Australian agricultural production (ABARE–BRS 2010, ABS 2008). The Basin included 61,000 commercial farm businesses in 2005–06, which has fallen by 20 per cent over the past decade. A similar pattern has been observed across Australia, reflecting diverse economic opportunities and changing preferences for employment and lifestyle in an expanding economy.

Irrigation is expanding

In recent years, the irrigation footprint has expanded both within and outside the Basin. In 2016–17, Western Australia and Tasmania, where irrigation has recently expanded outside the Basin, reported higher average returns per ML of water applied ($3,601 and $3,211 respectively). This reflects the nature of these new developments, which include farm layouts amenable to new technology and management standards, and enterprises that focus on higher value commodities following the changing nature of agricultural competitiveness. As a result, non-MDB jurisdictions as a whole reported $3,050 per ML applied, compared to $1,128 per ML applied within the MDB (Table 1). This disparity points to differences in comparative advantage, the spatial and temporal distribution of irrigation returns. In that sense the adjustment in the irrigated industry has still some way to go. The factors underlying this performance would be of interest to both industry and policy-makers. A complete assessment of performance based on total factor productivity across irrigated and non-irrigated enterprises would help better explain these partial productivity data and help align policies to improve water productivity.

Table 1: Some characteristics of water use in the Murray–Darling Basin and Australia 2016-17

State/Territory	Annual water use ML/ha	Annual returns		
		per ha - dryland ($)	per ha - irrigated ($)	per ML used ($)
NSW	5.16	265	4,937	957
Victoria	3.31	1,358	7,846	2,371
Queensland	4.54	102	7,554	1,663
South Australia	3.15	146	10,446	3,321
ACT	na	448	na	na
MDB	4.71	279	5,316	1,128
Western Australia	1.84	108	6,611	3,601
Tasmania	2.47	1,062	7,933	3,211
Non-MDB	3.06	119	9,344	3,050
Australia	5.06	265	4,937	957

Source: ABS 2018, Water use on Australian farms, 2016-17
na – not reported

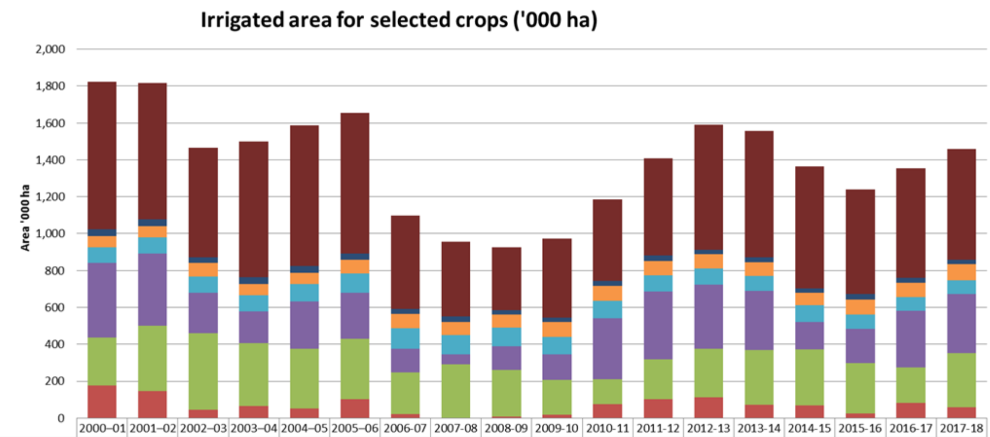
Dryland farming remains strong

Another matter of interest in the available public data is the relative importance of dryland farming operations within the Basin and elsewhere in Australia. Contrary to popular opinion, dryland farming is around two times more important than irrigation in the MDB, in terms of farm returns. Dryland returns per ha within the Basin ranged from $1,358 in Victoria to $102 in Queensland, whereas the average outside the Basin was $119 per ha (Table 1). This may point to complementary interactions between irrigated and non-irrigated enterprises such as dairy and cereal production, and other livestock and poultry.

2.5.1 Enterprise mix

The total area under irrigation since 2000–01 to 2017–18 and the relative changes in the mix of key commodities over that period is therefore of interest. Water availability with respect to volatile inflows have contributed more to the variation in annual crops —such as rice, cereals and cotton. This is expected, where irrigators adapt in line with seasonal water availability and the flexibility allowed by the production system technology in place. Overall, water use has been situated roughly in line with northern and southern Basin entitlement regimes and the annual allocations.

The area under perennial horticultural crops, primarily fruit crops and grapes as a group have remained virtually unchanged, however planting densities of some crops have increased under modern systems. Losses in grape area are being replaced with other horticultural crops such as almonds. While the total Basin irrigated area remains below the historical peaks of 2000–01 and 2001–02 there is no obvious trend for any particular commodity, except cotton, which has now become the single biggest irrigated crop in the Basin (Figure 4). It is also clear, however, that the area under certain commodities, such as almonds within the fruit and nut category, has increased significantly in recent years (refer section 2.5.4).



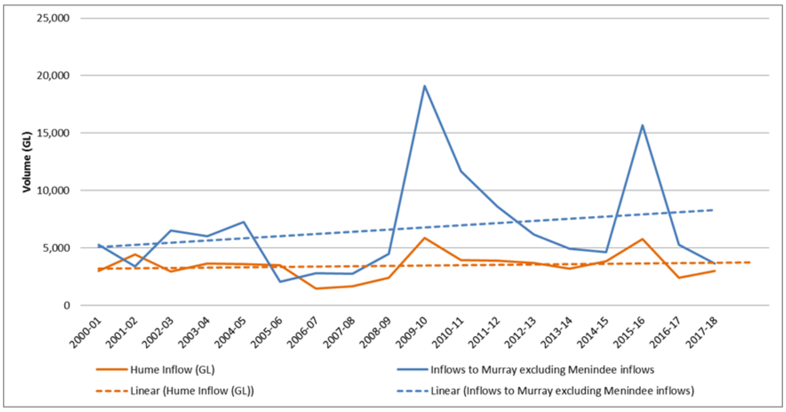
	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
Other agriculture (incl pasture & other crops)	801	741	594	736	765	763	508	405	342	429	443	529	678	685	663	564	592	601
Vegetables	37	35	31	40	35	32	26	28	25	25	29	28	24	26	24	32	28	24
Fruit (excl. grapes)	59	62	74	59	63	75	78	71	69	79	80	78	77	76	66	79	79	88
Grapes	84	86	89	87	92	106	112	106	102	96	94	89	88	79	91	79	73	74
Cotton	405	394	218	174	258	247	126	53	128	138	332	366	347	321	147	187	308	320
Cereals (excl. rice)	260	354	416	340	324	329	229	291	255	189	134	217	262	296	304	273	191	293
Rice	178	145	44	65	51	102	20	2	7	18	74	103	113	74	70	24	82	60

Source: Authors, based on Australian Bureau of Statistics, various years
(data from 2000-01 for businesses with over $5,000 estimated value of agricultural output (EVAO) 2010-11 are based on businesses with over $40,000 EVAO)

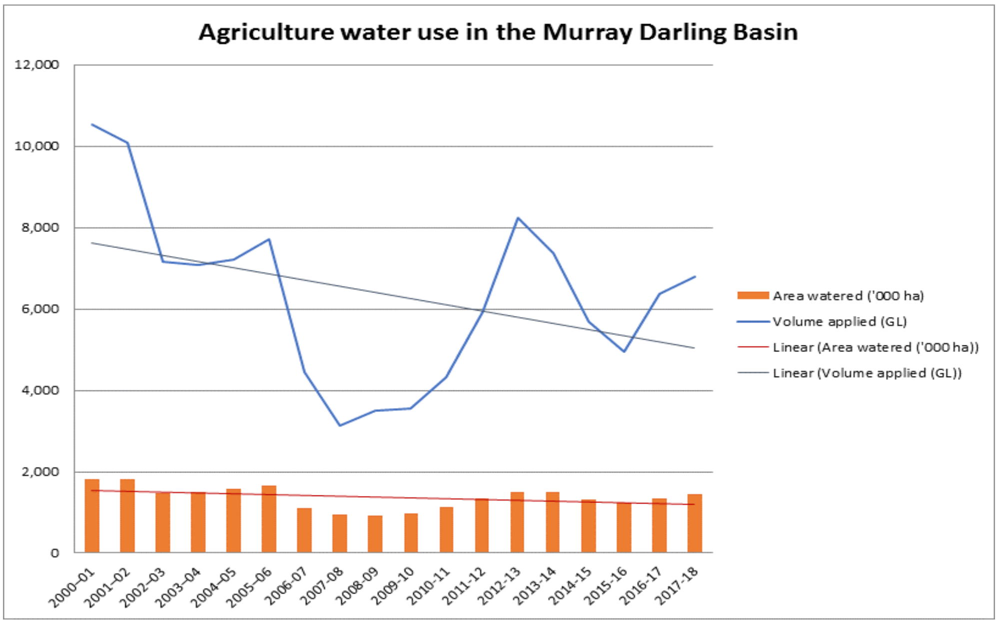
Figure 4: Area of agricultural commodities in the Basin, 2000–01 to 2017–18

2.5.2 Water use

The pattern of water use in the Basin has been a key issue of contention and the driver of policy change. After 2000–01 Basin water use fell sharply, culminating in a historical low in 2007–08 as inflows to the system and water availability in storages fell with the severity of the drought (Figure 5). The recovery in storages and adaptations by irrigators helped water use recover in 2008–09 to peak in 2012–13, which fell marginally until 2015–16 and recovered slightly thereafter. Incidentally, the most recent decline occurred around 2012, the year in which the Basin Plan was introduced. The uncertainly surrounding reform and the purchase of environmental water may have contributed to irrigators' decisions. A closer look at the trend suggests that the lagged effects of declining inflows and increased carry-over volumes may have also been a cause (Hughes, Gupta and Rathakumar 2016).



Panel a: Selected inflows to Murray, excluding into Menindee, 2000-01 to 2017-18



Source: Panel a- Murray–Darling Basin Authority; Panel b- Authors, based on Australian Bureau of Statistics, various years (data from 2010-11 refers to farm businesses with over $40,000 EVAO)

Panel b: Agricultural water use, 2000-01 to 2017-18

Figure 5: Annual Water supply and use pattern 2000-01 to 2017-18, Total Murray–Darling Basin

In any case, over the past two decades, the general trend in inflows has been slightly upwards, while that of agricultural water use in terms of both areas irrigated and the volume of water applied follows a downward trend. If that is to be sustained, then the residual user, the environment may also get an increasing share, albeit more slowly (Bureau of Meteorology 2019). This is consistent with the intent of policy reform—to direct water use along a long-term sustainable path. However, behind these aggregate outcomes, there may be shocks that could risk achieving the desired benefit, notably the effects of prolonged droughts and political responses to such episodes that take the focus off longer-term objectives.

2.6 Understanding directions

There is no single factor that drives the water use pattern in the Basin. The emphasis on water use as the sole focus of inquiry in discussions of water policy is largely misplaced. Being a derived demand, the observed pattern reflects factors that underpin the demand for water-derived goods and services, the evolving nature of the Australian agricultural economy, and its international links. Managing this demand with variable supplies involves a myriad of decisions, made by around 10,000 irrigators and numerous river managers each year, based primarily on trial and error. In broad terms, they can be influenced by:

a) *Water availability*. The primary factor that influences these decisions is water availability. For the Southern Basin, it is driven by flows to storages such as Hume, and into the River Murray from various tributaries, often with lag effects as storages are released over time (Figure 5, panel a).
b) *Water entitlements.* The second factor that determines water use patterns is the mix of different entitlement types, or water access licences, that have different levels of reliability attached to them.
    I. Traditionally, horticultural properties were associated with high reliability entitlements, whereas broadacre properties, such as rice in Murrumbidgee, were supplied with general (low) security water entitlements.
    II. Together, they provided a means to manage seasonal water supply variability allowing switching over to annual crops when water was abundant, but maintaining secure supplies to perennial crops across all seasons.
    III. With advances in technology and extensive water trading the spatial and economic organisation of farms has changed.
c) *Water trade.* Water trading offers an opportunity to balance seasonal water demand and supply, and given the complexity due to b) above, to build portfolios of entitlements to reflect perceived risks in an irrigation business. Yet, water trading is unreliable in determining *social opportunity costs* (Quiggin 2019), and market allocations may run the risk of exacerbating externalities.
d) *Productive efficiency.* Improvements in technology and shifts in market demand for commodities affect on-farm water use. Technological change, such as advanced soil moisture monitoring and precision application can alter water application rates, allowing expansion of area without increases in total water use. Similarly, changes in planting densities may increase the application rate per ha, but with increased crop yields and reduced costs. These and other management and technology practices interact with market demand and factor costs to alter land use patterns, inducing farm adjustment over time. The observed fall in Basin farm numbers, by 40 percent over the past decade, is indicative of such influences.
e) *Conveyance water.* Environmental water purchases and releases also influence the mix and the quantity of water access entitlements available to a region. Indirectly, environmental water releases can offer opportunities for irrigators to 'piggy back', or enjoy complementary benefits, as the general availability of water in the system increases. Environmental water purchases also provide opportunities for irrigators to realise capital gains.
f) *Government policies*. Government interventions, such as the on-farm irrigation infrastructure investment program and investments that address capacity constraints in the system, and rules such as carry-over provisions which alter consumption patterns, have enabled licence holders to postpone current year consumption to subsequent years.
g) *Climate variation and uncertainty*. Climate conditions influence seasonal water demand as well as strategic behaviour of irrigators, through responses to risks

associated with shifts in climate averages, or, climate change. This impact has been somewhat more pronounced in the Northern Basin. It's summer-dominant rainfall pattern, an opportunistic reliance on annual water harvesting, the recent declines in the rainfall patterns post 1990, and the relative absence of large storages to regulate supplies across seasons are the contributing factors. More focused work will inform the degree of influence of these factors over different time frames of analyses.

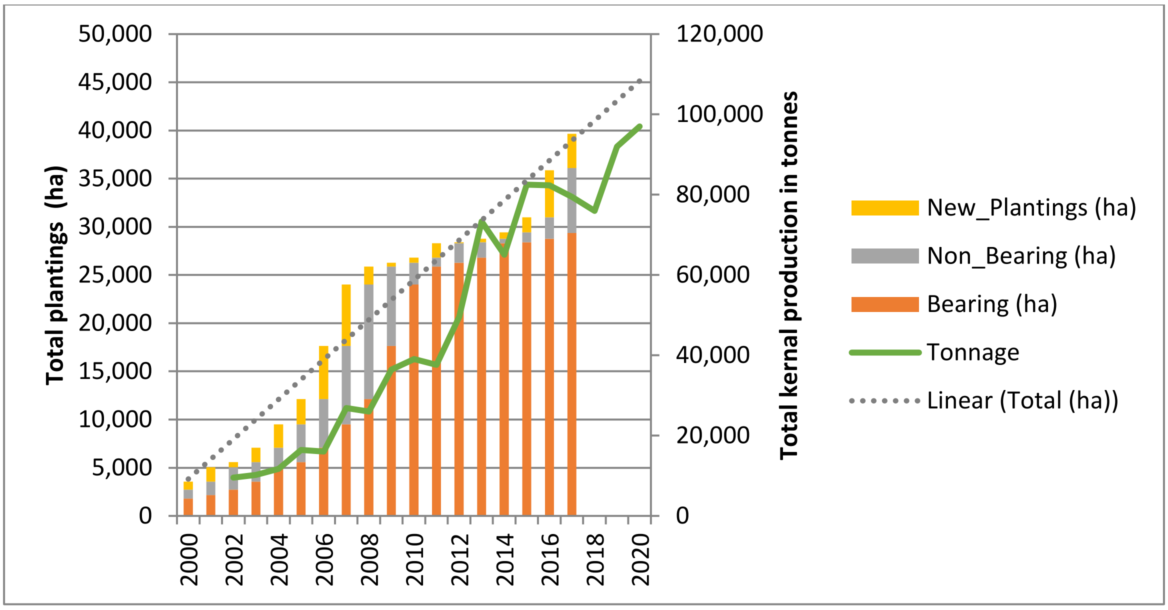
2.6.1 Almonds Case Study

The confluence of factors indicated above can be seen in the development of the almond industry in Australia since 1987. The growth in the Australian almond industry has been strongly driven by corporate investment, most significantly through Managed Investment Schemes (MIS) during the 2002–2008 growth spurt (Almond Board of Australia 2008), (Figure 6). The MIS was a regulatory framework for collective investments implemented in 1998 to protect investors in the aftermath of the financial deregulation of the 1980s. The framework offered personal taxation incentives to investors, providing a means to reduce personal costs of longer-term investments such as in forestry and horticulture (Australian Treasury 2008).

Despite recurring droughts and the collapse of MIS, the Australian Almond industry has grown to become the second largest producer of almonds in the world, behind USA. In 2018, the area under production was 39,662 ha —producing a harvest of 79,461 tonnes, behind a record crop of 82,509 tonnes in 2015–16 (Figure 4).

Almonds are grown along the Murray Valley in South Australia, Sunraysia in Victoria and Riverina in New South Wales (97%), and the Swan Valley in Western Australia (3%). Much of the almond plantings in the Southern Murray-Darling Basin are in established irrigation areas, with some new plantings established on adjacent greenfield sites. A key feature of these developments is that they are all in well-laid out blocks with improved varieties, advanced irrigation facilities catering for advanced plant nutrition and agronomic management to support higher average yields. As a latecomer, the industry has benefited from technological advancement over the past decade.

Although perennial crops such as almonds can be vulnerable to changes in water availability, those businesses with high security water entitlements and access to water trading have achieved a high-degree of adaptive capacity under changing water availability conditions. With highly mechanised large-scale orchards, modern processing facilities, and industry and government-backed R&D, the industry is experiencing a period of significant expansion.



Source: Authors, based on data from Almond Board of Australia

Figure 6: Australian almond production area, 2002 to 2018

Over the medium term, the industry plans to increase the orchard area to around 50,000 hectares, bringing Australia's productive capacity to 150,000 tonnes with a forecast farmgate revenue of more than $1 billion. Almond export revenue in 2017-18 was $429 million, a slight drop from $469 million in the prior year (Almond Board of Australia 2019, 2018), which is expected to grow over the medium term consistent with demand from consumers in markets with rising living standards and earning capacities.

The recent California drought raised concerns about the sustainability of water use in almond production in the US (Reisman 2019). However, projected minimum water requirements of around 250 Gigalitres for Australian almonds would be well within the historical availability of high security water and the capacity of the water market to handle in situations of limited water availability. This is so even considering the area of other perennial crops, as the water use in this group has remained below 25per cent of the total water use at all times (Figure 6). Furthermore, the industry is located within the southern connected Basin with good access to water trading at a stretch of the Murray River with reliable flow. It means even those who rely on general security water could manage with water allocation trade during times of shortage and adapt in the long run with strategic purchases of high security water entitlements. Although water demand for perennial crops can be price inelastic, the largely downstream growing location may increase risks to other irrigators, as physical restrictions, such as the Barmah choke, may influence water availability during peak demand.

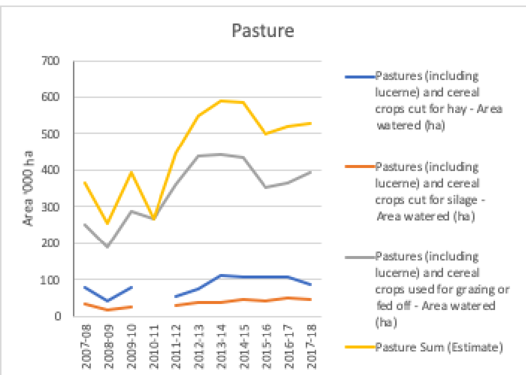
2.6.2 Extensive water use commodities and risk management

Pastures for fodder production, irrigated wheat, rice and cotton have traditionally been regarded as heavy water users amongst Australian irrigated commodities. As stated earlier, that trend followed the nature of irrigation licences, where these broadacre crops were grown on land associated with low security water entitlements.

For example, historical ABS data suggests that in 2000–01, dairy, pastures, rice, other cereals and cotton collectively used 85 per cent (8,995 GL) of the estimated 10,516 GL of water used in the Basin. This level of use remained in place to 2005–06, where the estimated water use by this group of commodities fell slightly to 80 per cent (6,179GL) and the total water use fell sharply to 7,720GL. However, with the separation of land and water entitlements and flexibility in infrastructure, irrigators have greater freedom to relocate production, considering other factors such as scale that affect management. For instance, while irrigated pastures remain integral to dairy farming, recent adaptations to market conditions, technology and climate variability have seen dairy farmers using a range of feeding strategies to remain viable, or relocating or leaving dairy altogether. Most producers use a combination of grazing, cut forage (hay and silage) and concentrate feeding (Mallawaarachchi et al. 2017). Irrigated dairy farming in the Basin is undergoing significant change, and similar risk management strategies would continue to be used in adapting to uncertainty. While adaptation to climate may not be a conscious decision, the fact that farmers are adapting new technologies and business management practices means that they are indirectly adapting to climate change, in ways consistent with economic theory.

Similarly, those large water use commodities, such as cotton, rice and other cereals are often grown as part of a rotation system. Hence it is difficult to apportion available data to a particular use or licence type, as has been done in the past. It is generally the case that water use systems have evolved significantly to adapt to the evolving policy, technological and market environment in ways to maximise returns on investment.

On the other hand, although grown extensively, some non-food crop enterprises, such as cotton are managed with high-intensity production methods, also involving widespread use of agricultural chemicals. While their use is subjected to regulatory standards, it will be harder for those industries to maintain a social licence, unless the impact of such extensive uses can be justified to a diverse population, particularly when production moves into areas traditionally used for food production. Hence, the recent rapid expansion in the cotton industry, in particular in the Murrumbidgee valley with a high proportion of low security water entitlements, raises sustainability questions. Such expansion could increase the risk of failure if dry conditions were to continue over consecutive years. And, depending on the nature of land use they replace, and the management protocols used for containing environmental impacts, they also have the potential to add externality risks to production system in the Basin. The relatively high realised financial value of water in food producing enterprises in downstream catchments could intensify such conflicts, raising additional questions about the Basin’s ability manage transboundary allocation issues and hence optimise social benefits of water use.



Source: Australian Bureau of Statistics, various years

Figure 7: Irrigated pasture production Murray-Darling Basin, 2007-08 to 2007-2018

Irrigators have shown an ability to diversify into new commodities with better prospects for managing risks. The Australian fodder industry is a case in point. Australian fodder exports have grown steadily over the past decade, and the production has also risen steadily (Figure 7). The export volume reached 936,000 tonnes in 2015 with an estimated value of $383 million (Australian Fodder Industry Association 2016). As fodder is a storable commodity, they can take advantage of seasons with high water availability to grow large areas and use precision technologies to manage crops in low availability seasons to achieve a higher return over a planning period. From 2008-09 in particular, the total area under irrigated fodder saw a steady increase. This would have eased pressure on dairy farmers as they were coming out of the drought. Industry capacity for hay and silage processing has also helped utilise failed cereal crops as hay in dryland areas when rainfall failed to arrive as expected. The significant proportion of cereal crops harvested for fodder in some years confirms this observation. As uncertainty in rainfall increases, complementarities between irrigated and dryland farming will become even more pronounced and important.

More detailed analysis at regional scales from catchments, states and the Basin could highlight complementarities among different uses, and would offer greater insights as to how these systems will adapt to changing preferences for agriculture, market conditions and the risk of more frequent and severe droughts and less frequent but more intense floods. It is the responsibility of governments to provide independent assessments, as information asymmetry will drive claims and counter claims by interested parties, which undermine community confidence. Further, the history of government intervention indicates that any risk of failure from individual action will be borne by the public, exposing taxpayers to increasing risks.

3 Economic issues in water governance

3.1 Historical context

Water access and use decisions are best understood in terms of the political economy of resource governance—concerning arrangements for appropriating natural assets for social gain. The central problem has been to recognise the specific context that regulates the level of effort to appropriate the ecosystem potential in a given locality. This effort has been influenced by the nature of the ecosystem itself, and the desires of the community to benefit from such appropriation, which in turn have influenced the skill and ingenuity applied in safeguarding the flow of benefits over time. Various modalities have been used to augment the resource and coordinate behaviours amongst members of a community; not only for appropriating benefits, but also for care and maintenance. Indeed, they later emerged to be the supporting governance institutions that have variously influenced the success or otherwise of those communities. Conflicts arise when individuals' desires for profiting from exclusive use undermine the collective desires of the community to derive well-being from collective uses that include both extraction and reservation. History offers many lessons.

The ability to take water from natural supplies enabled progressive civilisation, initially across river valleys with plentiful and continual supplies of water. Early systems in the river valleys of the Nile, Indus and Ganges, for example, bear testimony to the hydraulic civilisations that Karl A. Wittfogel proclaimed in his seminal work *Oriental Despotism* (1957). The success of those ancient systems drew on skills in cooperative water management, derived through coercive governance, for the majority benefit (Hassan 2003, Alvares 2008). Some such systems, dating as far back as the 3rd century B.C. but still in service in the valleys of the Sri Lanka Dry Zone (Brohier 2016), testify to the resilience achievable through good design and social coordination to reconcile private interest and social values (Ostrom et al. 1999). As one reviewer pointed out, "[T]he authoritarian tradition of irrigation in earlier centuries and societies identified by, and with, Wittfogel has plenty of support in Australian irrigation experience". The difficulties the Basin Plan has faced in meeting social objectives of water governance is largely symptomatic of the failure of modern societies to reconcile the acclaimed powers of market coordination with the cooperation required to build functional societies.

3.1.1 From a free good to regulated access

The evolution of water governance in the Murray–Darling Basin since Australian Federation[**], reveals a long series of attempts to allocate a 'free' natural endowment to create private economic opportunities and ensuing social surplus (See for example, Gross 2014, Musgrave 2008). Prior to Federation in 1901, pastoralism and gold mining were the dominant economic activities. With abundant land, and a growing European population, agricultural expansion occurred as a natural choice, rapidly displacing indigenous forms of land use.

Conflicts over water use, arising from land degradation related to mining activity, led early colonial governments in New South Wales and later in Victoria, to introduce 'water privileges' as early as the 1860s. In New South Wales, *The Goldfields Act of 1861*, provided rights over specified quantities of water for mining activities either from approved diversions or from rivers (O'Gorman 2012).

However, granting of exclusive rights to one sector meant that the rights were simultaneously withheld from other users, such as pastoralists and Aboriginal people. Hence, the notion of public good, with characteristic non-exclusivity in access and non-rivalry in consumption no longer applied to water. Rather, water became a common-property resource, whose access was specified and regulated through government legislation and investment programs. While river water was placed under the category of public utility and hence under government controls, water rights became a "means for exercising political and social exclusion, as well as acquiring economic advantage" (O'Gorman 2012, p. 88). This trend continues to this date.

3.1.2 Engineering solutions for expansion

Engineering feats, such as the Hume Dam completed in 1936 during the years following World War I, and the Snowy Mountains Hydro-Electric Scheme built between 1949 and 1974, provided the basis for expansion in irrigation and the establishment of settlements for returning soldiers. During this early phase, the social cost of expanding water use was low (Watson and Rose 1980, Randall 1981). Moreover, the impression that water was cheap and abundant led successive governments to expand irrigation. However, water use externalities, such as the onset of rising water tables and salinity caused by a combination of relatively wet climate, cheap water, and the dominant furrow irrigation technology during the period leading to 1990s, pointed to the growing public costs of high levels or water extraction. Coupled with the rising maintenance costs of ageing public irrigation infrastructure, governments were pressured to consider ways to curtail continued expansion. Concerns about over use in agriculture in particular prompted economists to advocate pricing and marketable

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[**] Historians have shown that Indigenous Australians, the Aboriginal people, who derived livelihoods from nature harvesting, organized the landscape so as to make those resources predictable. ABC Australia. 2014. Rethinking Indigenous Australia's agricultural past. Australian Broadcasting Corporation (ABC), Gammage, B. 2012. *The Biggest Estate on Earth: How Aborigines made Australia*. Allen and Unwin, Pascoe, B. 2014. *Dark emu: black seeds: agriculture or accident?* Broome, Western Australia: Magabala Books Aboriginal.

water rights systems, in an effort to improve equity and efficiency in the allocation and use of water (Randall 1981, Watson and Rose 1980).

3.1.3 Accommodating multiple use

By the early 1990s, Basin communities who are invariably reliant on irrigated agricultural industries, and those dependent on non-consumptive uses such as tourism and riverine livelihoods including fishing were torn between opposing groups, but both remained keen to support solutions that secured irrigation. For example, irrigation salinity and rising water tables attracted popular support, primarily to safeguard the irrigation investments and potable water needs of downstream users (Quiggin 1988). However, recurring environmental problems such as the blue-green algal blooms and fish kills in the Darling River brought intermittent public attention, including those residing outside the Basin.

In more recent years, improved knowledge and a growing appreciation that global warming may have altered the frequency and intensity of precipitation, temperature and hence the spatial distribution of water availability instream and on land, have highlighted that agriculture is becoming more vulnerable both to climatic variation and changing social values and expectations. Hence it has become crucial to focus on adapting land and water use systems to changing circumstances, characterised by an uncertain environment where reduced availability and high cost of securing water could make some agricultural systems economically unattractive.

3.1.4 False conceptualisation

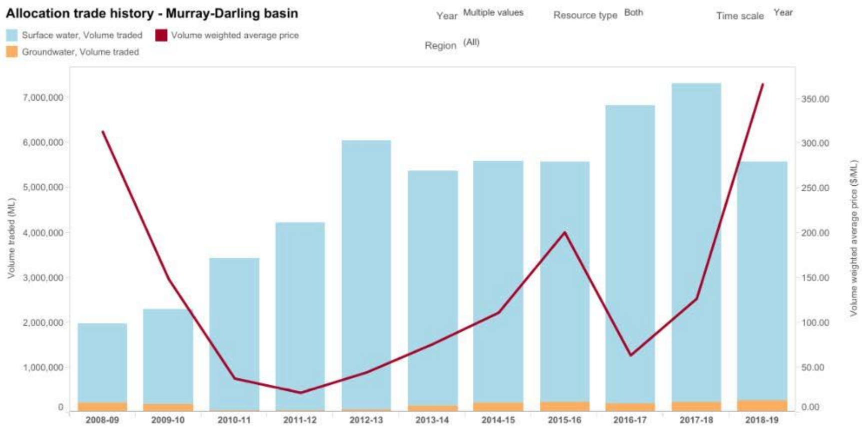
Fundamentally, though, many policy makers failed to see the emerging resource use conflicts as a natural consequence of growing environmental concerns, where the widening consumption bundle included goods and services derived from nature. Rather, preferences for the environment were seen as a threat to traditional users of natural resources such as agriculture, and more specifically irrigation in the case of water. This myopia drove conflict between government departments concerned with the environment and the provision of public environmental services, and the departments of primary industries, whose concerns were to protect the interests of agriculture, forestry and fisheries. Possibilities for gains from exchange in maximising social well-being were lost in battles for supremacy, in which lobby groups fought to maximise their share of the resource.

The resultant complex and contested policy process helped escalate the conflict rather than reassure the public of opportunities for collaboration. Further, as climate change has become a significant external force—with growing consequences for both the environment and agriculture—the inadequacy of policy frameworks has become more evident. A key issue in this setting is determining the appropriate role for governments in supporting adaptation to minimise losses in irrigation and to safeguard vital environmental assets that are facing unprecedented change beyond their evolutionary experience.

3.2 Restoring social coordination through market-led allocations

A move towards water governance through market mechanisms has been the primary focus in Australian water policy reform. However, the process has been challenging, slow and contested (McKay 2005, Crase, Pagan and Dollery 2004). Water trading commenced in the 1980s with the introduction of limited water sales in Victoria, which expanded with the introduction of the National Competition Policy in the early 1990s. Early modelling pointed to advantages in trade in reducing overuse, freeing up capital, minimising the risk of salting and waterlogging, and the potential to equate on-farm opportunity costs with the social cost of water (Hall, Mallawaarachchi and Batterham 1991).

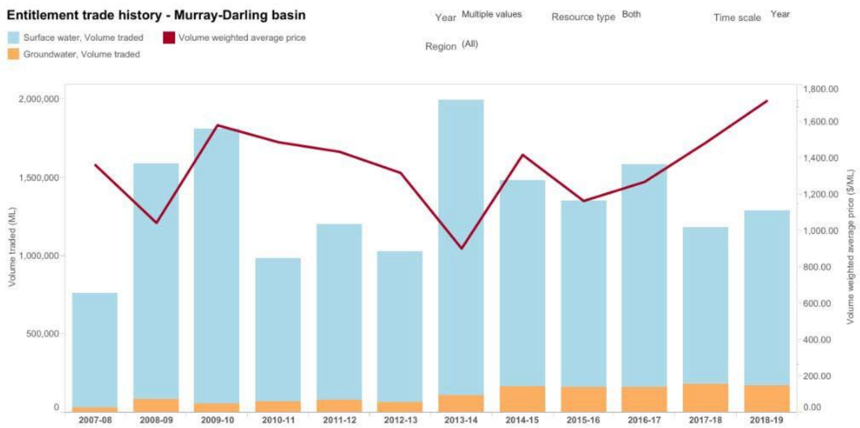
The demand for, and benefits of, trade grew with the separation of water access entitlements from land titles (ABS 2006). The ability to trade water became a key lever of structural reform in the irrigation industry, allowing the spread of irrigation beyond traditional locations and altering the crop mix towards higher value uses (Figure 4).



Allocation trade summary - Murray-Darling basin

Resource type	Region	Trades	Volume (ML)	MAX ($/ML)	MIN ($/ML)	VWAP ($/ML)	PTWP (%)
Groundwater	-	6,729	1,703,890	1,000.00	5.00	74.98	60.3%
Surface water	Northern MDB	9,752	3,734,738	1,000.00	5.00	182.05	43.3%
	Southern MDB	239,960	48,701,773	1,000.00	5.00	137.14	54.0%
OVERALL		**256,441**	**54,140,401**	**1,000.00**	**5.00**	**135.08**	**53.8%**

Minimum of 10 trades needed to calculate pricing values
VWAP: Volume weighted average price
PTWP: Percentage of trades with pricing reported



Entitlement trade summary - Murray-Darling basin

Resource type	Region	Trades	Volume (ML)	Max ($/ML)	Min ($/ML)	VWAP ($/ML)	PTWP (%)
Groundwater	-	5,315	1,317,974	6,000.00	50.00	1,247.55	32.9%
Surface water	Northern MDB	4,819	5,107,621	6,000.00	50.00	1,226.17	38.2%
	Southern MDB	55,815	9,840,303	6,000.00	50.00	1,388.41	55.8%
OVERALL		**65,949**	**16,265,898**	**6,000.00**	**50.00**	**1,331.70**	**52.7%**

Minimum of 10 trades needed to calculate pricing values
VWAP: Volume weighted average price
PTWP: Percentage of trades with pricing reported

Source: Bureau of Meteorology (2019)

Figure 8: Water trading, Murray-Darling Basin 2007-08 to 2018-19

Progressive reform has facilitated water trade, making trade more beneficial to participants in those transactions (Loch, Wheeler and Settre 2018). Australian water markets, with an estimated turnover of $1–2 billion annually, has thus become an integral part of managing water scarcity—particularly seasonal risks and droughts—while also creating efficiency gains (Brooks and Harris 2008), (Figure 8). Recent analysis of historical price movements suggest that the water allocation market is also taking a more strategic role and becoming more forward looking, in the sense that market prices are increasingly dependent on expectations about water availability in future seasons (Hughes et al. 2016). Yet these expectations seem to only concern private benefits, which leaves governments with the responsibility to address any social costs of resultant allocation decisions.

3.2.1 Water trading has failed to account for externalities

As Freebairn and Quiggin (2006) noted, most extractive uses of water by households, industry and government have private-good properties of rival consumption and low costs of exclusion, and therefore are readily amenable to market allocation. By contrast, many of the values to society derived from environmental and heritage services associated with water have public good properties, whether in natural settings or where provided by explicit environmental water allocations. Hence, their benefits will remain diffused to consumers, although their social value will rise with relative scarcity.

On the other hand, the price of goods and services derived from extractive uses that are traded in competitive markets will also likely rise with decreasing water supply, implying rising prices for water in extractive uses. Hence, unregulated markets will likely allocate too little water for environmental flows (Freebairn 2003). Although water trading will certainly signal opportunity costs amongst agricultural enterprises, the externality costs are not factored in water trade decisions due to inadequacies in the design of property rights (Adamson, Mallawaarachchi and Quiggin 2006, Dwyer et al. 2006). Hence, water trading alone will be inadequate as a mechanism to address externality issues of rising water scarcity.

In particular, policies that assign exclusive rights to individuals and firms also contribute to undesirable impacts on the collective welfare of society (Heaney et al. 2006). For example, the separation of water entitlements from land failed to account for a number of characteristics that were implicit in the joint right. This has given rise to a number of third-party effects as water is traded in an incomplete market (Heaney et al. 2006, ABC Australia 2014, Gross 2014).

Essentially, from a social welfare perspective, as drawn out from Coase’s (1960) initial exposition, the only social costs related to natural resource allocations are those to do with public goods and externalities. They also prevent allocations tending towards equilibrium prices and quantities. In the consideration of economic trade-offs at the production-environmental interface, missing clarity in analytical approaches have often contributed to much ambiguity. Notably, policy strategies including targeted instruments to internalise water use externalities (Young and McColl 2002), have not been fully implemented. Although, water rights systems have matured, including the specification of low and high security rights, access, delivery and use rights of various complexity, water trading remains an instrument that primarily facilitates extractive uses.

Furthermore, charges and other conditions of water delivery are yet to reflect relative scarcity and third-party effects that vary with time, region, location, capacity utilisation, seepage and evaporation rates, etc. These are gaining more currency with increasing supply variability and demand pressure associated with climate change and industry expansion (Kiem 2013, Loch et al. 2013). Yet, local resource characteristics—the features of the ecosystem, and demand patterns and supply constraints that inform the nature and severity of likely third-party effects, are often not considered in water transactions. Ultimately, efforts to maximise basin scale outcomes and efficiency gains through trade receive priority over potential losses through third-party effects. This again highlights the nature of trade-offs and the difficulty in coordinating desired outcomes at cascading scales. Some of these problems may be illustrated with reference to drip irrigation and laser levelling. These innovations improved water productivity and created opportunities for trade within the agricultural sector. However, they reduced return flows from irrigation to the river system, thereby increasing effective extractions.

3.3 Water resource planning

From an economic policy perspective, demand is best managed through the price system. Yet, price systems function only when economic transactions work to convey relative scarcity—the opportunity costs in resource use. In Australia, urban water supply remains largely in the hands of regulated monopolies, directed to adopt full-cost recovery pricing. For rural water, bulk water allocations follow mandated partial cost recovery, within a system of capped diversions. Those diversion limits are best designed following resource audits that inform prior use patterns, resource availability trends and likely patterns of uninterrupted growth. Only then, will they provide a useful mechanism to design regional water management plans consistent with negotiated, multiple use objectives, thereby reflecting the intents of national reform.

Once the parameters for sustainable, long-term management are agreed upon, economic instruments such as market trading of water rights and annual allocations could become effective tools in meeting strategic and operational water needs, respectively, for extractive needs of private developers, and to a lesser degree, between extractive users and the environment. Expansion of extractive uses will then become possible, subject to individual users acquiring an appropriate water entitlement from the extractive pool, via market trading, or economising an existing right through technological improvement.

Catchment scale water resource plans, are a key aspect of the *Water Act* and the implementation of the Basin Plan. However, as other analyses have noted, this aspect of implementation has run below expectations, leaving room for public criticism and inefficiency in public outcomes. In particular, the Productivity Commission review of the Basin Plan implementation (Productivity Commission 2018) and the New South Wales Government review of the Barwon-Darling Draft water sharing plan (Natural Resources Commission 2019) point to deficiencies in planning and implementation that could lead to poor ecological, social and cultural outcomes. Thus, the *Water Act 2007*, and the Basin Plan process that followed, has failed to provide an intended culmination to the long drawn out reform process. Conversely, the rejection of the Basin Plan by irrigator groups and the continuing push for its abandonment has left the main problems unresolved.

3.3.1 Plans need to guide adaptation

As droughts, irrigator obstruction and political imperatives complicate planning, the balance in water governance has deviated from longer-term objectives of adaptation to shorter-term activities for mitigating sectoral impacts. In this context, an alternative approach based on regional-scale arrangements may be required to address the conflict and the remaining externality agenda in future water reform.

3.3.2 Linking to regions where it matters most

Resource use planning provides a basis to allocate water between competing uses. It can also act as a reliable means to assess cost-effective ways for water recovery, paying closer attention to local environmental needs and physical barriers for water transfer (Adamson et al. 2009). Moreover, public negotiations, informed by competing interests and supported through independent analysis, can add clarity to planning processes and offer a collective basis to muster local public support for withdrawing water rights for the environment. Transparent planning processes can help identify diffused and distant public benefits of the environment to compare against more noticeable and near-term benefits of irrigation and land development.

Thus, well-designed regionally informed planning offers a pluralistic approach to managing conflicts involving trade-offs between production and environmental values, which appears to sit at the centre of public discourse related to Basin water management. Planning that promotes a partnership approach can also build closer ties with civil society organisations, especially at the regional and local levels, and stimulate a culture of water stewardship and proactive adaptation to minimise the regulatory burden for governments.

3.4 Principal-agent problems can increase costs

Principal-agent problems are common in public policy design. Information asymmetry—connected to both hidden knowledge, and hidden action— can distort decisions, deviating them from optimal choices, and leading to omissions that create public costs (Chambers 2002).

Since 1988, Australian ministers in charge of natural resources were aware of the need to cease additional diversions for irrigation. But action eventually came in 1994, after Basin water consumption reached unprecedented levels and growing demands were placed on increased access to groundwater. Unfortunately, design omissions or lapses in policy sequencing effectively weakened the bargaining position of Australian taxpayers, making subsequent policy corrections harder to accomplish.

The first omission occurred when a cap on Basin water extractions was introduced in 1994. The decision on quantitative restrictions led the NSW Government to activate unused ‘sleeper’ or ‘dozer’ licences. The suggested motive was fear of litigation (Kerin 2017, p 565). However, the effect was to greatly enhance the value of these licences, which were previously not tradeable. The mishandling of this reform created an opportunity for a segment of the population to make windfall profits in scarcity rents, while diluting the impact of the cap, as demand for diversions grew with new prospects for trading water now unbundled from the land. Compounding this, governments also agreed to grant the water rights to prior licence holders, effectively granting perpetual capital transfers to irrigators. The better approach would have been to first abolish unused licences and then introduce quantitative restrictions, the Cap. It would then have been possible to undertake a resource audit to reallocate existing water licences as a rights system, thus providing an equitable basis to achieve efficiency gains through water markets, as they developed.

In combination, these two mistakes have cost taxpayers billions of dollars in money now set aside for withdrawing rights from irrigators to restore water for environmental needs. Benefits to the environment now come at the expense of potential cuts to other government programs, or increased public debt, which represents the opportunity cost of public funds contributed through tax revenue.

Similar principal-agent problems arise in many cases of delegated responsibility, and the ability of policy mechanisms to circumvent such possibilities presents a key source of building trust and confidence in public decisions. For instance, mechanism design—a key tool in behavioural economics derived upon social norms and economic incentives—can thus be used effectively to enhance the economic efficiency and social net benefits in collective interactions. The approach works best when the nature of risks in decisions and influence pathways are understood so that appropriate safeguards in terms of deterrents, incentives and revelation mechanisms can be incorporated to tackle hidden action and hidden knowledge. When dealing with externalities, information mechanisms can help mediate conflicts by resolving individual differences and biases in understanding, such as through the provision of prior information that reduces the difficulty in making complex choices under uncertainty (McFadden 2009).

3.5 Understanding uncertainty and risk

The terms 'uncertainty' and 'risk' have been used in different ways in the literature in relation to making choices. Informally, 'risk' is often used to refer to the possibility of an unfavourable outcome. In the decision theoretic literature, this possibility is commonly referred to as 'downside risk'. The more commonly used definition begins with a well-defined set of possible states of nature—the conditions that predispose an outcome to be favourable or unfavourable.

Decisions are risky in this sense to the extent they involve possibilities of failure. The future is inherently uncertain as it involves unforeseen possibilities and hence unknown distributions of costs and benefits over time and space that variously affect parties to decisions. Government decisions invariably influence the allocation of resources with implications for private economic returns and the determination of social benefits. And, in the presence of uncertainty, consideration of costs and benefits in decisions becomes complicated, controversial and often at odds with the political imperatives of governments.

State variables—those measures that we can only observe, but cannot change within a decision cycle—define the 'nature' of the system, giving rise to different 'management options' (a production possibility set) that can be employed to achieve different outcomes (consumption bundles) under different states of 'nature'. The domain that is defined by the possible states of nature and the management options gives rise to a subset of 'manageable configurations' that would yield a set of 'state-contingent' outcome bundles.

For example, Adamson et al. (2007) MDB modelling, consider High, Normal and Low levels of inflow to the system. In this logic, water availability in a 'dry year,' where the rainfall (and other forms of precipitation) in the Basin is in the lower portion of its historical distribution could be associated with an 'unfavourable' outcome. Similarly, water availability in a 'wet year' where rainfall is in the upper portion of its distribution would lead to a 'favourable' outcome, when measured against the historical average of rainfall, designated by its arithmetic mean. This rating of utility relates to the additional management effort required to achieve a desired outcome under each natural state, measured against prior experience. The basis of management is to minimise exposure to unfavourable states of nature, by choosing within a set of feasible actions. The feasibility is defined by the expendable effort, or the budget constraint, or actual physical availability of an input. Hence, variations in states of nature define the level of absolute scarcity—the physical limit of availability. Then, the stock of knowledge and other resources available determine the subset of feasible action, or the production possibility set, to achieve a desired set of consumption bundles.

A situation where the probability of each state is known, typically on the basis of historical experience, is one of objective risk. A risky action is one that yields different outcomes in different states of nature. With known probabilities, the outcome of such an action is a random variable.

Even when probabilities are not well known, or there is insufficient evidence to determine probabilities objectively, decision-makers whose preferences satisfy appropriate consistency properties may hold well-defined subjective probabilities over the different possible states. Following Savage (1954), this situation is commonly described as one of uncertainty.

Unlike the case of objective risk, individual subjective probabilities will not, in general, coincide. In the case of climate change, for example, differences in attitudes and beliefs have prevented the broader agreement required for a coordinated response to match the problem at hand. This arises, in part, due to differences in risk preferences of individuals, where perception of costs and benefits of action are contingent upon personal evaluations, including beliefs. The personal utility derived upon addressing a problem that one does not believe in would be negative, despite evidence to the mounting externality cost, because inaction means transfer of burden to others. Similar issues of attribution confront the consideration of opportunity costs in environmental water allocations and hence determining the risk to society of changed water allocation rules. The consequence of these and other complexities in decision making is that the full social cost of actions are often not considered—for the underestimated costs and overstated benefits of achieving a desired consumption bundle.

Under some conditions, such as that of rapid climate change, it may be impossible to form well-defined subjective probabilities. Ellsberg (1961) argued that such conditions arise when decisionmakers are faced with ambiguous information. In subsequent usage, the term 'ambiguity' has been applied to situations where well-defined probabilities are not available.

More recently, decision theorists have considered problems of bounded awareness, where decision-makers fail to consider, or distinguish, some possible states of nature. Grant, Guerdjikova and Quiggin (2019) examine the relationship between unawareness and ambiguity.

More complex problems arise when the choice set—the set of possible actions—involves interactions with other objectives and agents who represent them. Hence apart from the uncertainty relating to the distribution of states of nature, any uncertainty in the perceived interactions with each other increases the complexity of decision making[††].

The state-contingent approach to uncertainty and choice investigates ways to partition uncertainty within ranges of possibility based on limited information. Hence, tools created using the state-contingent approach could offer useful insights to consider potentially Pareto optimal outcomes that are superior to the traditional approach of allocation under certainty, which subsumes complete knowledge (Crean et al. 2013, Chavas 2011, Chambers and Quiggin 2000).

4 Enhancing the effectiveness of the Murray–Darling Basin Plan

The Basin Plan represents a cascading set of targets and activities aimed to fulfil a legislated national goal to restore the health of the Murray–Darling River system. In terms of

[††] A key source of complexity that relates to water management is the inability to determine the ecological production function, which complicates the choice problem about the level of reservation uses.

effectiveness, what it takes to achieve the goal should be considered in relation to economic issues of water governance discussed above; in particular its' ability to enhance the capacity of stakeholders to manage contingencies and reduce vulnerability to unfavourable outcomes.

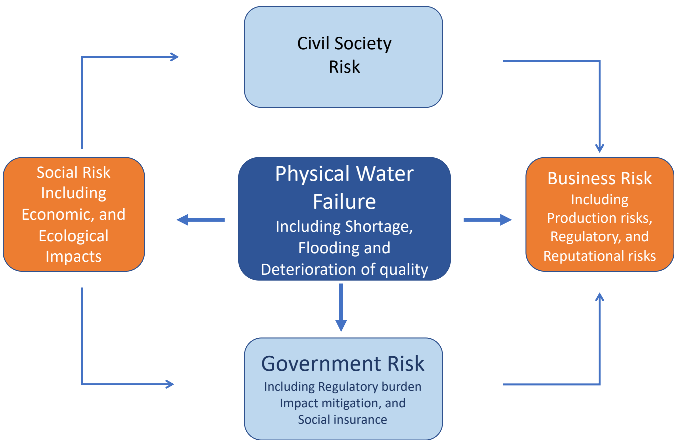
In the *Water Act 2007*, the key outcomes sought through a Basin Plan were to:

- improve water security for all uses of Basin water resources;
- ensure that the management of Basin water resources considers the broader management of natural resources in the Murray-Darling Basin;
- achieve efficient and cost-effective water management and administrative practices in relation to Basin water resources; and
- provide for the collection, collation, analysis and dissemination of information about:
    - Australia's water resources; and
    - the use and management of water in Australia.

As mentioned earlier, these were to be achieved, principally through a cap and trade system, and involved the definition of a Sustainable Diversion Limit (SDL) and strengthening water trading regime that was already in place. Information mechanisms, such as strengthening the capacity of the Bureau of Meteorology for water accounting and reporting was a complementary strategy.

4.1 Risk assignment

In the case of Basin water resource management, there are two clear sources of risk, which arise from the uncertainty associated with physical water failure: business risks and social risks. They also contribute, in turn, to Government risk and civil society risks (Figure 9).



Source: Adapted from, CEO Water Mandate (2019)
Figure 9: Nature of risks and their assignment

4.1.1 Business risk

The first, a downside risk, will accrue to businesses through their exposure to water dependent activities and comprise direct production risks, indirect regulatory risks and reputational risks. In terms of risk management, irrigation production functions are reasonably well-known and attendant private risks are amenable to normal business management, and hence best dealt with by business owners. In the case of dryland farmers and other myriad businesses in the Basin, such risks are ordinarily managed by individual businesses in concert with community standards and normal government policies. There is no reason why a different policy should apply to around 10,000 irrigation businesses in the

Basin, which represent only a quarter of Basin farm businesses and a very small fraction of around half a million Basin households.

Irrigators are adapting

Water account data indicate that the utilisation of assigned water rights is inversely proportional to scarcity, in that a greater proportion of the entitlement is used in a wet year (Bureau of Meteorology 2019). This relates to the *ex ante* nature of watering decisions and the *ex post* availability of allocation information. While more detailed analysis is needed to better understand this behaviour, this is consistent with the risk averse nature of irrigators' behaviour, who seek to avoid losses by not committing an annual crop in a lean season. The fact that this occurs in regions with a high proportion of entitlements may suggest that it may also be related to holding carry-over to subsequent years, in particular by speculative vendors (Seidl, Wheeler and Zuo 2020).

Clearly, irrigators are adapting to both the state of nature and alternative policy settings. The production system is transitioning towards opportunistically irrigating in favourable states of nature and reducing the exposure to unfavourable conditions via improved management. They are thus displaying the capacity to take responsibility for their own welfare. Hence, it is timely that governments leave the private welfare of irrigators to their own control, and only intervene to manage related externalities. We expand on this below.

4.1.2 Social risk

Ecological degradation affects all Australians, but damage functions are insidious

The greater risk that accrues to broader society is the potential loss of well-being that arises from irreversible changes leading to loss of capital (natural, financial and social) associated with physical water failure. In this regard the nature of failure is uncertain, often not easily detectable, slow and patchy, making it harder to assign attribution and hence responsibility to individuals for their remediation. Naturally, therefore, governments and civil society are collectively left to deal with them on behalf of the broader community. Economists broadly classify them as the externalities and public goods that were discussed earlier. Hence, in natural resource allocation, this category of costs and associated market failure are the only sources of social costs that warrant government intervention to manage.

Land use change impacts

On the other hand, farmers' endogenous adaptation to climate change, technological change and market demand for irrigated commodities have induced significant land use change in the Basin, thus altering the spatial distribution of irrigated production and economic benefits and costs thereof to local communities. These changes are occurring in both irrigated and non-irrigated agriculture, while water reforms have focused primarily on irrigation and environmental uses. The close nexus between irrigation and dryland rainfed farming within the Basin and across Australia means that unfavourable climate can have large negative impacts on rural incomes and wealth. For example, some predominantly irrigated industries, such as dairy, rely heavily on fodder production on rainfed land, and droughts that constrain hay and fodder grain production in rainfed areas diminish feed supplies, thus raising costs on milk production and reducing dairy productivity. The government focus on irrigated farming may have prevented a clear appreciation of complementarities between production systems.

For the Basin as a whole, significant difficulties exist in meaningfully specifying, standardising, quantifying and monitoring attributes of health. Hence, assessing reform progress involves how these attributes are impacted by Basin Plan implementation *vis a vis* external events such as climate variation, changes in economic conditions and social values, and aspirations at an operational scale. Indications are that, at least in gross terms, water allocations are beginning to equilibrate towards a lower use regime compared to a pre-reform era (Figure 4). And, issues such as salinity and waterlogging are largely controlled or technological solutions for low cost mitigation are available.

However, some changes in cropping patterns primarily facilitated through water trading raise sustainability risks. The inability to assign risks means that information asymmetry will rule and designing social contracts for elimination of risks may become impossible. Negotiations would therefore be open to rent-seeking and other collective bargaining failures. This context exposes the Basin Plan to the risk of not meeting the expectations for community scrutiny and continued exposure of taxpayers to increasing costs of meeting the underlying aspirational targets. Solutions to this may exist in the reassignment of risks to related entities.

Irrigators do not account for social costs

The irrigators' unwillingness to part with their entitlement, and the attendant uncertainties including that of the environmental production function and related externalities, are a key source of social costs. However, during the Basin plan development, negotiation, and implementation, there has been a clear conceptual failure in regard to determining social costs, and such failures have led to double counting and inappropriate assignment of risk. As such, the time is now ripe to correct such anomalies[‡‡]. The framework presented above, drawn from the CEO Water Mandate (2019) provides a good starting point for progress towards cooperative adaptation to heightened uncertainty.

Public good provision is best achieved through collaboration

In the context of the Murray-Darling Basin water governance, the *Water Act 2007* offers a strong basis for cooperation: For instance, S 19(2) of *Water Act 2007*, requires that

> "The Basin Plan will provide for limits on the quantity of water that may be taken from the Basin water resources as a whole and from the water resources of each water resource plan area. It will also provide for the requirements to be met by the water resource plans for particular water resource plan areas".

That is, to strengthen the role of civil society. This could be accomplished by reinvigorating the regional natural resource management regime to good effect.

Failure to address water resource planning

The failure to accomplish water resource planning exposed the government to a number of risks from Basin Plan implementation. The first, relates to the failure to settle water resource planning across the Basin, and in particular to "provide for limits on the quantity of water that may be taken from the Basin water resources as a whole and from the water resources of each water resource plan area" (Water Act 2007, s19.2). The second, the failure to reach agreement on ways to recover water for the environment has escalated government risks, its regulatory burden, and the costs of social insurance. Numerous analyses and commentary that allege poor decision processes, lack of transparency and escalating public costs, are symptomatic of these risks.

Therefore, democratic processes that account for the nature of ecosystem within each of the regional water management plan areas could be used to redesign regional water management targets, recalibrate the SDLs, and bargain them across the Basin through a process of

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[‡‡] One such area involves the implications of the misplaced concept of triple bottom line. [Elkington, J. (2018) 25 Years Ago I Coined the Phrase "Triple Bottom Line." Here's Why It's Time to Rethink It. *Harvard Business Review*.]

transparent negotiations. In doing so, mechanisms to help increase environmental water holdings and to leverage private investment may be explored; for example, to assist financially marginal activities with greater social benefit to pass the cost-benefit test during water resource planning negotiations. As information asymmetry is clearly the source of current distrust and disunity, coordination mechanisms at the regional level could be supported through appropriate information, to bring opposing parties to a common understanding. However, uncertainty in estimating values of all sorts will enter into such deliberations, and managing transaction costs in collective determination in a distributed democracy would likely be substantial.

Over reliance on the cap and trade system

The Plan made the simplifying assumption that water management across the Basin can be achieved through the water access entitlement system —the system of allocated water rights— for access and use from a designated consumptive pool. It was further assumed that water access entitlement holders would bear the risks of any reduction or less reliable water allocation arising from reductions to the consumptive pool, as a result of:
(i) seasonal or long-term changes in climate; and
(ii) periodic natural events such as bushfires and drought.

Invariably, this risk assignment assumed that farmers have perfect knowledge about the impact of their activities on wider water use, and that the external costs of their decisions can be internalized to the decision-maker. They were expected to act in the social interest. Therefore, so long as institutional arrangements were properly structured, and barriers to trading of water entitlements amongst competing users removed, then it was implicitly assumed that farmers would adopt land use and water management practices which maximised their profits over the long term, while also considering the longer-term impact of their activities on future land and water use. This naivety made the benefits of the Plan, at most, ambiguous.

Exclusion of climate change

Moreover, the exclusion of explicit consideration of climate change, for political exigency and scientific uncertainty reasons, has made the Basin Plan's water supply and demand calculations outdated. On the one hand, the sustainable diversion limits (SDL the safe withdrawal limits designed on the basis of simulated historical flow), is likely to prove unreliable as climate change intensifies (Chiew et al. 2011). Since the mid-1990s, streamflow in southeast Australia is around half the long-term average. During the same period, streamflow in the Murray–Darling Basin has been 41 per cent lower than average and in some basins in the west and central regions of Victoria, such as the Campaspe Basin, streamflows have declined more than 70 per cent (CSIRO 2019). In the context that, on average, only four percent of annual precipitation contributes to runoff in the Basin, declining rainfall will have a disproportionate impact on run-off. As such, the challenge facing planners and policy-makers is to transform the water management philosophy from regulating known supplies to manage seasonal water scarcities, to one of containing exposure to more likely, prolonged unfavourable conditions of varying intensity and duration.

Government investments that complicate risk taking

On top of these changes, government's own investment programs that were targeted at facilitating on-farm irrigated infrastructure improvements, water use efficiencies and water recovery for the environment have influenced the rates of irrigator adjustment.

Several government programs have been presented as responses to public demand, backed by water scientists and economists for improving water productivity as a mechanism to cope with increasing demand for water, to address resulting conflicts among extractive and natural uses, and improve profit or market access (Department of Agriculture Fisheries and Forestry 2004). However, potentially large rebound effects—the increased consumption that follows an improvement in the technical efficiency—together with attendant externalities could partly undermine the targeted policy effects (Loch and Adamson 2015, Li and Zhao 2018).

4.1.3 Civil society risks

Deepening loss of trust on state institutions

The recent escalation of commentary on government involvement in water management and the Basin Plan in particular points to a deeper social problem. Australia has generally well-functioning institutions, a responsive Public Service and a R&D system that promotes innovation and entrepreneurship. However, the Banking Royal Commission (Royal Commission 2019), the South Australian Murray-Darling Basin Royal Commission and the recent Productivity Commission Inquiry on Water (Productivity Commission 2018), for example, collectively point to a scenario of deepening loss of trust in state institutions.

Loss of trust represent weak institutions

It is well-known that the state—the machinery and powers of government—is a potential resource or threat to every industry in society (Stigler 1971). Weak institutions and translucent decision-making escalate concerns of marginalisation, unequal access and impropriety, and make societies more vulnerable to unfavourable conditions as they undermine the collective resilience of society. They tend to create an environment more conducive for competition among pressure groups for political influence, thus pushing the political equilibrium in favour of lobbying pressures, and escalating the deadweight cost of taxes and subsidies (Becker 1983).

Weak institutions make policy implementation difficult

When faith in institutions is low, achieving reform goals that pursue national interest becomes all the more difficult: behaviours become toxic, negotiations difficult and trade-offs insurmountable. Marginal issues with minor ramifications could gain strength to derail desired reform, thus extending costs on the economy and society as a whole.

Civic society can help build trust

Conversely, as insights from the World Bank development experience suggests (Georgieva 2019), expansion of civic space toward fair participation in political and economic decision-making could enhance the quality of decisions and engender cooperation in achieving national goals. Addressing boundary issues becomes feasible at much lower cost, thus enhancing the cost-effectiveness of reform. Effective institutions and broad-based governance can build trust, making behaviours more constructive and conducive for cooperatively managing risks and uncertainty for greater social benefit.

Self-protection enhances collective well-being

As people are encouraged to take greater responsibility for their collective well-being—as is the case for dryland farming—they learn from successes in managing difficult issues. And, complexity in decision-making eases allowing new ideas to take root. Government assurance of support becomes substitutable for personal insurance and risks become amenable for leveraging through diversification, allowing for greater diversity and resilience in economic and social space. Governments can play a more appropriate role in supporting infrastructure, investing in research and development, which in turn contributes to greater innovation and growth opportunities.

Knowledge management is crucial

While scientific information will define the nature of physical and biological constraints, the social cost of meeting those constraints requires thorough economic analysis. There is no current modelling capacity in Australia, that can accommodate the cascading nature of the local to national scale issues that arise from multiscale interactions between conflicting land

and water use within the diverse agricultural landscape. That weakness has significantly overstated the costs of solutions, because spatial and temporal complementarities, in particular between irrigation and dryland farming has been ignored. It is in the national interest to invest in building that capacity and maintain through appropriate investment in information gathering.

Risks needs to be shared

Climate change risks are pervasive, unpredictable and arise from hazards that can be both abrupt (floods) and slow emerging (droughts). Hence, risk needs to be shared by all parties with a view to encourage proactive adaptation where governments take on the additional burden of meeting exceptional circumstances and funding social services and R&D. In general, specific risks should be borne by those best able to manage them. Negligence could lead to catastrophic risks with devastating consequences as most impacts are irreversible (species loss; loss of human lives).

4.2 Securing public goods and collective assets

Economists have long argued that unmitigated resource extraction leads to overuse, excessive production and deterioration of environmental assets leading to loss of collective welfare. Well-defined property rights, coercive laws or taxes, provide rational agents the incentive to use a common property resource (CPR) at a level that is collectively efficient (Akhundjanov and Muñoz-García 2019). Hence, environmental policies by their very nature have the potential to impose costs on private individuals. At the same time, such policy-induced changes could make individuals better-off in that they are better able to cope with the impacts of externalities that their activities generate, thus helping to eliminate them in the long run. For instance, in the case of transboundary externalities, where impacts cuts across administrative boundaries, tighter regulation could encourage firms to adapt, and thereby mitigate aggregate production, increase market prices, and generate a positive effect on profits. The magnitude of these effects depends on the extraction rate, the extent of environmental damage and the coordination mechanisms of the polices.

Hence, the Basin Plan implementation and review processes needs to engender discussions about ways to eliminate conflicting positions and consider whole of system solutions, that work also at the local levels, particularly in the presence of production externalities that cut across boundaries (Nikitina 2019).

4.2.1 Acknowledging diversity

The Basin is diverse and the Northern and Southern Valleys are vastly different. Just as diverse are differences between the states in the ways governments have reconciled geographical, political, settlement and product differences. While the Southern Valleys has achieved a high level of supply resilience, as droughts linger longer, under current management instruments, governments will not be able to assure supply reliability for the Northern Valleys that are governed mainly by Nature. The recent rates of development only exacerbate the natural supply and demand imbalance exposing the agricultural system to ongoing costs.

4.2.2 Determine acceptable loss

Sources of community outrage, such as the fish kills observed in the first half of 2019, are likely to happen again. While the agricultural industries need to rethink their development strategies, it is inconceivable that under intensifying climate variation, attempts to secure all environmental amenities across the Basin would be socially feasible. Some things would need to be given up. It follows that ways to prioritise management protocols, investment regimes and cost-sharing arrangements for the Northern Valleys needs to be carefully reconsidered. Certainly, the development of regional water management plans, such as the Barwon Darling, provides useful opportunities invoke new ideas (Natural Resources Commission 2019).

4.2.3 Optimisation

The overall objective of the *Water Act 2007* and policy reform in general is to maximise net economic returns to the Australian community, from all water use activities in the Basin. As discussed in sections 3.4 and 3.5, water management systems are complex and relate to uncertain behaviours of agents managing the system. Therefore, they are difficult to optimise. For example, the economic evaluation of water allocation and use options involves the consideration of interactions between them that cut across time and spatial boundaries. While stylised analysis provides useful general insights on near term options and strategies, they fail to inform viable medium-long term strategies as issues evolve over time and extended scales. Options chosen with myopic analyses may in fact increase the net social cost. The difficulty is exacerbated as rights and obligations amongst uses are not well-understood and some users override the interests of others, albeit inadvertently.

The widely used ABARES Water trade model (Hughes et al. 2016) and the Murray-Darling Basin Model developed by the Risk and Sustainable Management Group (Adamson et al. 2007) have useful elements that highlight the nature of difficulty in quantitatively assessing the likely impacts of the Basin Plan as a whole. But, in moving forward, the capability to assess cascading impacts from water management plan areas through state jurisdictions and to the Basin scale is not currently feasible at a desired level of confidence.

4.2.4 Data – a source of information asymmetry

Models are as good as the data they depend on. Externality impacts of development are not ordinarily reported in market transactions, and the level of their incidence and impact is estimated indirectly. In particular, private entities who create externality impacts as joint products of legitimate economic activities, such as farmers, have little or no incentive to truthfully report their activities in official data collections that support public discourse. Although advancements in data capture, communication and storage have led to greater access to available data, interconnected issues related to security, privacy, commercial risk, cross-border data flows, reputational concerns, due process, and regulatory uncertainty have all created an environment that hinder public-private data sharing.

Certainly, data sources relating to Basin management are increasingly becoming available. Yet, complexity surrounding the understanding on interactions have led to a profound and growing lack of trust among individuals, institutions, and governments (Hoffman et al. 2019); the end result being that the level of externalities in economic development are likely to be understated. Lack of data prevents informed analyses, enhances uncertainty, perpetuates the depletion of trust and accountability that nurture conflicts amongst competing interests, and diminishes the impact of policies and programmes intended to address issues of common good.

5 Conclusion

In this paper, we have focused on the social cost of water allocation. As absolute scarcity of water increases at a point in time in a given location, society will face increasing risks in maximizing the desired consumption bundle. Social coordination mechanisms other than markets are clearly important as risks need to be shared across the community, giving resilience to the collective. The Basin Plan is to be seen in that perspective. In the context of the Basin plan, the initial resolution of the SDL remains a vulnerability, as significant uncertainties surround its determination, particularly in the context of advancing climate change.

Irrespective of these weaknesses, the Basin Plan and other ongoing changes have induced Basin farming systems to adjust to changing circumstances. In particular:

- Irrigation water use now represents levels consistent with the Cap in place
- The Murray outflows to the sea have stabilized at a low level since Basin Plan introduction, but flows in the Darling have declined sharply with frequent drought.
- The Darling (Northern Valleys) essentially remains a difficult-to-manage system, whereas the Murray (the Southern Valleys) represent a well-managed system given the complexity of the task.
- As external shocks such as climate variability intensify, and evaporation losses rise, allocations to all entitlement holders will decline, reducing the general reliability of the system.
- Water trading provides a financially efficient strategy to allocate water amongst extractive uses, but not for the accounting of social costs of water allocation.
- Equally, water trading remains inadequate as a measure to divert water for environmental uses.
- While some explicit allocations have improved the prospects for securing certain environmental assets, those allocations and assets remain vulnerable as the reliability of the system falls with climate change.

This means that the risk assignment frameworks embedded in the Water Act, drawn from the NWI needs closer scrutiny.

- Water reforms have matured to a stage where downside risks to private irrigators can be left to their own devices, as is the case for dryland farmers.
- Building resilience through planning remains the most efficient option; as uncertainty increases, plans need to be flexible and diverse.
- Mechanisms other than public finance to increase the environmental water holding, such as leveraging private investment, could be pursued to assist financially marginal activities with greater social benefit to pass cost-benefit tests during water resource planning negotiations.

Political economy analyses narrate that the state’s capacity for economic development—the government's ability to accomplish its intended policy goals—plays an important role in market-oriented economic development (Dincecco 2017). Given the decentralised nature of market economies, public policies such as those relating to water reform are the key means to exert authority on their citizenry: they influence people’s choices, both emotionally and materially and thereby interfere with prevailing social norms, customs or personal values that translate into personal gains and losses, either perceived or real.

Objectives of water policy will remain production-focused: the bundle of consumption now clearly includes environmental goods and services and hence the effort will also go to producing those services. Managing social externalities in the new production setting will then become the responsibility of the State and the Civil society. Hence Civil society calls for scrutiny of the Basin Plan are justified. The way forward involves better recognising the Civil society role, to dilute rent-seeking attempts and maximise net social benefits through pluralistic political processes.

The only social costs related to water allocations are those to do with externalities and public goods. Their resolution will involve clear assignment of risks to fully reflect social costs of water use in extractive uses. Regulation alone is unlikely to achieve that goal as monitoring is costly, inefficient, and enforcement costs are equally high. While the recently announced Inspectorate for the MDB is a step in the right direction, conflicts are better managed through anticipation rather than resolved *ex post*. Managing them requires social coordination mechanisms as conflicts are rarely created wilfully but are joint products of planned production for profit, a legitimate basis to create social benefits.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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