Water market literature review and empirical analysis

Prepared for the Australian Competition and Consumer Commission (ACCC)

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Contents

List of Tables

List of Figures

Abbreviations

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABC	Australian Broadcasting Corporation
ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
ATO	Australian Tax Office
AWBA	Australian Water Brokers Association
COAG	Council of Australian Governments
CEWH	Commonwealth Environmental water holder
EWH	Environmental water holder
GL	gigalitre (one billion litres)
GMID	Goulburn-Murray Irrigation District
GMW	Goulburn–Murray Water
GS	General security
GVIAP	Gross value of irrigated agricultural product
HS	High security
IIO	Irrigation infrastructure operator
IO	Infrastructure operator
IR	Irrigation right
IVT	Inter-valley Transfer
KL	kilolitres
LMW	Lower Murray Water
LP	low pressure
LTAAY	Long term average annual yield
LTDLE	Long-term diversion limit equivalent
MDB	Murray–Darling Basin
MDBA	Murray–Darling Basin Authority
MI	Murrumbidgee Irrigation Limited
MIL	Murray Irrigation Limited
ML	megalitre (one million litres)
NMDB	Northern Murray-Darling Basin
NRAR	Natural Resources Access Regulator

NRM	National resources management
NWC	National Water Commission
NWI	National Water Initiative
PC	Productivity Commission
PIIOP	Private Irrigation Infrastructure Operators Program (NSW)
SDL	Sustainable diversion limit
SMDB	Southern Murray-Darling Basin
VWAP	Volume weighted average prices
WRP	Water Resource Plan

Executive summary

Water market overview

Water trading occurs in water markets, and can be defined as the process of buying and selling water licences (also called entitlements or rights), by formal or informal means. There are three prerequisite institutional factors needed in establishing water markets: 1) enabling institutions (science, economic and social); 2) facilitating gains from trade; and 3) monitoring and enforcement.

Australia's water market in the Murray-Darling Basin (MDB) is mature and, in comparison to many other countries, ranked highly in terms of institutional foundations, economic efficiency, and environmental sustainability. The southern Basin is one of the most active water trading regions worldwide and the largest water market in Australia in terms of geographic area and volumes/numbers of water entitlements. However, northern MDB water markets observe lower water-trading volumes/numbers attributed to relative illiquidity, lower storage, less hydrological connectivity and crop diversity, less regulated entitlements, more homogenous agricultural production; coupled with far greater on-farm water storage and groundwater extraction. There are also significant institutional differences regarding water institutions between the southern and northern parts of the Basin – with the northern Basin needing significant institutional reform before greater water trading should be facilitated.

Two broad types of water trading can be defined: 1) short-term or temporary transfers of water (known as water allocation trading), which also includes other temporary products such as parking (right to use carry-over space owned by a different entitlement holder), water leases, water forwards and water options; and 2) permanent transfers of water entitlements – namely: a) the ongoing property right to either a proportion or fixed quantity of the available water at a given source (known as water entitlement trading); and b) water delivery rights – the right to have water delivered.

In the MDB, irrigators became more favourably disposed to water trading from the 1990s to the 2000s, with water allocation trading far more accepted than water entitlement trading. By 2000, even though water markets had been in operation for almost two decades (albeit opportunities for trade were still limited), less than 10% of irrigators in the southern MDB had conducted a water market trade, although the implementation of the cap on total water resources contributed to a spike in temporary trade in the early 1990s. By 2010-11, it was estimated that 86% of NSW, 77% of Victoria and 63% of SA irrigators had undertaken at least one temporary or permanent water trade. Adoption of temporary trade accelerated after the introduction of major water reforms from 2004 onwards, and the adoption of permanent trade took off after the beginning of the Millennium Drought (during which water recovery started in 2007-08). By 2015, adoption had increased further and around half of all irrigators in the southern MDB had made at least one water entitlement trade, while 78% had conducted at least one water allocation trade.

Adaptive capacity of the irrigation industry is enhanced by diversity of different types of agricultural production in the MDB, and, in particular, by the presence of opportunistic annual crops (e.g. cotton and rice) in the MDB. Although it is often argued that Australia should not be growing cotton or rice due to their high water extractions, this ignores the adaptability of such crops in dry and wet conditions, and the role that many of those farmers play in providing water to more permanent crop irrigators in times of drought.

Understanding participation in water markets

Chapter Two discusses the participation of five stakeholder types within MDB temporary and permanent water markets, namely: irrigators; non-landholders; environmental water holders (EWH), urban and First Nations stakeholders. To date, the majority of the literature has focussed solely on irrigator behaviour in water markets, using cross-sectional individual surveys.

1) Irrigator participation

Water market participation is driven by fundamentally different factors for buying and selling different types of water market products.

Studies mainly associate temporary water trading with short-term considerations in response to seasonal fluctuations of prices or water availability (to manage risk and uncertainty within and between seasons) and personal characteristics (e.g. higher education level, greater irrigated area, having a whole farm plan, etc.). Earlier studies profiling the difference between allocation traders versus non-allocation traders found significantly more areas of difference in personal characteristics than in later years, highlighting that the difference between traders and non-traders seems to have fallen over time.

Generally, permanent water trading is driven by the aim of long-term structural change on the farm: to reduce debt; and to either exit, or control long-term risk exposure (e.g. to secure a particular level of water availability, or change farm location or type, which may be followed by the use of the temporary water market to adjust for the new risk position). The following factors predicted permanent water sales the most successfully: older age, less education, attitudes to farming, larger number of children, used government as an information source, have previously sold water allocations, had a farm plan, had larger water entitlement holdings, land use (lower percentage of annual and permanent crops), lower farm net operating surplus, higher debt, lower allocation levels, and the location (VIC and SA were more likely to have sold). It has also been found that decisions to sell permanent water were influenced by neighbours' water selling decisions, and the majority of permanent water sellers remained in farming, after they had sold a part of their water. Dominant reasons for selling permanent water were debt and cash flow.

2) Non-landholder participation

Overall there has been little research to date focusing on non-landholders' participation in water markets. Lessons that may be relevant from the commodity ouptut price trading literature suggest that speculators do not destabilise commodity markets, but instead contribute to lower volatility levels and enhanced market quality by improving short-run price efficiency and liquidity, although some studies have found short-term effects.

Non-landholders have increasingly invested in water because of the long-term rise in water asset values, the diversification against other assets, and the fact that variability in water market prices presents significant opportunities for investment trade returns. Current estimates in Victoria suggest that 'non-users' water ownership is relatively small, while other research suggests that non-landholders provide a variety of market benefits – such as new water market trade innovations.

It is suggested that the current small number of water market financial investors probably have limited market impact overall, however this impact is dependent upon: a) the liquidity of the local water market they operate within and imperfect competition factors; b) the volume of their trade; and c) imperfect information asymmetry (e.g. insider information knowledge). Growth in this water market segment is also likely to be limited by the substantial financial investment and trading skills required, and also due to the fact potential investors have the option to trade on other financial stock markets (with greater turnover possibilities).

3-5) EWH, Urban and First Nations' Participation in Water Markets

The Commonwealth Environmental Water Holder (CEWH) is the largest water access entitlement owner in the MDB, and has strict rules regarding its involvement in water markets. It has sold water allocations in markets previously, and for the first time was considering buying water allocations in 2020, which many commentators support as a further adaptation tool to maximise environmental watering benefits.

In the MDB there has been a very small, yet growing, use of water markets by urban and other sectors. Mining participation tends to be most concentrated within groundwater entitlements. In Victoria, the share of water entitlements owned by water corporations rose from 0% in 2009 to 3% in 2018. Although there have been major water infrastructure investments to allow cities to utilise water markets, to date, many of these investments have had limited operational use due to political reasons.

There is also a history of First Nations' having very few rights to water in Australia. The National Water Initiative was the first occurrence, at a federal level, whereby it was acknowledged the need to include and recognise indigenous interests in water management. Even though $40 million was allocated in mid-2018 to support indigenous Basin communities by investing in cultural and economic water entitlements, to date there is no evidence that any cultural water has been purchased.

Drivers of movements in water market volumes and prices and water valuation

Chapter Three focuses on the macro-studies (e.g. times-series analysis; regional level analysis; hydro-economic and theoretical models) examining movements in water market volumes and prices. The supply of surface-water entitlements on the water market is influenced by: water allocations; environmental water; carry-over; water trading rules; infrastructure investment; and government policy. The demand for surface-water entitlements is influenced by rainfall and soil moisture; temporal factors; groundwater availability and quality; commodity prices and input prices; land quality and regional factors; and on-farm infrastructure investment (public or private).

The temporary water market has easily been the most studied in the MDB, given the greater availability of data. Studies have found that seasonal factors, such as water allocations, drought and low water storages, are the main drivers of temporary water prices. Studies also indicated that irrigators switch between groundwater and surface-water use, and that permanent and temporary markets are interlinked – with unidirectional transmission spillovers occurring in both markets, from prices to volumes. A few studies have examined whether water markets exhibit characteristics similar to other financial markets. For example evidence has been found that temporary markets in the MDB show price leadership to both groundwater and permanent markets, while other studies have revealed evidence of both price bubbles and insider trading in temporary markets.

One of the most raised questions recently in Australia has been the impact of government water recovery on water markets. A variety of academic and consultancy studies have addressed this, from theoretical, to empirical studies. The only empirical econometric study to date that has utilised appropriate methodology and a sufficient time-series of data to investigate the causal question of buyback of high security water entitlements on the water market in the Goulburn Murray Irrigation District – found no significant impact of water recovery on temporary water prices, nor on permanent high security market prices and volumes. However, it was found that government water recovery increased the volatility of temporary market prices and volumes. Further research is required on modelling the impact of recovery on low and general security water allocation shares and permanent prices in the MDB.

A variety of studies have found both positive and negative impacts on the environment due to the presence of water markets. Negative impacts include: concentrating water extraction in areas suffering from high water tables; increased salinity in areas that require minimum irrigation intensities and have experienced water entitlement loss; moving water into locations where extraction might have a negative impact on river water quality; increased groundwater substitution and increased groundwater use can lead to increased salinity problems if saline groundwater flows into rivers due to discharge; moving water use upstream, thereby resulting in reduced river flow from the new point of extraction to the old point of extraction; and activating previously unused water leaving less water in rivers to support ecosystems (plus less water in storages for future water allocations). Positive impacts include: the water market provides a way for the environment to own water entitlements with the same rights and security as consumptive users; water markets can decrease salinity when water is traded away from high impact areas; and changing water extraction downstream is predominantly associated with beneficial ecological impacts.

Chapter Four investigates issues with water asset valuation (and implications for markets). Problems of water asset valuation are greatest in 'thin markets', where data scarcity and lower data quality arguably require the use of longer time-periods and multiple data sources. It is recommended that there is a need for guidelines on a dedicated water valuation methodology, and that transparent valuation of water resources should follow a standardised approach in regards to data cleaning, data sources considered and valuation methods employed.

Efficiency Benefits of Water Markets and Market Failure Issues

Chapter Five discusses three distinct forms of economic efficiency associated with water markets: 1) *Allocative* – improving water resource short-term decision-making to better reflect seasonal conditions is facilitated by water allocation trade; 2) *Dynamic* – where the existence of permanent water markets allows and can improve structural or long-term decision making, enabling new investment opportunities, regulatory shifts in access arrangements or personal strategic choices; and 3) *Productive efficiency* – where the existence of water markets and flexible water prices offer incentives for the efficient use of water resources as either an investment or input for productive outcomes. A substantial number of theoretical and empirical models have demonstrated the major economic and financial benefits that have been derived from having water markets in place in Australia.

However, there is strong evidence of market failure in water markets within Australia. **Imperfect competition** does seem to exist in some forms, especially in regards to the Northern Basin, inter-valley trade (IVT) issues, tagging, interstate trade issues and unregulated water broker behaviour. **Negative externalities** are also clearly present, mainly because of the lack of clear property rights, enforcement and monitoring, and institutional rules. Such externalities have also resulted from government policy, particularly irrigation infrastructure subsidies to recover water. There may also be negative externalities present in terms of reduced entitlement reliability security, which require further investigation. Furthermore, there is evidence of both positive and negative environmental externalities from water markets. **Information asymmetry** is also clearly present in water markets – again in relation to IVT issues – as well as data and information on prices, water registers and weather, insider-trading issues and unregulated water brokers.

Many of the perceived costs of Australian water markets represent **pecuniary externalities** (e.g. increases or decreases in market prices from various actions) – which can have different distributional issues, but are not necessarily market failure per se. Distributional issues include: a) initial distribution of property rights can make markets inequitable – especially the case for First Nations communities; b) legacy and gifted asset issues – the increased sale of permanent water out of districts (along with not keeping delivery rights or not paying for delivery rights) can increase the spread of fixed costs across less users in irrigation districts and have the potential to cause stranded assets, which may particularly impact smaller irrigation dependent rural economics; and c) profile of buyers and sellers – buyers of water allocations are more likely to be younger, own less water entitlements and in higher debt, compared to those buying water entitlements, selling water or not trading.

Hence, overall there are a variety of lessons identified, including:

- Water markets only exist within institutions, hydrological rules and structures which allow and govern the transfer of water – which includes the implementation of state water resource plans. If these institutions and structures are corrupted or are missing, then this can result in negative impacts for society. Greater attention needs to be focussed on ongoing attempts to reform both state water institutions in terms of monitoring and compliance; and water licence conditions through water resource plans, especially in the northern Basin. Further improvements are needed in providing water extraction information from satellite and thermal imaging, along with increased information and development of water registers, water accounting, water hydrology and connectivity, water pricing and trade products.
- Although non-stakeholder involvement is likely limited, monopolistic concentration of entitlement ownership and market power can lead to price gauging by landholder and non-landholder actors alike, particularly in illiquid or 'thin' markets or when combined with insider

information and information asymmetry. There is a need for more quantitative evidence (such as linking both ownership and trading register data) to be collected and analysed.
- Other water market reforms in the areas of data; rules and regulation; and new institutions development and infrastructure are required.

New survey statistical analysis

Chapter Six presents new analysis of water trade participation, using six irrigator survey datasets across the southern MDB from 1998-99 to 2015-16, and 63 qualitative interviews with non-landholders in 2018-19. A variety of methods were used: descriptive statistics; principal component factor analysis; and a multinomial logit model – to analyse the difference between traders and non-traders in a variety of water market products over time. Broadly, results highlight that the greatest differences were found between groups of irrigators in the earlier rather than later years – highlighting that as the adoption of trade occurred over time, the difference between individuals' trading decreased.

Factor analysis created a typology of five farm management clusters of irrigators' in the southern MDB in 2015-16 (n=1000) namely:

- Cluster 1: *Expanders* mainly purchase water allocations, in combination with increasing irrigated area and accommodating strategies such as changes in irrigation production and improvements in irrigation efficiency.
- Cluster 2: *Expanders and Diversifiers* mainly purchase water entitlements, which are accompanied by farmland purchases.
- Cluster 3: *Downsizers* clearly identifies a group that are downsizing or exiting by selling both water allocations and entitlements.
- Cluster 4: *Transitioners* are mainly in the process of switching from irrigation to dryland production, while
- Cluster 5: *Savers* are those mainly using carryover.

The results highlight the importance of water scarcity in driving irrigator behaviour, with scarcity issues more likely to increase the likelihood of being an *Expander, Expander/Diversifier or a Downsizer*. Alternatively, increases in water availability were more likely to increase the probability of being a *Saver*; while the higher the local area temperature, the greater the likelihood of being in Cluster 3: *Downsizer*. *Transitioners* are less likely to have diverse water holdings, while *Savers* typically have diverse water holdings. Irrigators with high security water ownership are more likely to belong to *Expanders*.

Attitudes by irrigators towards water trade have been variable over time, while at the same time adoption of water markets has increased steadily over time. In particular, there has been an increase in irrigators disagreeing with the statement 'water trade has been good for farming' in the southern MDB between 2010-11 and 2015-16. In 2015-16, a very small percentage of irrigators in the southern MDB (n=1000) agreed that corporate non-farm entities should be allowed to invest in water (<10%) – while around one third agreed that retired irrigators no longer farming should be allowed to retain and trade water. There were differences between cluster attitudes; with *Transitioners* more likely to agree water trading had been good for farming.

1 Water market overview and literature review

ACCC QUESTION: A literature review of what is known about trading behaviour of water market participants, drivers of water market and efficiency and equity issues.

This chapter is broken up into two main parts. The first part provides an overview of the concept of water markets, the water market literature over time, various frameworks that have been proposed to evaluate water markets, market failure issues relevant for water markets; and the institutional conditions needed for successful water markets. The second part provides an overview of water markets in Australia, particularly in the Murray-Darling Basin, summarising the entitlements on offer, relevant water policy and reform historical legislation, trade types that occur, irrigation and irrigator information (e.g. water extractions, numbers, irrigation operations, adaptation behaviour), trade zones, various stakeholders and current trade barriers and restrictions that exist.

1.1 Water markets as a water demand management instrument

Water trading occurs in water markets, and can be defined as the process of buying and selling water licences (also called entitlements or rights). Three broad types of water trading can be defined: i) short-term or temporary transfers of water (known as water allocation trade); ii) medium-term leasing of water allocations to secure access to water for a period of time specified in a contract (known as water leasing); and iii) permanent transfers of water entitlements – namely a) the on-going property right to either a proportion or fixed quantity of the available water at a given source (known as water entitlement trading), and b) water delivery rights - the right to have water delivered (Wheeler & Garrick 2020).

Water markets are a common example of an economic water demand management instrument to provide a flexible, voluntary and efficient allocation of a scarce resource (e.g. Howe et al. 1986; Randall 1981). In general, demand management instruments aim to reduce water demand and increase yields and income per unit of water used (Pereira et al. 2002) while facilitating the allocation of water to higher value uses (Grafton 2014). Other demand management instruments comprise, for example, water use and behaviour regulation (e.g. metering), education on water conservation, and other economic instruments, such as water pricing, taxes, and subsidies (Griffin 2006; Settre & Wheeler 2016). Overall, economic water management instruments aim to address the key global challenges in water: Water scarcity, water quality deterioration, conflict across competing users and over-allocation of water resources (Grafton & Wheeler 2015).

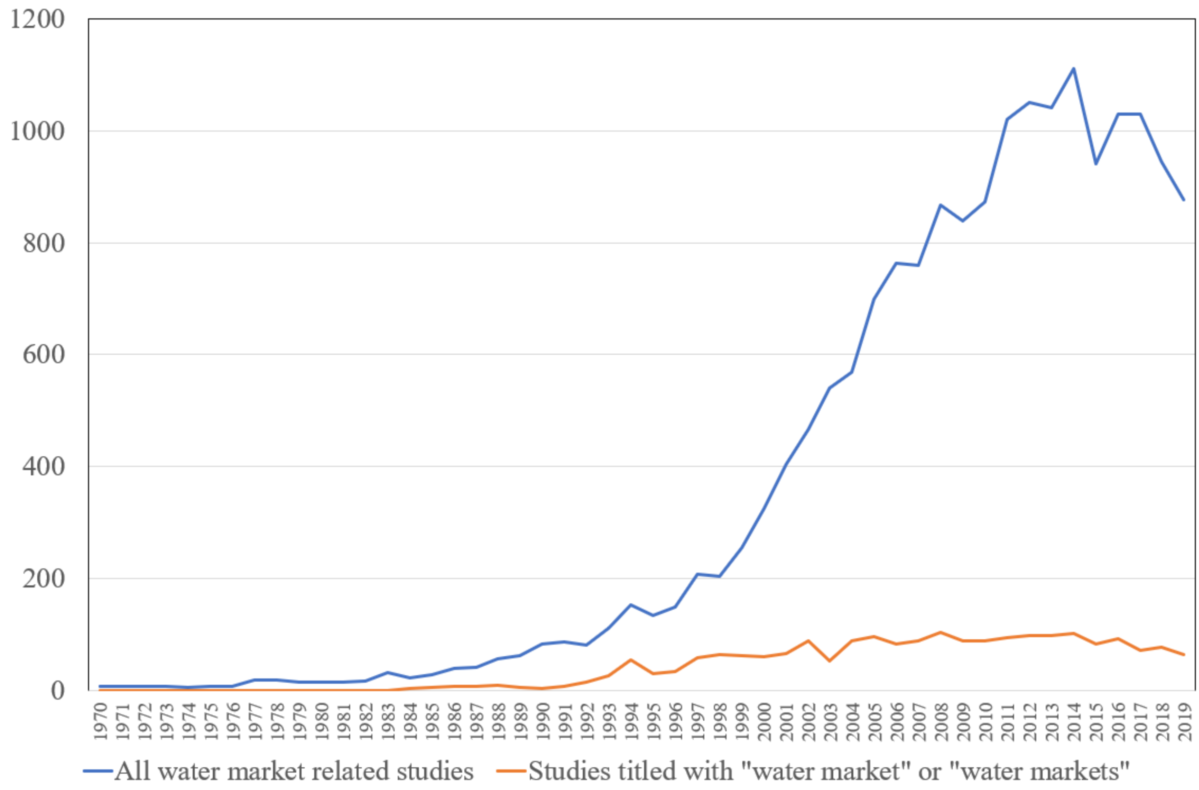
On the other hand, water supply management instruments comprise, for example, increasing storage capacities, improving distribution systems, drilling wells and developing new sources of water supplies, e.g. desalination plants (Griffin 2006; Pereira et al. 2002). Water supply and demand management are interdependent as, for example, effective demand management relies on advanced water supply conditions (Pereira et al. 2002). Water demand management instruments were gradually adopted over recent decades in Australia after governments traditionally focused on improving water supply (Settre & Wheeler 2016).

Many studies have illustrated the public gains derived from the reallocation of water resources through water markets (e.g. Easter et al. 1999; Knapp et al. 2003; Vaux & Howitt 1984). There are several key advantages of water markets over other water allocation schemes: (1) flexible reallocation over time in response to economic, demographic, and social-value changes; (2) involving only willing sellers and buyers; (3) willing seller/buyers provide security of tenure of property rights; (4) by providing the value of water, water users are confronted with the real opportunity cost of their water; and (5) measures can be put in place to keep transaction costs low (Howe 2000).

Water markets allocate water to its highest value user by establishing a price signals. Thus, optimal water allocation requires the assessment of the value of water in various uses (Grafton & Wheeler 2015). The total economic value of water comprises direct (i.e. benefits for individuals or agricultural businesses from using the water) and indirect (i.e. non-use water values, such as aesthetic values) use values (e.g. Grafton & Wheeler 2015; Rolfe 2008). Note, a water value is not static; it is dependent upon quantity (e.g. volume held), quality (salinity/pollution issues), reliability (e.g. different securities of entitlements owned), hydrological conditions (e.g. area where water can be traded to influences liquidity), substitutability (e.g. groundwater for surface-water), timing (e.g. seasonal availability compared to crop needs), location (e.g. spatial regulations and climatic factors) and heterogeneity in use (e.g. different crop needs influence liquidity) (Grafton & Wheeler 2015). Values are also different from one user to another, and even within the same industry. Water can be classified as either a ***private*** (e.g. household water use) or ***public*** (e.g. recreational water use) good in its different types of uses, and hence is most commonly known as a common pool resource, where establishing property rights in common pool resources has been discussed widely in the literature (e.g. Ostrom 1990). From the outset it is important to note that water trading can change the location, timing and technical efficiency of water use (Bauer 1998; Easter et al. 1999; Howe et al. 1986).

Figure 1.1 illustrates the considerable growth in the water market literature from the 1970s to 2019.[1]

Figure 1.1 Published water market related literature, 1970-2019



Source: Wheeler and Xu (2020)

Most of this literature has been published by the United States (in particular the western states); Australia; Chile and Spain (Wheeler & Xu 2020). Water markets can be established ***formally*** (i.e. through government legislation) or ***informally***, and typically involve water users located in a specific region or sharing a water resource. Informal water trading arrangements, for example, can include arrangements

[1] The returned search results from Google Scholar advanced search show the annual numbers of published studies that 1) include the phrase “water market” or “water markets” anywhere in the text, and 2) include the phrase “water market” or “water markets” in the title. These published studies include books, book chapters, journal articles, reports, openly accessible working/research papers archived by research institutions, and archived PhD dissertations/theses.

between neighbours (e.g. Maestu 2013) and formal water trading arrangements may comprise sanctioned rules, processes, catchment areas managed by governments and/or communities.

Formal water markets have evolved widely in the world since the 1970s (Chong & Sunding 2006) and exist in many countries in the world (with differing development stages), for example in the USA, Spain and Chile (e.g. Grafton et al. 2011; Hearne & Easter 1997; Howitt 1994; Palomo-Hierro et al. 2015). Formal water markets can be slow to develop in some regions due to a number of reasons, such as local political circumstances and the interrelated nature of water use (e.g. return flows) (Vaux & Howitt 1984; Young 1986).

However, informal markets are widespread and come in diverse forms (e.g. private tube-wells in India or informal swapping of water in US, Spain and Mexico without going through formal administrative procedures) (De Stefano & Hernández-Mora 2016; Mukherji 2008). But, few countries have come close to the institutional preconditions associated with active water markets in Australia.

Grafton et al. (2011) introduced an integrated framework to assess and compare the institutional foundations, economic efficiency, and environmental sustainability of water markets around the world. The following criteria are used to assess the ***institutional foundations*** of water markets:

- recognition of the public interest (legal and practical recognition of multiple interests in water resources);
- administrative capacity (sufficient administrative authority, resources, and information to manage water resources effectively);
- well-developed horizontal and vertical linkages (robust and clear institutional relationships, both at a given level of governance and between different levels of governance);
- legal/administrative clarity (including definition and recognition of water rights and trading rules as well as transparent administrative actions);
- priority of use (provision of water for basic human needs and the existence of beneficial use requirements);
- initial allocation and reallocation (transparent processes for allocating water rights and reallocating as priorities evolve);
- dealing with market failures (recognition of third party effects and appropriate and robust mechanisms for resolving conflict); and
- adaptive management of institutions (capacity for institutional adaptation).

The measures of the ***economic efficiency*** of the framework involve:

- size of the market (volume of water traded from permanent and temporary water rights as a percentage of total water rights);
- estimates of the annual monetary gains (in U.S. dollars) from water trade;
- size of storage (which allows for trades over a longer duration and trades upriver);
- nature of water rights (the extent to which they are unbundled so that water rights are separated from land rights);
- breadth of market (capacity for water trading between catchments, including upstream trades, as well as intersectoral trading); and
- market price formation and availability (predictability of prices given changing water availability and accessibility of price information).

Water allocation regimes, such as water markets, typically aim to comply with economic efficiency terms (focusing on wealth creation by a resource) and social equity considerations (focusing on the wealth distribution among sectors and individuals) (Dinar et al. 1997). Building on above, there are three distinct forms of economic efficiency associated with water markets:

1) *Allocative efficiency*: improving water resource short-term decision making reflecting seasonal conditions (e.g. weather, commodity price adjustments, cropping choices) is facilitated by water allocation trade.
2) *Dynamic efficiency*: improving water resource structural or long-term decision making to reflect new investment opportunities, regulatory shifts in access arrangements (e.g. extraction limits or embargos) or personal strategic choices (e.g. retirement) – which is best achieved through water entitlement trade.
3) *Productive efficiency*: water price changes (both temporary and permanent) offer incentives for the efficient use of water resources as either an investment or input for productive outcomes (Loch et al. 2013).

And finally, the following criteria in Grafton et al. (2011) were used to assess preconditions for meeting ***environmental sustainability***:

- adequate scientific data to determine hydrological requirements of water-based environmental resources;
- adequate provisions for environmental flows;
- adaptive management of environmental flows, including the capacity to monitor the environment;
- water quality considerations in water planning and markets; and
- complementary basin and catchment level planning.

The framework highlights important linkages between water market development, institutional constraints, and management goals and helps to identify which water markets contribute to integrated water resource management, which features of water markets require further development and how water governance can be improved (Grafton et al. 2011).

Grafton et al. (2016) builds on Bakker (2007) and Grafton et al. (2011) to provide another way for thinking about differing points of view about water market issues. This includes the concepts of:

- privatisation (allocation of individual rights);
- deregulation (diminishment of the regulatory role of public organisations);
- decentralisation (transfer of decision making and responsibility to a subsidiary level of authority);
- corporatisation (shift from public to corporate ownership);
- commercialisation (adoption of business models of practice and decision making);
- marketisation (use of markets to determine use);
- resource commodification (treatment of natural resources, including water, as a market good).

This framework provides key insights into why there are such differing views of water markets. Often those who argue against markets is because they believe markets are a tool of global capitalism that results in appropriative privatisation, where state or private actors obtain water resources (without meaningful compensation) previously held in common ownership. Other arguments against markets include that they ignore uses that are not directly valued by markets (such as environmental use) and hence are not given any primary importance (Harvey 1993). To achieve optimal resource allocation, water allocation schemes can be evaluated according to several criteria: flexibility, security, real opportunity cost, predictability, equity, political and public acceptability (Howe et al. 1986) as well as efficacy and administrative feasibility/sustainability (Winpenny 1994).

But as Grafton et al. (2016) outline, while there may be examples of privatisation leading to appropriation, the issue that must be focussed upon is if this is the markets fault, or if it is a result of the institutions that surround markets and market failure. Part of this issue is needing to understand where market failures in water markets exist. The next session provides an overview of market failure.

1.2 Market failure in general

Modern economic theories generally hypothesise that, in perfectly competitive markets where there are numerous buyers and sellers who are price takers, the market will act as if guided by an ‘invisible hand’ that automatically equalizes demand and supply, resulting in market clearing where there is no leftover supply or demand (Smith 1976). While this belief often holds, market clearing relies on a series of assumptions. The ‘invisible hand’ described by Adam Smith as first published in 1776 is indeed the price mechanism: there will be one and only one equilibrium price for a certain good given the law of demand (supply) stating that demand (supply) decreases (increases) with market price, ceteris paribus. This implicitly relies on several prerequisites regarding price formation. First, the good is neither infeasible to supply (when cost is too high, such as endangered wildlife species) nor non-scarce (supply is abundant and thus free, such as fresh air). Second, both producers and consumers are price takers without any bargaining power. Third, there is clearly defined property rights that guarantee all costs and benefits will be accountable. Fourth, both producers and consumers have full information regarding the good being bought and sold in the market, as well as the rational behavioural patterns of each other.

Although markets can function well in allocating resources through the price mechanism, these prerequisites often cannot hold. Violation of any of these prerequisites will result in market failure(s), where the market mechanism cannot efficiently allocate resources. Quiggin (2019) provides a full discussion on market failure issues. Particularly, infeasibility or non-scarcity will directly result in incomplete or missing markets. Several major types of market failures can further occur even when markets exist, which are discussed below.

1. **Imperfect competition** will occur if output markets are not contestable but nevertheless characterised by monopoly, oligopoly, bilateral monopoly or some other market imperfection. In these cases, the ‘invisible hand’ may fail to allocate resources efficiently. Multiple factors can prevent competition from occurring. Particularly, certain endowment of a critical resource used in the production of certain goods can prevent market entries of resource-poor competitors, which may include the climatic conditions of growing certain crops or producing certain food products. Also, geographic features as remote locations and great distances can discourage/reduce competition. Moreover, governments often create monopolies through the legal system, licensing regulations, patent laws, import restrictions, etc., to encourage innovation. In these cases, producer(s) can exercise some pricing power so as to maximize profits at the cost of consumer welfare losses, rendering market unable to allocate resources efficiently. In fact, most modern markets are of a ‘monopolistic competition’ nature where, though there are numerous producers/sellers, the goods being produced are all slightly different from those of competitors. Therefore, sellers all have some bargaining power in pricing (Dixit & Stiglitz 1977).
2. **Externalities** will occur when property rights are not clearly defined, and so costs and/or benefits observe spillovers to others. In this case, discrepancies between private and social benefits and costs will be observed, and the resource allocation generated by markets will not be efficient because market prices do not reflect the ‘full’ or social costs involved. Hence, individual market behaviours will have an impact on the welfare of others, and market mechanisms cannot yield socially optimal levels of consumption and production. A typical problem is the ‘tragedy of the commons’, stating that certain resources without clearly defined property rights will be overexploited. For instance, in absence of monitoring efforts, state-owned forests or unclaimed surface/groundwater resources will usually become open access, as observed in developing countries. As markets cannot allocate these resources effectively, government intervention is usually needed. For instance, government production/procurement will be needed when the benefits are not privately enjoyed and/or the costs of producing certain goods cannot be renumerated, as profit-seeking private agents will supply these goods. Examples include the provision of medical services in the event of epidemics, and the conservation/restoration of ecosystems.

3. **Information asymmetry** describes the situation where one party of a transaction has better information than the other. In this case, the information-rich agent can act towards their own interests at the cost of the information-poor. Two typical problems are adverse selection and moral hazard. Adverse selection describes the situation where the information-rich agent might participate selectively in trades which benefit him or her the most, at the expense of the other trader (Akerlof 1970). Moral hazard depicts the case that economic agents will take more risks when they can pass the cost of their risky behaviours on others (Finkelstein et al. 2015). These two problems are related in that they describe scenarios before and after the transaction under information asymmetry. For instance, risk-seeking farmers will more likely get crop insurance coverage, and once covered, they may exercise riskier practices in their cultivation as they do not need to bear the costs in terms of crop failures.

A more general consideration of market failures also incorporates macroeconomic dynamics, and specifically consider efficiency issues in face of issues such as high inflation, high unemployment rates, and recession. In most cases, since pure market mechanisms cannot allocate resources efficiently, government intervention(s) will be needed to correct for market failures and maintain transaction efficiency in relative markets, which also brings up issues in regards to inequality. Chapter 5 discusses in more detail.

1.2.1 Distributional issues and pecuniary externalities

Pecuniary externalities are different from the externalities discussed above in that they work through the price system, where the actions of an economic agent cause an increase or decrease in market prices (Laffont 1989). For instance, the substantial consumption of a certain good by some consumers can increase the price of that good, thereby hurting the welfare of other consumers who enter the market later. In complete markets, pecuniary externalities do not jeopardise the optimality of resource allocation through prices. In this case, certain consumers' buying a good raises the price, but the loss of other consumers due to higher prices is precisely offset by the gain of producers, and the market mechanism still works in efficiently allocating resources.

However, pecuniary externalities do matter when markets are incomplete, and the welfare effects of a price movement on consumers and producers do not generally offset each other (Greenwald & Stiglitz 1986). Particularly, when some agents are subject to resource constraints, the updated decision due to price changes may no longer be optimal. This typically occurs when there is a capacity requirement/threshold to access certain agricultural and resource markets, or when smallholders are usually marginalised by modern market organisational forms such as contract farming due to high transaction costs. Net welfare consequences would occur in those cases and the market could fail to allocate resources efficiently.

Market failures are confounded with income inequality and distributional issues in a complicated manner. Particularly, market failures can take the form of occupational, educational, managerial, and capital rents that are generated by institutional barriers that restrict the free flow of capital or labour. This existence of rents are associated with observed income inequality. Based on this notion, market failures can generate income inequality in numerous ways. Ravallion (2014) investigates income inequality in developing countries, and discusses some of those mechanisms. For instance, even though all may know about various new technical innovations, the wealthier and more connected have an increasing advantage in adoption and testing of new ideas, which may create path dependencies (where current and future choices and options are influenced by decisions made in the past). Therefore, higher current inequality implies lower future wealth in similar conditions.

In most cases, institutional changes are called for to correct for identified market failures and improve social welfare. The following section addresses the institutions needed for well-functioning markets in more general. If markets do play the central role in water appropriation, then this means that marketisation has to be the primary or single cause of the privatisation. But, across the wold there are well-documented examples of privatisation without marketisation (Bakker 2007; Trawick 2003) which highlight that exploitation through privatisation does not need water markets to exist and indeed are more a result of fundamental income, wealth and power inequalities (and the institutions that underlie them) rather than the operation of markets per se. Indeed, the most successful water market in the world, the southern MDB, was not established by appropriation by accumulation. But, Wheeler and Garrick's (2020) analysis of the operation and performance of two water markets (the South and the North) in the MDB highlight the issues associated with institutions, wealth and power issues impacting water use (see section 2.1 for more comment on this). Furthermore, water marketisation is synonymous with commodification. However, this is not necessarily in opposition to the 'commons', as shown by the Murray-Darling Basin Plan that has used the market to return water from consumptive to environmental use (Grafton et al. 2016).

Another argument that needs to rectified is that water markets fail to account for vital community, environmental or social values (Kiem 2013). Evidence shows that disadvantaged communities have been given right-based resource allocations (e.g. Parsons 1993; Wilson 2014) to protect their overall community interests or to resolve past injustices, hence it can be used to reflect community, environmental, and social values.

The following section addresses what are the basic conditions required before resource commodification and markets should be used for water, to avoid some of the potential negative impacts that may arise.

1.3 Conditions required for establishing formal water markets

A key criterion for establishing water markets are well defined, enforced, and transferable water use rights (Grafton et al. 2004). Wheeler et al. (2017b) outline three institutional factors as a prerequisite for establishing water markets. It is important to note that a country's legal framework and level of decentralisation will influence reform types and sequences. The institutional factors are graphically depicted in Figure 1.2 and can be summarised as:

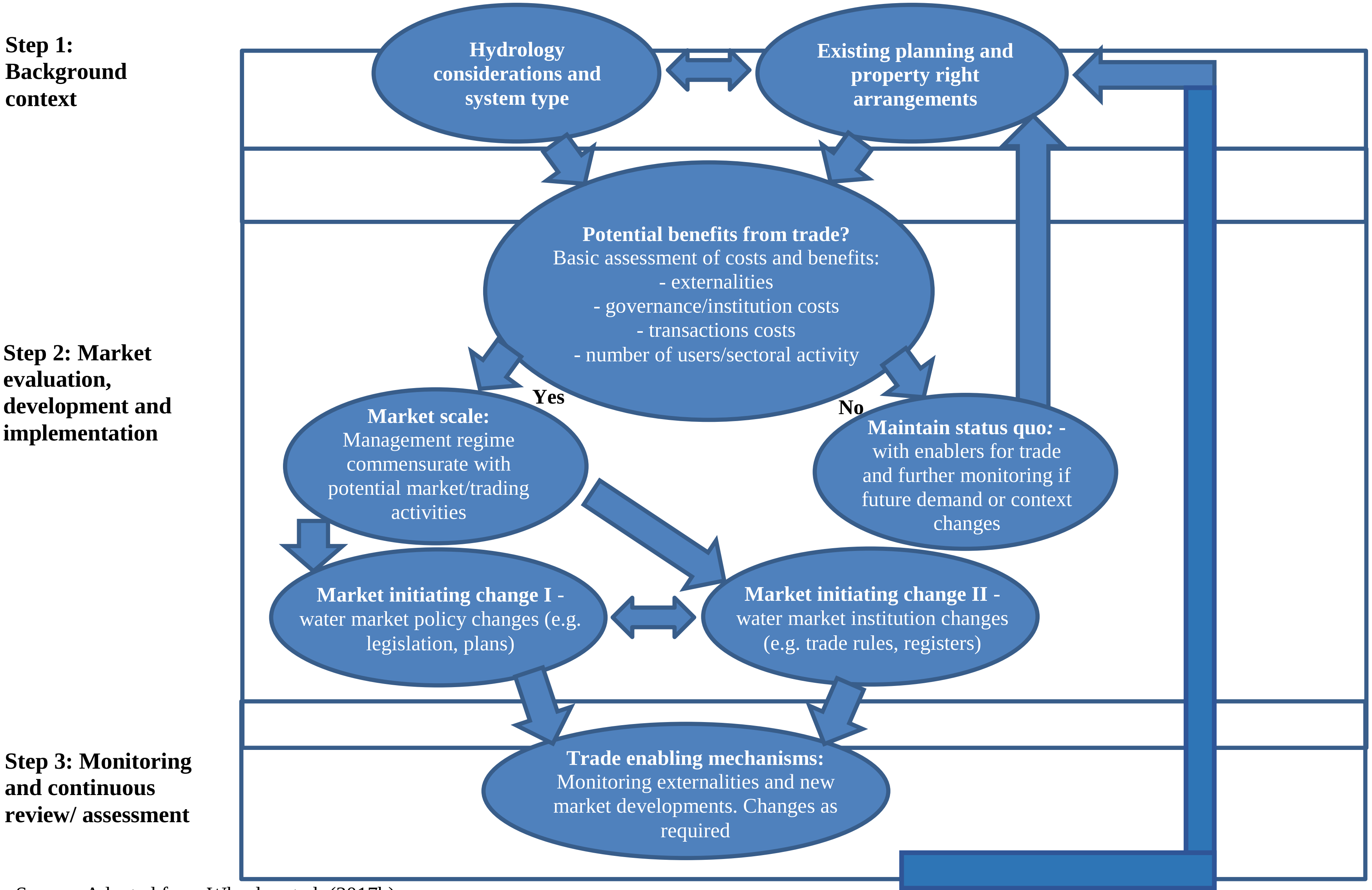
(1) ***Enabling Institutions***: defining the total resource pool available for consumptive use and hydrological factors of use; and evaluating the current institutional, legislative, planning and regulatory capacity to facilitate water trade, involving: i) specifying each resource share in perpetuity while allowing for changes in the proportion allocated to each share (comprises setting caps and regulations on use); ii) fully assigning responsibility for managing supply risk to users; iii) ensuring enforcement, strict regulation of caps and monitoring/compliance; and iv) keeping transaction costs low.

(2) ***Facilitating Gains from Trade***: developing clear and consistent trading rules; assessing benefits and costs of market-based reallocation; for example, numbers of individuals who can trade (versus adoption of trade); homogeneity of water-use, adaptation benefits, cost of water reform, ongoing trade transaction costs, and assessment of externalities. There is a difference between legislating for water trade to occur, allowing transfers between a small number of individuals, versus broader water reform legislation (e.g. creating water registers with transparent, complete and fully accessible data, clearer trade rules, public information sources).

(3) ***Monitoring and Enforcement***: use of water markets and water extractions need ongoing monitoring and enforcement to ensure compliance, as well as continued development of trade enabling mechanisms, including: seeking to limit/reduce transaction costs, scanning for unanticipated externalities, developing new market products (e.g. option contracts or forwards) and then implementing, if needed, new legislative changes and planning requirements. Water market rules need flexibility to ensure water security and manage future uncertainty (Wheeler et al. 2017b).

Only point 2) represents specific institutional factors required for water markets while points 1) and 3) are needed for any property rights regime. Water markets are complex economic instruments to design, develop, implement and sustain over time (Wheeler et al. 2017b). However, if designed effectively, water markets can provide sustainable and effective outcomes for farmer adaptation and environmental resilience in the longer-term (Crase & O'Keefe 2009).

Figure 1.2 Conceptual approach for considering where water markets can be introduced



Source: Adapted from Wheeler et al. (2017b)

1.4 Australian Water Markets Overview

Australian water management developed from largely supply management approaches focusing on expansion, to more sustainable practices that seek to balance competing water demands. Accordingly, water demand management strategies, including water markets, were increasingly developed and implemented to manage water allocation issues and are expected to be progressively adopted as a result of projected increases in future water demand (Grafton et al. 2016).

Today Australia's water market (particularly in the southern MDB) is mature and, in comparison to many other countries, ranks high in terms of institutional foundations, economic efficiency, and environmental sustainability (Grafton et al. 2011). Although Australia's water market in the southern MDB guides many other nations in the world that experience similar water scarcity concerns (Wheeler et al. 2017b), there are still numerous issues that remain about how they can be improved (Seidl et al. 2020b; Wheeler & Garrick 2020). But, water trading has become an important tool to manage water scarcity and is widely adopted by irrigators as an adaptation strategy (Wheeler et al. 2014a).

The southern MDB (sMDB) is one of the most active water trading region worldwide and the largest water market in Australia in terms of the geographic area and volumes/numbers of water entitlements (NWC 2013). On the other hand, the northern MDB water markets observe lower water trading volumes/numbers attributed to relative illiquidity, less hydrological connectivity and crop diversity coupled with widespread farm water storage and groundwater use (Wheeler & Garrick 2020). Schedule D of the Murray-Darling Basin Agreement outlines permissible transfer between different catchments (MDBA 2010).

Water markets in Australia have an estimated annual turnover of AUD$1–2 billion. Aither (2019a) estimated a water allocation trade value of $566 million in 2018-19 (a threefold increase on 2017/18 value) and total water entitlement transfers value of $699 million. The estimated value of total water entitlement on issue was $22.7 billion.

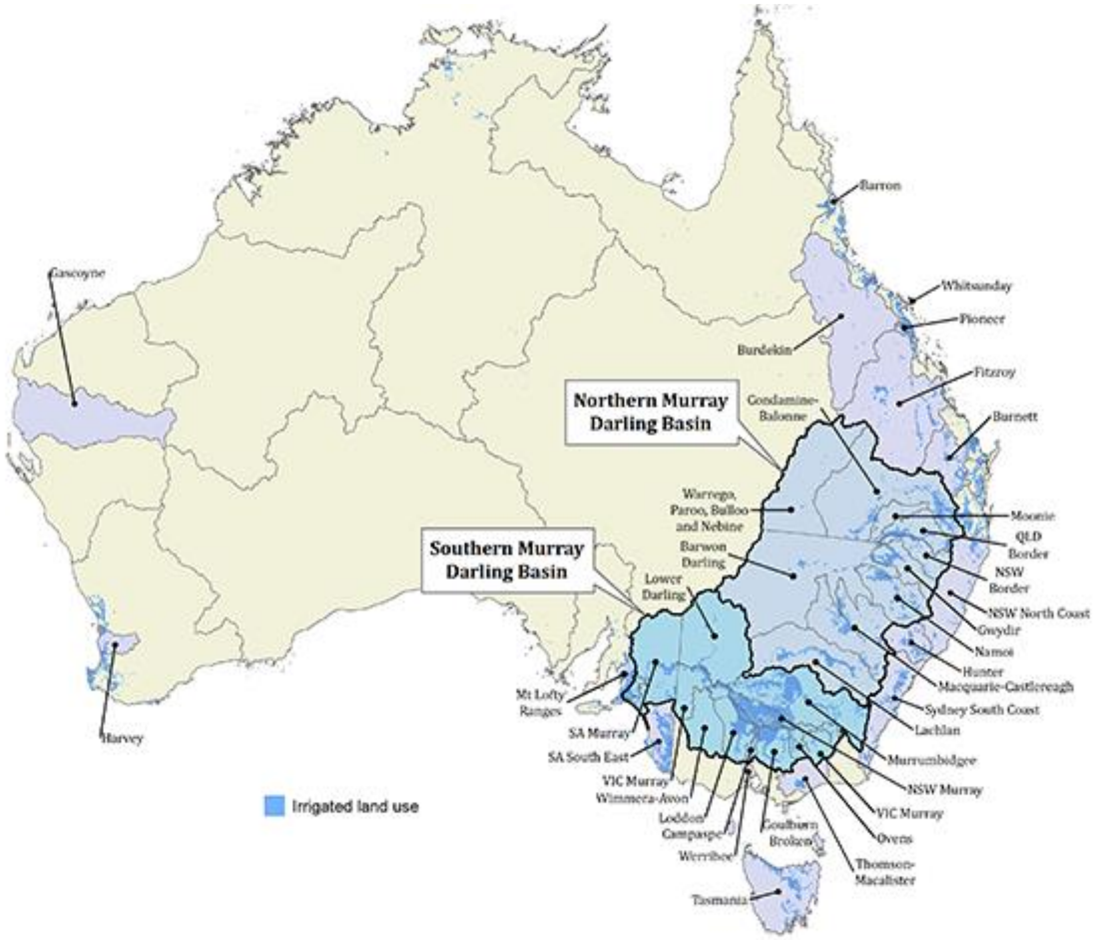
Tables 1.1 to 1.3 present recent water market statistics for Australia by state and water resource. New South Wales and Victoria are the most active water trading states.

Table 1.1 Water Allocation Trade Summary 2018/19 by State and Water Resource

	Resource type	**Number of trades**	**Volume traded (ML)**	**Median price ($/ML)**
New South Wales	Surface water	11,944	2,214,112	420
	Groundwater	1,132	263,616	160
Queensland	Surface water	1,805	233,974	*Na*
	Groundwater	269	12,672	*Na*
South Australia	Surface water	1,540	356,311	425
	Groundwater	102	4,907	1,000
Tasmania	Surface water	180	9,386	114
Victoria	Surface water	20,000	2,681,244	430
Western Australia	Surface water	85	4,576	31
Grand Total		**37,057**	**5,780,798**	**420**

Source: BOM (2020)

Figure 1.3 Australian water systems with water allocation trade activity as at 2015-16



<u>Source:</u> ABARES (2019)

Table 1.2 Entitlement Trade Summary 2018/19 by State and Water Resource

	Resource type	Number of Trades	Volume traded (ML)	Median price ($/ML)
New South Wales	Surface water	2,177	633,696	1,646
	Groundwater	441	87,680	1,000
Queensland	Surface water	1,208	205,163	4,000
	Groundwater	495	55,534	8,571
South Australia	Surface water	704	184,415	4,539
	Groundwater	598	93,317	1,000
Tasmania	Surface water	365	30,956	1,090
	Groundwater	1	100	Na
Victoria	Surface water	4,315	258,295	3,100
	Groundwater	831	110,389	120
Western Australia	Surface water	49	4,929	476
	Groundwater	211	66,620	1,179
Grand Total		**11,395**	**1,731,094**	**2,700**

<u>Source</u>: BOM (2020)

Table 1.3 Water Entitlement on Issue Summary June 2018/19 by State and Water Resource

	Resource type	Number	Volume (ML)
Australian Capital Territory	Total	314	79,207
	Surface water	138	77,522
	Groundwater	176	1,685
New South Wales	Total	38,274	14,911,212
	Surface water	27,633	12,953,631
	Groundwater	10,641	1,957,581
Northern Territory	Total	523	570,890
	Surface water	65	268,061
	Groundwater	458	302,829
Queensland	Total	28,064	6,771,697
	Surface water	19,663	5,691,772
	Groundwater	8,401	1,079,925
South Australia	Total	15,166	2,756,028
	Surface water	6,507	1,197,671
	Groundwater	8,659	1,558,357
Tasmania	Total	10,085	2,337,533
	Surface water	10,018	2,328,714
	Groundwater	67	8,819
Victoria	Total	81,666	7,751,336
	Surface water	74,110	6,824,171
	Groundwater	7,556	927,165
Western Australia	Total	12,253	3,946,575
	Surface water	1,346	984,479
	Groundwater	10,907	2,962,095
Grand Total		**186,345**	**39,124,478**

Source: BOM (2020)
Note: Nominal values (actual water made available for use depends on water allocated to each entitlement type)

The following provides an overview of the history and development of water policy changes in Australia, focussing on the Murray-Darling Basin (MDB) which has the majority of water markets.

1.4.1 Water markets in the Murray-Darling Basin

The MDB is the catchment for Australia's longest rivers, the Murray and the Darling Rivers. The Basin covers an area of more than 1 million square kilometres (14% of Australia's total surface area), and includes 75% of New South Wales (NSW), more than 50% of Victoria (VIC), 15% of Queensland, 8% of South Australia (SA), and all of the Australian Capital Territory (ACT). There are 22 major catchments (or sub-Basins) within the MDB. Northern catchments running to the Darling River form the northern MDB and southern catchments running to the River Murray form the southern MDB (see Figure 1.3) (MDBA 2018). The region is called a Basin because all watercourses run to a common point.

The MDB is Australia’s most important agricultural production region and is an area of great agricultural, ecological, cultural and recreational significance (MDBA 2009). For example, 75,000 First Nations people live in the MDB (Taylor et al. 2016). Irrigated agriculture in the MDB makes a significant contribution to both national and regional economies (Ashton 2014) but went through various extreme events over the past few decades, such as droughts, over-allocation of resources, economic depressions, government subsidies, rising water tables and salinity levels, and increasing water prices (Hallows & Thompson 1995). Particularly, widespread losses in water and land quality in addition to a decreased and more variable water supply threatened irrigated agriculture (Connell 2007; Quiggin 2001). Thus, water resources management in the MDB has a long history of water governance producing a myriad of agreements and other initiatives (Cummins & Watson 2012; Quiggin 2012).

Figure 1.4. The boundary of the Murray–Darling Basin

Source: MDBA (2016)

In general, the southern MDB is much more connected than the northern MDB. When the rivers are connected, water trading is possible. Hence, water trading occurs much more in the southern MDB, than water trade from the Darling into the southern system. Also, water markets are not as developed in the northern MDB compared to southern MDB water markets, attributed mainly to large water supply variations between and during years and fewer regulated rivers, and Section 2.1 elaborates on the reasons for this further.

From the mid-1980s, uptake of private dams or off-river storages (also called ring-tanks) increased widely on the floodplains, with the purpose of ‘capturing’ flows from unregulated tributary rivers, spills of major dams and floodplain inundation into these off-river storages. Heavy rainfall and tropical cyclone events are predicted to become more frequent, which will increase rainfall variability in the north-eastern regions of the MDB. Furthermore, drought frequency is predicted to increase in the southern and south-eastern regions, with reductions in water availability and increased temperatures (CSIRO 2012).

Table 1.4 Water Resource Management and Basin Plan Roles in the MDB

	Australian Government[a]	*Basin States*	*Joint Basin Governments*[b]	*MDBA*	*Productivity Commission*
Resetting the balance					
Setting and reviewing SDLs				▲	
Recovering water	▲				
Implementing SDL adjustment measures	▲	▲	▲	■	
Reconciling SDL adjustment measures				▲	
Delivering structural adjustment programs	▲				
Funding to improve Indigenous outcomes	▲				
Management arrangements					
Water resource planning	▲	▲ ●		▲	
Environmental water management	▲	▲ ●	■	▲■	
Facilitating water trading	▲	▲■●	■	▲■	
Facilitating Indigenous values and uses	▲	▲■●	■	▲■	
Meeting critical human water needs		▲■●	■	▲■	
Managing water quality and salinity		▲■●	■	▲■	
Ensuring compliance with SDLs and Basin Plan				▲	
Ensuring compliance with water take rules		■●			
Reporting, monitoring and evaluation	▲	▲ ●	■	▲■	▲
River management		■●	■[c]	■[c]	
Asset management and operation		■●	■[c]	■[c]	
Resource manager		■●	■[c]	■[c]	

[a] Includes the roles of the Commonwealth Environmental Water Holder, Department of Agriculture and Water Resources, and Department of Infrastructure, Regional Development and Cities. [b] Consists of Basin States and the Australian Government. [c] River Murray only.

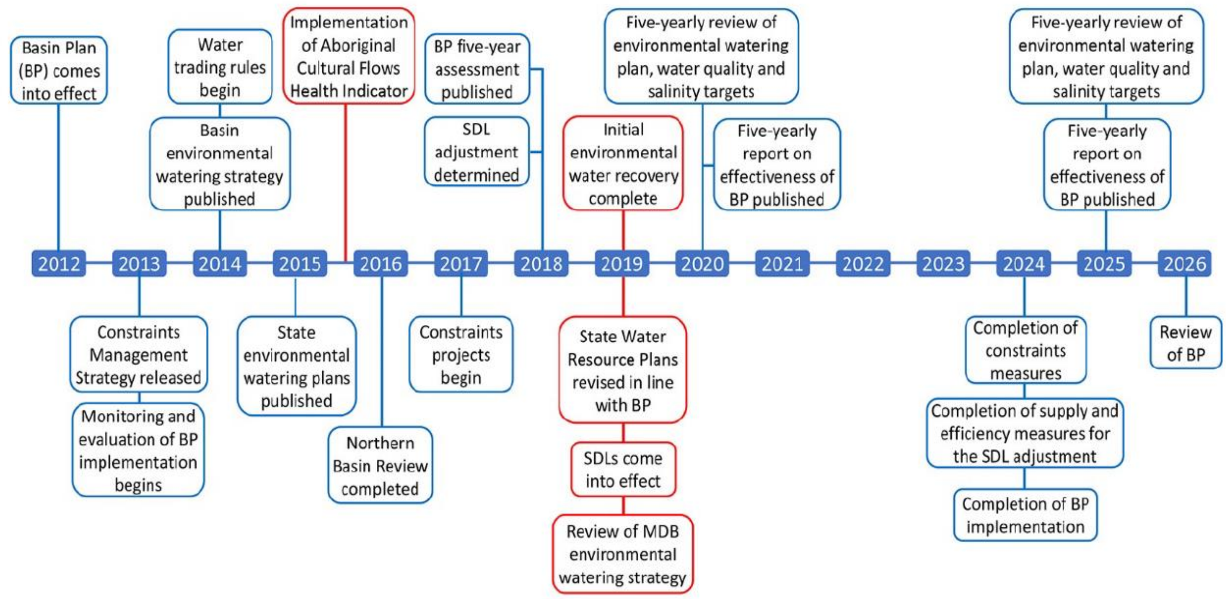
▲ Basin Plan ■ MDB Agreement ● State water resource management laws

Source: Productivity Commission (2018, p. 345)

The MDB is federally managed and an independent Authority (the Murray-Darling Basin Authority (MDBA)) is responsible for Basin-wide planning. The states are responsible for managing water extraction within agreed limits. Authorities with water management responsibilities include the Australian government, state governments, MDBA, Productivity Commission (PC) and the Australian

Consumer & Competition Council (ACCC) (whose role is to enforce and monitor water market and charge rules). Table 1.4 below highlights some of these roles. Figure 1.5 shows a timeline of Basin Plan implementation. This water market literature review does not provide detailed commentary on Basin Plan issues, for further detail on the Basin Plan and progress to date, see Grafton and Wheeler (2018); AAS (2019) and Grafton et al. (2020).

Figure 1.5 Basin Plan implementation timeline



<u>Source:</u> Grafton et al. (2020, p. 5)

Irrigators in the MDB have a number of adaptation options available to them when facing water scarcity issues (or to reduce water supply risk) on the farm. Table 1.5 illustrates the many adaptation measures that irrigators can adopt from each of the categories of information; trade; agronomy; farm structure; land; infrastructure and environment.

Note, such incremental adaptation measures can be completely different to transformational change that may include: a) a complete shift to dry-land operations, and selling all water entitlements; b) large-scale buying of irrigated land and/or water entitlements in a variety of different areas to hedge against declining water allocations and climate risk; c) selling the farm and relocating to an area with more reliable rainfall; and d) leaving farming to take up job opportunities elsewhere. Incremental adaptation is more related to the adoption of actions that do not require major decisions and or information (Wheeler et al. 2014a). Dinh et al. (2017) found that irrigators and dryland farmers in the MDB adjust using a wide range of strategies, with irrigators adopting more strategies (especially investment-related and water related strategies) than dryland farmers. Irrigator adjustment was found associated with: large, intensive-farms, less off-farm income and cropping farms. Irrigators also generally place more importance on water-related strategies than output- and input-related strategies. On the other hand, it was found that less intensive dryland farmers (such as hobby farmers) were more likely to adjust than other dryland farmers.

1.4.2 History of water markets in the MDB

In Australia, there have been reports of water being informally traded between irrigators during the World War II drought. Various market trials have also been in place for a number of decades. This meant that water trade was an individual decision made by irrigators in either an irrigation district or a private irrigator with surface or groundwater rights (Wheeler 2014).

Table 1.5 Irrigation Adaptation Measures

Type	Strategy	Specifics
Information	• Utilise a variety of information to predict risk of water scarcity for the season, through a) utilising historic records of inflows and allocations, and b) utilising Southern Oscillation Index data and a range of climate projections for rainfall and evaporation predictions • Utilise water trade information to understand intra-seasonal trade prices & demand	• Provides better predictions about risk of crop failure, whether to plant or trade water for the season • Similarly, use crop insurance/reinsurance options to hedge against climate risk • Can sell/buy water allocations/entitlement at the point in the intra-season where private gains are maximised
Trade	• Utilise alternative water market products such as options, entitlement leasing • Buy (or sell) more water allocations and/or entitlements • Carry-over	• Helps to even out price hikes, provides more certainty about prices and returns over the medium term • Swap lower security entitlements for higher security entitlements. Make greater use of resources not yet fully allocated or subject to restrictions (such as groundwater) • Adopt carry-over techniques (where available) and buy water allocations when cheaper to carry-over
Land	• Buy (or sell more land) • Increase (or decrease) irrigated areas (e.g. irrigate a larger section and improve input efficiency or only irrigate part of an area) • Dry-land practices	• Larger enterprises provide a number of benefits in terms of business scale – can build greater flexibility & capacity to respond more quickly to changed conditions or volatility. Shift growing areas to southern locations (e.g. viticulture to Tasmania) • If production is limited by available water supply, irrigators may need to abandon the idea that production can be maximised on individual paddocks. It is likely that optimal farm performance in irrigated settings will be arrived at by sub-optimal paddock performance & spreading the water where land is abundant • Learn & implement dry-land practices (such as stubble retention and/or supplementary feed for livestock) because future farming with less water is less likely to focus on purely irrigated practices
Farm structure	• Increase off-farm work • Portfolio management • Develop ownership structures to better manage risk	• Reduce risk associated with one source of income • Optimise responsiveness to water availability, such as growing a mix of permanent and annual plantings. Put mechanisms in place to share or transfer risk to others. • Includes further consolidation, possibly at an accelerating rate, to larger, better capitalized family enterprises or corporate structure agricultural enterprises. Establish succession early on for the farm. • Longer-term supply contracts with key purchasers
Agronomy	• Change basic agronomy and management farm practices	• Different crop mixes; precision agriculture; short rotation and pasture-spelling regimes; row configuration; diversify production; varieties, planting dates/times, irrigation, fertilizer regimes; soil management practices, substitute pasture for bought feed; fallow production area; shift timing of livestock reproduction; focus on more water flexible & annual/semi-annual crops; minimum/no-tillage; crop cover; and use deficit irrigation when needed
Infrastructure	• Adopt more efficient irrigation water infrastructure • Improve irrigation management	• Install automatic bay gates, drip irrigation, laser grade paddocks, update reuse system, recycling system, solar energy use, on-farm water storage • Improve irrigation scheduling, soil moisture monitoring, decrease furrow lengths; crop protection treatments (greenhouse, polytunnel, solar radiation shading and evaporative cooling)
Environment	• Employ sustainable practices	• Plant trees, crop cover, improve soil management, adopt conservation tillage, grade banks; improve sediment runoff via grassed waterways and erosion control structures; wetland creation; reduce carrying capacity

Sources: Adapted from Wheeler et al. (2014a) and AFI (2019)

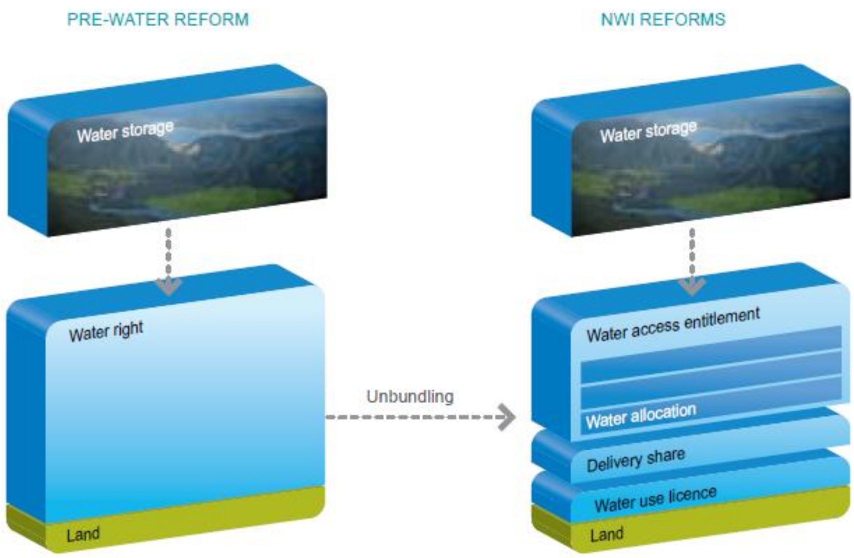
Temporary water trade has been more officially occurring since the early 1980s in NSW and SA, and since 1987 in Victoria. Permanent water trades were introduced later with a slower adoption rate. Formal water trading was formally introduced in the 1990s in response to decades of environmental issues (e.g. periods of drought, algal bloom), over-allocation/regulative problems of water resources and inefficiencies within the MDB (Bjornlund 2006c; Crase et al. 2004; NWC 2011b). Over the years, irrigators in the MDB had been adapting to fluctuating seasonal water allocations during droughts and to various changes in their operating environment while governments introduced policies to alleviate the pressure on environmental, economic, and societal systems. Generally, policy initiatives involved improvements to the water market, changes to pricing for water storage and delivery, funding for modernising irrigation infrastructure, buying back water entitlements, and the development of the Basin Plan (Ashton 2014).

Major water reforms were driven by the Council of Australian Governments (COAG) arranging for the separation of water rights from land rights and enabling the expansion of water markets across borders of the MDB (COAG 1994). With COAG's introduction of the ***National Water Initiative*** (NWI) in 2004 (i.e. Australia's blueprint for water reform aiming to improve water pricing, expand trade, introduce registers and water accounting, and prepare water plans), water markets became a central tool for water management and water reallocation in the MDB (Bjornlund 2006a; COAG 2004).

The NWI aimed to remove barriers to water trade with one of the main aims being the unbundling of land and water ownership (Crase et al. 2014a). Figure 1.6 provides an unbundling example. Water ownership was separated into four different rights:

1) a water entitlement, granting the right to extract a share of available water into perpetuity,
2) a water use entitlement, allowing irrigators to use the water on their land,
3) a water allocation account, tracking water extracted against allocation available under an entitlement, and
4) a delivery share, irrigators' right to have water delivered to their property using the infrastructure of their irrigation district.

Figure 1.6 Unbundling of Water Rights under the National Water Initiative



Source: NWC (2011b, p. 83)

Droughts or other crises have typically been the major catalyst for water policy changes in the MDB (e.g. Grafton & Horne 2014; Wheeler 2014). Table 1.6 provides a comprehensive list of water institutions and relevant reforms in the MDB. One of the major water reforms was the introduction of a cap (limited diversions to 1993-94 levels in Victoria, NSW, SA (where the cap was set at an average use of 90% of entitlements), and 1999-2000 levels in Queensland) on further surface-water extractions and use alongside markets (e.g. 'cap and trade'). Caps apply to all surface-water and groundwater diverted, with water resource plans to be developed and were meant to be all implemented from mid-2019 onwards (Grafton & Wheeler 2018). The other major reform addressing water over-allocation was introduced in 2007 in response to the prolonged Millennium Drought (common time-period 2001-02 – 2009-10), i.e. National Plan for Water Security formalised in the *Water Act 2007.* This program was expanded in 2008 with the new *Water for the Future program* involving an AUD$12.9 billion budget over a ten-year period (Parliament of Australia 2010). The budget allocated AUD$3.1 billion towards a water buyback program, which aimed to buy water entitlements from willing irrigators and return these to the environment, and AUD$5.8 billion towards Sustainable Rural Water Use and Irrigation Infrastructure (SRWUI) projects (DEWHA 2010). In this program, an irrigator receives a subsidy to implement specific infrastructure works and transfer a share of the assumed water savings in entitlements to the Australian Government. An additional subcategory of this mechanism – namely off-farm infrastructure modernisation –also contributes to assumed water savings (Grafton & Wheeler 2018).

Table 1.6 History of water institutions and reforms in the MDB

Reform/institution	**State(s) and description**
Water Conservation and Distribution Act 1881	VIC; allowed trusts to borrow for irrigation
Irrigation Act 1886	VIC; developed from the Deakin Royal Commission review in 1884 and was a radical departure from existing laws on riparian rights. Private water riparian rights were abolished, and landowners could apply for a diversion license. The Lyne Royal Commission followed with similar recommendations in NSW, with other states following
Water Authorities Act and the Irrigation Act 1891	QLD; provided for construction and maintenance of dams and weirs
Australian Constitution 1901	Commonwealth; allowed for state negotiations over river resources
Water Act 1905	VIC; established the State Rivers and Water Supply Commission in 1906
Water Conservation and Utilization Act 1910	QLD; vested control of natural waters with the state
Water Act 1912	NSW; established water licenses/extraction requirements, some environmental flow protection, as well as the right for the government to purchase entitlements
River Murray Waters Act 1915	Cwlth; first cross-boundary MDB agreement after agreement by the Commonwealth, VIC, NSW, and SA in 1914; created the River Murray Commission in 1917 that controlled development and works on the River Murray up to 1988
Water Act 1926	QLD; granted water allocation powers, water license, and use rules
River Murray Waters Agreement Amendment 1934	Commonwealth; amended to rationalise river use from navigation to irrigation and allow constructions, e.g., Snowy Mountain Scheme in 1949
Water Act 1958	VIC; granted more control over surface water
Groundwater Act 1969	VIC; controlled groundwater development and use, driven by urban town scarcity that relied on groundwater
Environment Protection Act 1970	VIC; protected groundwater quality
National Parks and Wildlife Act 1974	NSW; protected wild rivers and water bodies
Water Resources Act 1976	SA; implemented more controls over surface waters
River Murray Waters Agreement Amendment 1982	Commonwealth; expanded scope to include water quality, environmental and recreational issues
Water (Amendment) Act 1983/1984/1986	NSW; initially allowed water transfer scheme with permanent water trade transfers allowed in 1986

MDB Ministerial Council 1985	Commonwealth, NSW, VIC, and SA met to discuss problems
Water Administration Act 1986	NSW; allowed for greater environmental allocations
Planning and Environment Act 1987	VIC; regulated groundwater land management impacts
MDB Agreement 1987	Amended/renamed River Murray Waters Agreement
Salinity and Drainage Strategy 1989	Commonwealth, NSW, VIC, and SA; ministerial agreement to undertake works and measures to reduce average salinity
Water Act 1989	VIC; introduced water trade and direct water allocation to environment
Water Act and Water Resources Act 1989	QLD; introduced transferable water entitlements within the same water area
Heritage River Act 1992	VIC; protected wild rivers
MDB Agreement 1992	Formalised rules for implementation of salinity and drainage strategy of 1989 and amended 1987 MDB agreement; established the MDBC to replace River Murray Commission
Native Title Act 1993	Commonwealth; recognised native title holders' rights to use water for domestic/personal purposes, but they had no right to negotiate
Catchment & Land Protection Act 1994	VIC; protected quality and quantity of water supplies in declared catchments
COAG 1994	Commonwealth; introduced cap on extractions and agreed to unbundle water from land
National Heritage Trust of Australia Act 1997	Commonwealth; provided support for sustainable water management activities and funded the Murray-Darling 2001 program
Murray Lower Darling Rivers Indigenous Nations (MLDRIN) 1998	The Murray Lower Darling Rivers Indigenous Nations (MLDRIN) is a confederation of Indigenous Nations or traditional owners in the lower southern part of the MDB. MLDRIN was formed in 1998 during the Yorta Yorta Native Title Case with the aim to care for rivers and achieve water rights for Aboriginal people. The group currently represents 25 nations.
Environmental Protection and Biodiversity Conservation Act 1999	Commonwealth; protected Australian wetlands under Ramsar Convention for Wetlands of International Importance and created the Environmental Protection and Biodiversity Conservation Regulations 2000
National Action Plan for Salinity and Water Quality 2000	Commonwealth; endorsed by COAG in 2000, plans to reduce MDB salinity
Water Management Act 2000	NSW; developed water sharing plans, water access licenses, monitoring, enforcement
The Living Murray 2002	Six icon sites along the River Murray were selected across VIC, NSW, and SA to return to health through infrastructure expenditure and purchase of 500 GL of water
National Water Initiative (NWI) 2004	Commonwealth and all states agreed to a national blueprint of reform (following COAG 1994) in regard to water plans, sustainable water use, trade, pricing, urban water, registers, water accounting, and some recognition of indigenous water access and management
National Water Commission (NWC) Act 2004	Established the NWC, an independent statutory authority (abolished in 2014) that led the National Water Initiative (NWI)
Natural Resource Management Act 2004	SA; amendments in 2007 and enforced in 2009 for unbundling of water from land, with unbundling in River Murray Prescribe watercourse, Southern Basins, Musgrave Prescribed Wells Area
Wild Rivers Act 2005	QLD; protected wild rivers and water bodies
National Plan for Water Security 2007	Commonwealth; AUD10 billion to be spent over 10 years on governance, modernizing irrigation, and addressing over-allocation of water in the MDB
Water Act 2007	Commonwealth; removed trade barriers, introduced carryover, unbundled declared systems, dictated development of MDB Plan
Water for the Future 2008	Replaced National Plan for Water Security and increased funding to AUD12.9 billion
Water Amendment Act 2008	Commonwealth; created the MDBA that replaced the MDBC
Murray Lower–Darling Rivers Indigenous Nations 2008 & Northern Basin Aboriginal Nations 2010	Represents >75,000 indigenous MDB people across 46 indigenous nations
The Basin Plan 2012	Commonwealth; to be reviewed and revised through 7-year implementation phase

Water Amendment (Long-term Average Sustainable Diversion Limit Adjustment) Act 2012	Commonwealth; included the adjustment mechanism which would allow the reduction of water recovery for the environment by up to 650GL/year
Environmental Protection and Biodiversity Conservation Amendment Act–Water Trigger 2013	Commonwealth; assessed proposed coal seam gas and mining on water resources
Water Amendment (Water for the Environment Special Account) Act 2013	Commonwealth; made the acquisition of 450GL of additional water discretionary, limited acquisition to purported savings from on-farm efficiency projects and no enforceable link to environmental outcomes in SA
Foreign Acquisitions and Takeovers Regulations 2015 and Amendment Act 2017	Commonwealth; foreign owners must register water entitlements with Australian Taxation Office
Water Amendment Act 2015	Commonwealth; surface-water purchases capped at 1,500 GL, added more flexibility with efficiency measures
Natural Resources Access Regulator Act 2017	NSW; established Natural Resources Access Regulator
NSW Water Management Act 2018	NSW; established individual (and total) daily extraction limits and temporary water restrictions to protect environmental water
Basin Plan Amendment Instrument 2017	Commonwealth: allowed water recovery to reduce the volume of water entitlements held by the environment by 605 GL/year as a result of: (i) supply projects to more efficiently deliver water for the environment; (ii) efficiency projects to 'save' water for the environment; and (iii) constraints projects intended to allow for the more effective delivery and flow of water.
Reforms for better access to water for economic purposes for Indigenous groups 2017/18	NSW: Indigenous people can seek access to an Aboriginal Community Development Licence; VIC: Government has allocated $5 million to develop a roadmap for Aboriginal access to water for economic development; Australian Government committed $40 million for direct investment in cultural and economic water entitlements
Water Amendment Act 2018	Commonwealth; reduce surface-water recovery in the Northern Basin by 70GL, increased groundwater extractions, and allowed water recovered for the environment in one catchment to count towards a water recovery target in another catchment

Source: Updated from Grafton and Wheeler (2018) and NSW EDO (2018)
Abbreviations: COAG, Council of Australian Governments; GL, gigaliters; MDB, Murray-Darling Basin; MDBA, MDB Authority; MDBC, MDB Commission; NSW, New South Wales; NWC, National Water Commission; QLD, Queensland; SA, South Australia; VIC, Victoria.

The original target under the Murray-Darling Basin Plan was 2,750 (gigalitres-GL) in long-term average annual yield (LTAAY) to be returned from consumptive extraction to the environment. Given that downstream states (SA) thought it was inadequate, an additional 450GL was negotiated in 2012, to be acquired through on and off-farm infrastructure upgrades (Grafton & Wheeler 2018). Since 2013, buying water from willing irrigators through open tender was shelved, with some focus given to ‘strategic purchases’ via closed negotiations with large corporates. Such purchases have been criticised due to their lack of transparency, potentially inflated values and negative environmental externalities (Grafton, 2019; Seidl et al. 2020b).

Water is now predominantly recovered from infrastructure modernisation projects rather than buying back water entitlements (Loch et al. 2016), with a cap put on buybacks of 1500GL in 2015 (AAS, 2019). In 2018, further amendments were introduced that reduced entitlement recovery to 2,680GL (plus recovery is also flagged to be reduced a further 605GL, subject to the implementation of 36 ‘supply measure’ projects that are meant to offset water that would otherwise have to be recovered under the Plan in exchange for ‘equivalent environmental outcomes’) (Grafton 2019; Productivity Commission 2018). Suffice to note that these projects have been heavily criticised and have a very high probability that they will not achieve their predicted savings (Colloff & Pittock 2019; Productivity Commission 2018).

While the reemphasis on irrigation infrastructure water recovery is the preferred option for many farmers (though note, many do prefer market-based options) (Loch et al. 2014a), it is not cost-effective, and may not meet long-term sustainability aims of being able to flexibly respond to uncertain and variable future water supply, as put forward by a number of studies (e.g. Adamson & Loch 2014; Crase & O'Keefe 2009; Grafton 2007; Grafton 2010; Lee & Ancev 2009; Productivity Commission 2010; Wittwer & Dixon 2013).

1.4.3 Water rights in the MDB

As described previously, three broad types of water trading can be defined: i) short-term or temporary transfers of water (known as water allocation trade); ii) medium-term leasing of water allocations to secure access to water for a period of time specified in a contract (known as water leasing); and iii) permanent transfers of water entitlements – the on-going property right to either a proportion or fixed quantity of the available water at a given source (known as water entitlement trading) (Wheeler & Garrick 2020).

Various types of water property rights exist in the MDB: 1) ***water access rights*** (i.e. right to take/hold water from a water resource); 2) ***water delivery rights*** (i.e. right to have water delivered); and 3) ***irrigation rights***. There are two broad types of water access rights: *water (access) entitlements* and *water allocations*. A water (access) entitlement (also known as permanent water) is defined as *"a perpetual or ongoing entitlement to exclusive access to a share of water from a specified consumptive pool as defined in the relevant water plan."* A water allocation (also known as temporary water) is defined as *"the specific volume of water allocated to water access entitlements in a given season, defined according to rules established in the relevant water plan."* (COAG 2004, p. 30). Water allocations are seasonally announced as a percentage of their access entitlement depending on the water availability in the specific water resource to prevent water over-allocation. An overview of water allocations received by southern MDB irrigators in the last 20 years is provided in Table 1.7. This seasonality of water use is shown in Figure 1.7, which illustrates the MDBA's measurement of water extractions across the MDB under two forms of water accounting (old Cap accounting and SDL accounting). It also illustrates the growing ownership of Commonwealth environmental entitlements.

Table 1.7 Water Allocations in the MDB

	High reliability rights					Lower reliability rights			
Year	*Vic Goul-burn*	*Vic Mur-ray*	*NSW Mur-ray*	*NSW Murrum-bidgee*	*SA Murray*	*Vic Goul-burn (low)*	*Vic Murray (low)*	*NSW Murray (general)*	*NSW Murrum-bidgee (general)*
1998-99	100	100	100	100	100	0	100	93	85
1999-00	100	100	100	100	100	0	90	35	78
2000-01	100	100	100	100	100	0	100	95	90
2001-02	100	100	100	100	100	0	100	105	72
2002-03	57	100	100	100	100	0	29	10	38
2003-04	100	100	100	95	95	0	0	55	41
2004-05	100	100	97	95	95	0	0	49	40
2005-06	100	100	97	95	100	0	0	63	54
2006-07	29	95	69	90	60	0	0	0	10
2007-08	57	43	50	90	32	0	0	0	13
2008-09	33	35	95	95	18	0	0	9	21
2009-10	71	100	97	95	62	0	0	27	27
2010-11	100	100	100	100	67	0	0	100	105
2011-12	100	100	100	100	100	0	0	100	105
2012-13	100	100	100	100	100	0	0	100	105
2013-14	100	100	100	100	100	0	0	100	63
2014-15	100	100	97	95	100	0	0	61	53
2015-16	90	100	97	95	100	0	0	23	37
2016-17	100	100	100	100	100	0	5	100	100
2017-18	100	100	100	95	100	0	0	51	45
2018-19	100	100	97	95	100	0	0	0	7
LTAAY	0.95	0.95	0.95	0.95	0.9	0.35	0.24	0.81	0.64

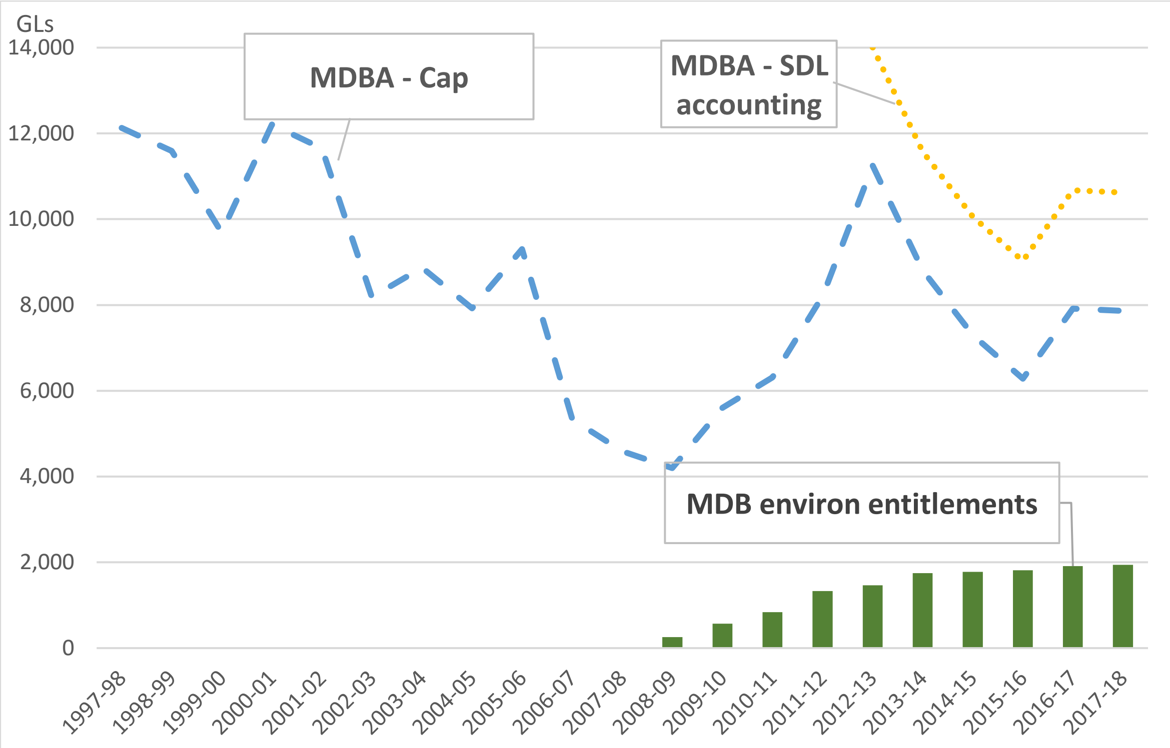
Note: LTAAY = long-term average annual yield permitted to be taken for consumptive use under a water access entitlement. Currently, all LTAAY figures are calculated using the long-term diversion limit equivalent (LTDLE) factors, with these factors to be accredited in finalised state water resource plans. See Appendix A of Wheeler et al. (2020) for further comment.

Each state introduced individual legislative and administrative processes (water trading regulations) depending on the individual historical developments in water resources management, as well as the characteristics of the water resources and water demand. For example, each state adopted their own terms to describe water access entitlements and water delivery rights. Table 1.8 summarises the different terminology for tradeable water rights currently used in the MDB.

Over 150 different water entitlements types currently exist in the MDB (MDBA 2019d). Water entitlements can have different security levels: high, general and low security (reliability in Victoria), reflecting the probability of receiving a full water allocation. Other water market products comprise water delivery shares (i.e. right to deliver water in an irrigation system (Crase et al. 2015)), parking (right to use carry-over space owned by a different entitlement holder), water leases, water forwards and water options. Table 1.9 introduces important water market definitions for the MDB.

There are a number of restrictions on trade that govern the movement of water within and across states. As part of the Basin Plan requirements, all states had to notify the MDBA of all restrictions on surface-water trade, and in 2014 provided a list exceeding 1500 (Productivity Commission, 2018). Restrictions include managing constraints on the physical delivery of water and externality effects from trade, including effects on the environment such as increased channel erosion or unseasonal flows. A number of restrictions were correspondingly lifted by states (e.g. the cap on trade out of irrigation districts removed by Victoria in 2014).

Figure 1.7 Total annual MDB water extractions (by two forms of water accounting), and Commonwealth MDB environmental entitlement ownership



Notes: The MDBA provides two water accounting estimates of MDB surface-water extractions: 1) Cap data: water extraction data, where water extractions were referred to as 'diversions'; and 2) SDL accounting: 'annual actual take' (volume of water used for consumptive purposes from watercourse or land-surface diversions), currently available from 2012-13 to 2017-18 (e.g. includes Cap data plus additional estimates of surface-water extractions not measured under the Cap).
Sources: Wheeler et al. (2020), MDBA (2019c). MDB environmental entitlements are the LTAAY owned by the Australian Government, not the use of entitlements.

Table 1.8 Tradeable water right terminology

	Water access rights		
	Water access entitlement (WAE)	**Water allocation**	**Water delivery right (WDR)**
Who is required to approve a trade?	Basin state approval authority	Basin state approval authority	Irrigation infrastructure operator (IIO)
ACT terminology	Water access entitlement	Allocation	Not applicable
New South Wales terminology	Water access licence	Water allocation	Varies by operator: often 'delivery entitlement'
Victorian terminology	Water share Take and use licence	Water allocation	Water delivery share
South Australian terminology	Water access entitlement	Water allocation	Varies by operator: often 'delivery entitlement'
Queensland terminology	Water allocation	Seasonal water assignment	Water supply contract

Source: provided by the ACCC

States all have their own water registers, where they report water market trades. However, there are also considerable issues with data in water market registers (Deloitte 2019; MDBA 2019e). These include:

- no mandatory price reporting, leading to a large number of trades without price, or with a price of zero;
- entitlement transactions as a part of a land transaction are not always identified, potentially skewing reported prices, and this is a particular problem in the Queensland water register;
- even if reporting errors have been identified, they are either not corrected, or a correct; transaction gets inserted into the data, without removing the erroneous transaction record; and
- in contrast to land registers, water ownership registers are not accessible publicly. Individual water licence information is often behind a pay-per-record paywall, making it difficult to discern the size and value of various water holdings. Also, authorities often require stakeholders' permission to share water licence information (Seidl et al. 2020a).

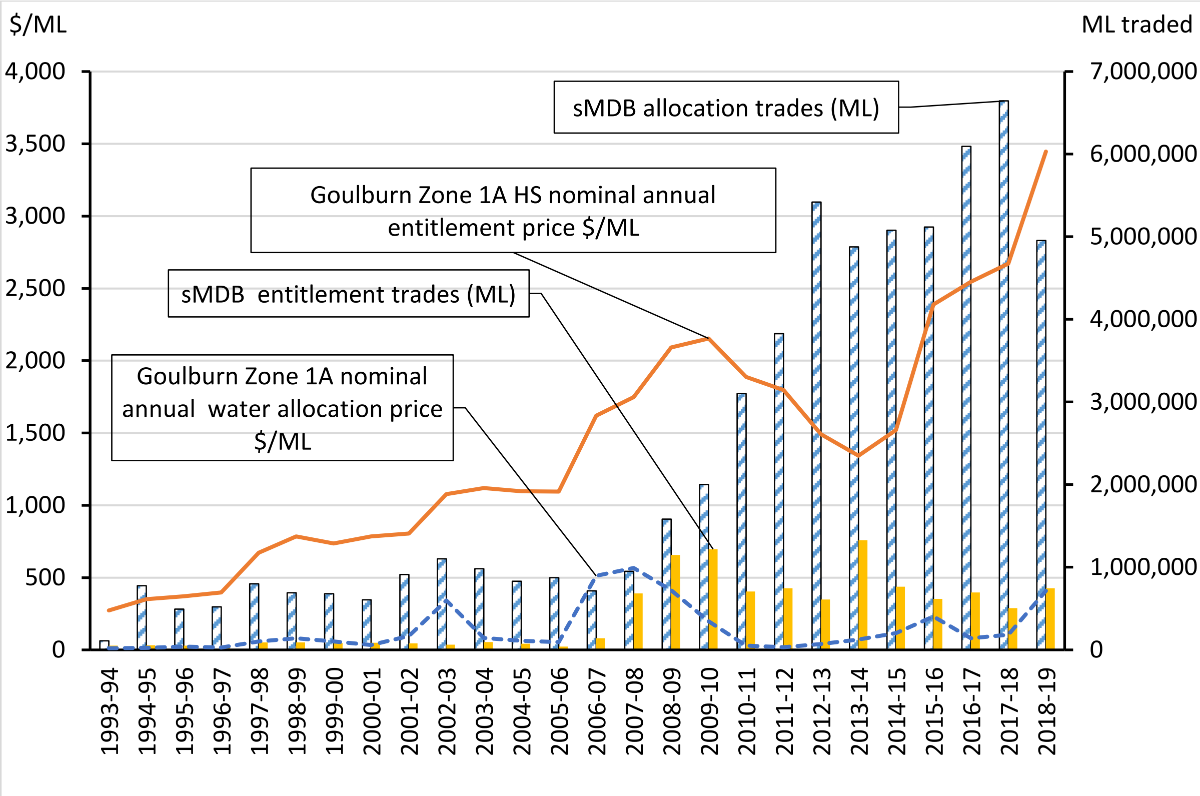
Table 1.9 Water market definitions

Term	***Explanation***
Permanent water	
Water entitlement	Also called permanent water, and a water access entitlement, it is a right to extract water from a watercourse/body every year, subject to climatic conditions. Some water entitlements provide access to carry-over. Water entitlements come in different securities, with high security yielding a full allocation in 90-95 of 100 years, general security 42-81 of 100 years, and low security 20-35 of 100 years. Supplementary and conveyance entitlements only yield water in flood years. Unregulated entitlements are in unregulated river systems (Cheesman & Wheeler 2012)
Delivery share	The legal, and tradeable, right to have water delivered within an irrigation system, region or trust run by an irrigation infrastructure operator (Wheeler et al. 2014a)
Temporary water	
Water allocation	Also called temporary water, the seasonal allocation received by a given water entitlement (Wheeler et al. 2014a)
Carry-over	Arrangements which allow water entitlement holders to hold water in storages (water allocations not taken in a water accounting period) so that it is available in subsequent years (ACCC 2010b)
Parking	A contractual arrangement permitting the buyer to store their water allocation on the carry-over of the seller, usually from one water accounting period to the next (ABARES 2018a)
Spill risk	The risk of losing carried over water in the event that a water storage is full and needs to release water for storage security purposes (Productivity Commission 2010)
Water forward	A contractual arrangement whereby the seller guarantees to deliver a defined volume of allocation, for a predetermined price, at a predetermined point in time in the future to the buyer. The buyer guarantees to honour the contract (Bayer & Loch 2017). Can be for one year, or multi-years (up to five years).
Water lease	A contractual arrangement whereby the lease taker (lessee) receives all allocation attributed to a leased water entitlement. The entitlement remains property of the lease giver (lessor). Can be for one year, or multi-years (up to five years) (ABARES 2018a)
Water option	A contractual arrangement whereby the buyer has the option, but not obligation, to deliver/have delivered a defined volume of allocation, for a predetermined price, at a predetermined point in time the future to/by the seller (Wheeler et al. 2013a)

Source: Adapted from Seidl et al. (2020b)

Figure 1.8 provides further water trading and price statistics for temporary and permanent water rights in the Goulburn and sMDB from 1993-94 to 2018-19.

Figure 1.8 Temporary and permanent nominal water prices and water trade volumes in the Goulburn and southern MDB (sMDB) from 1993-94 to 2018-19



Source: Adapted from Seidl et al. (2020a) (prices are nominal)

As an example of the recent prices that different water market products trade at, see Table 1.10.

Table 1.10 Overview of the main MDB water market products in 2018-19

Water products	*Murrumbidgee $AUD/ML price 2018-2019**	*Goulburn (1A) $AUD/ML price 2018-2019**
Entitlements (regulated and unregulated)		
• High security (HS)	4850-7000	3000-4000
• General security (GS)	1600-2200	not available (n/a)
• Low security (LS)/ supplementary/ conveyance	310-2575	400-550
• Unregulated	175-800	n/a
• Groundwater	4000-4500	n/a
Water delivery shares**	150-250	37 **(seller pays)**
Allocation		
• Surface-water	250-550	230-540
• Groundwater	200-250	n/a
Water lease		
• 1 year	n/a	LS: 20-30 HS: 250-350 (p.a.)
• Multi-year (mostly up to 5 years)	GS: 80+ (p.a.) HS: 350+ (p.a.)	LS: 25-35 (p.a.) HS: 250-350 (p.a.)
Carry-over space (parking)	21-33	5-15
Water forwards		
• 1 year	160-385	140-350
• Multi-year (up to 5 years)	n/a	n/a
Water options	n/a	n/a

Source: Adapted from Seidl et al. (2020b)
Notes: *Water allocation and entitlement prices are based on monthly median prices, excluding prices of AUD$0/ML, and are sourced from BOM (2019) for Murrumbidgee and DELWP (2019b) for 2018-19 Goulburn water season. Private broker water trading platform data provided values for groundwater, delivery shares, leases, parking and forwards.
**One delivery share in the Murrumbidgee allows the delivery of 1.2 ML and can be traded annually MI (2015). One delivery share in the Goulburn delivers 270 ML (1ML per day per irrigation season (270 days)) and are valid indefinitely. Licencing fees amount to $2,925–5,333 per year per share, with a termination fee of $29,250–53,333 (GMW 2018). Therefore, sellers in the Goulburn pay the buyer around $10,000 per share, or $37/ML, to take on the ongoing liability.

1.4.4 Water Market Intermediaries, Irrigation Infrastructure Operators and Irrigator Numbers

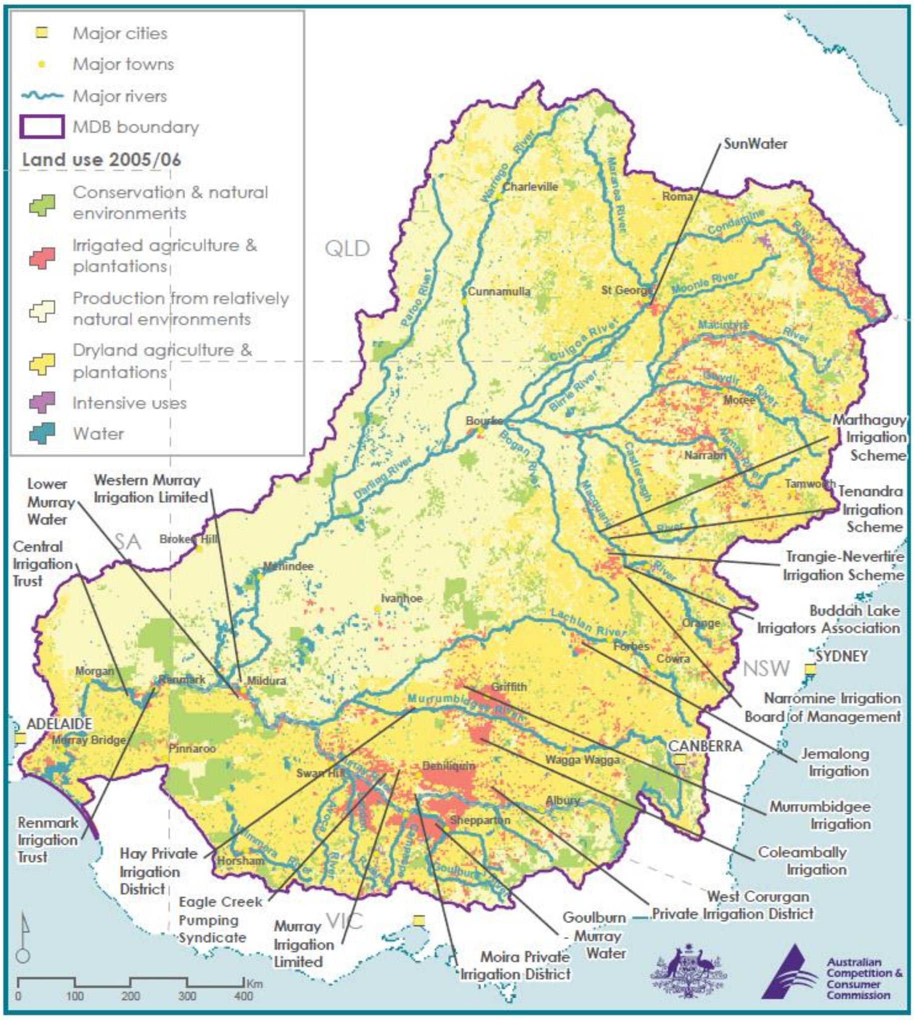
Water market intermediaries' comprise of water brokers and water exchanges. ***Water brokers*** perform a number of roles, e.g., finding a water trading partner, advising on price and water trading rules, negotiating with a water trading partner, and/or completing the necessary paperwork for a trade to proceed. Not all brokers, however, perform all these services. Brokers also often conduct water trades through exchanges. ***Water exchanges*** operate as a water trading platform by matching buyers and sellers, either through an automated process or a bulletin board. Water exchanges also organise and submit the necessary paperwork to the relevant trade approval authority(ies), and may provide information on water trading rules, prices and water trading volumes (e.g. ACCC 2010a, 2019b). Water banks also exist as a central institution which act as a clearinghouse for those wishing to sell/buy water (Hadjigeorgalis 2009).

Currently, a number of different water exchanges operate in the MDB, including (but not limited to) Waterfind, H2OX, Waterexchange, Murray Water Exchange, Wilks Water, Murrumbidgee Water Exchange and the National Water Market. There are ongoing fluctuation in water brokers and water exchanges, for example, Watermove shut down in mid 2012.

An irrigation infrastructure operator (IIO) owns or operates water service infrastructure for the purpose of delivering water for the primary purpose of irrigation. Table 1.11 and Figure 1.9 illustrates this diversity. Many IIO customers are not irrigated farmers, and own only a few ML for stock and domestic use.

Using ABS data (Table 1.12), there were 9,496 irrigation businesses[2] in the MDB in 2017-18, with an average extraction rate of 4.66 ML/ha.

Figure 1.9 Infrastructure operators in the MDB



Source: ACCC (2017, p. 14)

[2] ABS water extractions on farms is gross application and not 'net use', and does not include diversion losses associated with transporting water. From 2015-16 onwards, water extractions were estimated from farm businesses undertaking agricultural activity above a minimum threshold of the estimated value of their agricultural operations (AUD$40,000). Agricultural census level data was available for 2005-06; 2010-11; and 2015-16. Before 2015-16, the ABS used an estimated agricultural value of AUD$5,000. The impact of this change was that from 2015-16 onwards, irrigation business numbers are estimated to be reduced by 22%, and water volumes by 4%. Thus, ABS water volumes and extraction rates from 2015-16 onwards should have been higher in Table 1.12 if following the same method as used prior to 2015-16 (Wheeler et al. 2020).

Table 1.11 Important IIOs, their entitlement ownership and serviced trading zones

State	IIO	River valley	Trading zones	Volume of water entitlements owned (ML) in 2017/18
NSW	Murray Irrigation Ltd	NSW Murray	Zone 10, Zone 11	1,305,620
	Murrumbidgee Irrigation Ltd	Murrumbidgee	Zone 13	504,820
	Coleambally Irrigation Corporation Ltd	Murrumbidgee	Zone 13	849,099
	Jemalong Irrigation Limited	Lachlan	Upper Lachlan, Lower Lachlan	94,420
	Western Murray Irrigation Ltd	NSW Murray	Zone 11	38,044
VIC	Goulburn-Murray Water	Goulburn, Broken, Loddon, Campaspe	Zone 1A Zone 1B Zone 2 Zone 2a Zone 2b Zone 3 Zone 4a Zone 4c Zone 5a, Zone 5b Zone 6 Zone 6b Zone 7	1,389,157 (based on 2015-16)
	Lower Murray Water	VIC Murray, Goulburn	Zone 1A, Zone 7	129,160
SA	Central Irrigation Trust	SA Murray	Zone 12	109,995
	Renmark Irrigation Trust	SA Murray	Zone 12	37,039

Source: Adapted from ACCC (2019b) and ACCC (2017)

Under the Basin Plan water trading rules, IIOs are required to transparently communicate their fee structure, and not impose trading rules which unnecessarily hinder water trade (such as the 10% and 4% rule in Victoria). ACCC (2019b) documents considerable progress in fee structure reporting. IIOs' fee structure can be extremely complicated, sometimes including hundreds of different fees (ACCC 2016; Cooper et al. 2014b). Delivery share products and conditions vary significantly between IIOs.

Table 1.12 MDB farm irrigation water extractions in ABS data

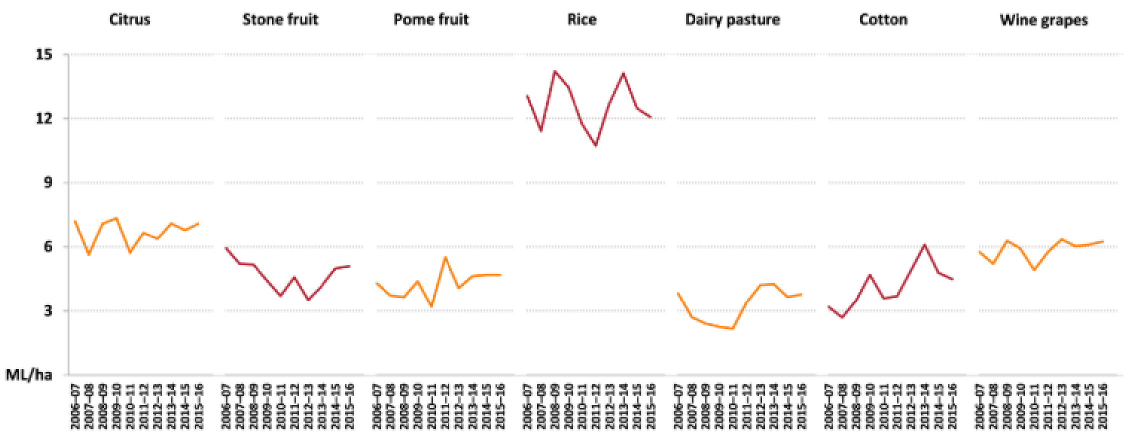
Year	*Agricultural businesses (no.)*	*Irrigation businesses*	*Area irrigated (ha)*	*Volume applied – including farm irrigation surface, groundwater & floodplain (ML)*	*Extraction rate (ML/irrigated ha)*
2005-06	61,504	18,674	1,664,000	7,397,678	4.45
2006-07	59,864	17,063	1,101,000	4,458,279	4.05
2007-08	56,585	15,875	957,753	3,141,659	3.28
2008-09	54,096	15,476	929,074	3,492,409	3.76
2009-10	53,681	15,486	975,660	3,564,480	3.65
2010-11	54,023	15,794	1,194,253	4,518,369	3.78
2011-12	53,946	14,684	1,411,612	5,875,449	4.16
2012-13	51,203	13,361	1,597,454	8,283,439	5.19
2013-14	50,929	14,496	1,559,565	7,736,385	4.96
2014-15	49,096	14,587	1,366,738	5,868,785	4.29
2015-16	35,465	9,216*	1,238,106	4,938,381	3.99
2016-17	36,083	9,196	1,347,592	6,355,072	4.72
2017-18	35,203	9,496	1,460,054	6,797,678	4.66

Source: ABS (multiple years) and Wheeler et al. (2020)

Note: * From 2015-16 onwards, water extractions were estimated from farm businesses undertaking agricultural activity above a $40,000 minimum threshold of the value of agricultural operations, previously it used to be AUD$5,000. Note this significantly decreases farm businesses from 2015-16 onwards.

Figure 1.10 uses ABARES data and illustrate water application rates (ML/ha) of various key irrigation industries in the MDB. Similar to ABS data, it illustrates that application rates are increasing in some industries.

Figure 1.10 Industry water application rates in the MDB, 2006-07 to 2015-16 (ML/ha)



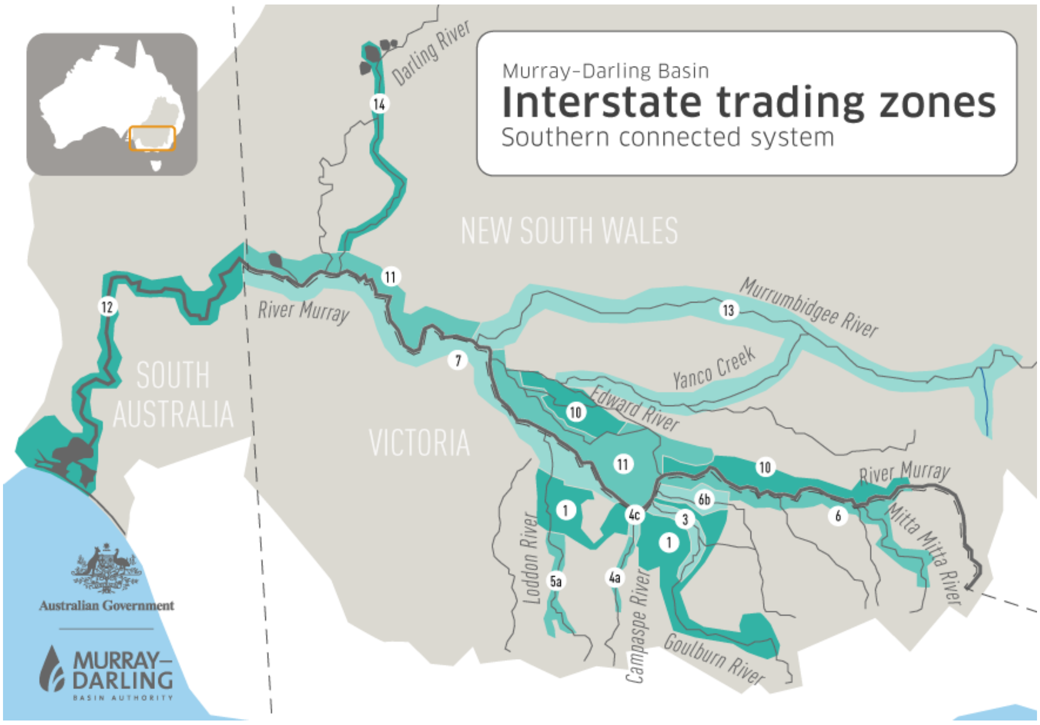
Source: ABARES at https://www.agriculture.gov.au/abares/research-topics/surveys/irrigation/overview

Cooper et al. (2014a) investigated the processes for establishing water charges that are generally cost reflective and shows how political manoeuvrings to relocate water can markedly distort best practice water pricing. An assessment framework that draws from best practice pricing principles embodied in the NWI, the Water Industry Regulatory Order and the Victorian Essential Services Commission Act (2001) is used as a framework to consider areas of improvement.

1.4.5 Water trading zones

Water trading in the southern MDB is arranged within and between water trading zones (Figures 1.11 and 1.12). In connected river systems, such as the southern MDB, water trading is allowed across state borders (MDBA 2017).

Figure 1.11 Interstate trading zones in the southern-connected MDB



Source: MDBA (2017)

Figure 1.12 Interstate trading zones in the northern connected MDB

Source: MDBA (2017)

1.4.6 Trading Restrictions, Carry-over, IVTs, Transmission losses, Tagged Trade and Capacity Sharing issues

Many feared that the unbundling of water from land would lead to an exodus of water entitlements out of upstream towards downstream catchments, particularly in Victoria. Following this, Victoria implemented a suite of permanent trading restrictions. The "4% rule" limited annual water entitlement trading out of an area in a given catchment. A "10% rule" was also established, limiting water entitlement ownership by the non-water user group[3] to 10% of entitlements on issue (DELWP 2020b). Later on these trading restrictions were removed (namely the Victorian "10% rule" was removed in 2009, and others removed with the introduction of the Basin Plan trading rules in 2014 (DELWP 2020b)).

Additional concerns surrounded potential negative impacts of water markets on the environment, by changing the location and timing of natural flows (Wheeler et al. 2014a). However, evidence suggests that compared to drought and river regulation (i.e. weirs and locks), the impact of water trading is small, while also not affecting key ecological assets (NWC 2012).

Carry-over

Carry-over includes arrangements that allow water entitlement holders to hold allocated water in storages so it is available in subsequent years (subject to evaporation/loss or spill factors). Conditions for carry-over vary, and those who do not have access can purchase unused carryover capacity access from brokers. The objective of carry-over is to increase risk management and flexibility in water use for irrigators. Carry-over was introduced during the Millennium drought for the first time in South Australia and Victoria, while in NSW carry-over limits were temporarily increased. ABARES (2016, p. 22) summarise carry-over rule changes since 2007–08 as:

- 2007–08: South Australia and Victoria introduce temporary carry-over arrangements
- 2008–09: Victorian annual carry-over limit increased from 30-50%
- 2009–10: Murrumbidgee annual carry-over limit increased from 15-30%
- 2010–11: South Australia removes carry-over, while Victoria introduces permanent carry-over arrangement in the form of spillable water accounts, with no limit on annual carry-over volumes
- 2011–12: Review of Victorian carry-over rules
- 2012–13: South Australia adopts a permanent carry-over arrangement
- 2013–14: Changes to Victorian carry-over rules introduced, including a 100% annual limit.

The introduction of carry-over in water markets has had a range of impacts. First, without carry-over the NWC (2011b) suggested that many consumptive users may adopt a strategy of either using all of their available water each season and/or trading surplus water allocation in the water markets. However, qualitative interviews with irrigators in 2008-09 suggested that without carry-over access water users would have previously allowed some unused water to flow downstream each season (Loch et al. 2012). Previous water user behaviour in regards to carry-over has led to changes in rules. It is expected that the economic benefits of lower prices in drought years will in the long-run outweigh the economic costs of higher prices in non-drought years (ABARES, 2016). The other impact of carry-over is the fact it leads to increased utilisation of water entitlements, where previously excess water was forfeited and hence 'socialised', increasing available storage and allowing an increase in water allocations the following season.

Currently, a large portion of the leasing market is done to acquire carry-over space, with carry-over used to support water availability, manage seasonal price risks and to deliver on other contractual arrangements such as forward contracts. H2OX (2019) describe carry-over as changing (evening out) within season prices, and indeed Wheeler et al. (2010a) found statistically significant evidence on the

[3] Non-user stakeholders are water allocation accounts without a water use licence attached (DELWP 2019a).

negative impact of carry-over on weekly water allocation price bid and offers in the Goulburn from 2001 to 2010.

Intervalley Trade (IVTs) Restrictions

While water policy reform has sought to reduce barriers to water trade, some trade barriers still remain (NWC 2011b). Barriers are both a function of hydrological necessity and historical configurations.

The most prominent IVTs are:

- *Murrumbidgee IVT*: limits trade between the Murrumbidgee and the NSW Murray, NSW Lower Darling, Victorian Murray and South Australian Murray, with its IVT account representing the net trade of temporary traded or tagged water out of the Murrumbidgee. When water is temporary traded **out** of the Murrumbidgee the IVT account balance **increases**, and it **reduces** when water is temporary traded **into** the Murrumbidgee. Contrary to the Goulburn IVT, the Murrumbidgee IVT operates between a lower and an upper limit of the IVT account, closing and stopping trade when the account balance moves outside of these limits. The lower limit is an IVT trade balance of 0 GL, closing trade into the Murrumbidgee as water cannot flow uphill; whereas the upper limit is a balance of 100 GL, closing trade out of the Murrumbidgee, to minimise third party impacts from large volumes of Murray water sitting in Murrumbidgee storages. While at first glance counterintuitive, water delivery influences the IVT in the opposite direction as trade, in that water delivered to the Murray reduces the IVT, and water delivered from the Murray into the Murrumbidgee increases the IVT. The operation of the IVT is complicated, as trade does not open or close with the lower and upper limit. Instead, trade into the Murrumbidgee opens when the account balance has reached 15 GL. Whereas trade out of the region opens when the IVT account balance falls under 85GL (DPI 2018).
- *Goulburn-Murray IVT*: limits trade between the Goulburn and the VIC Murray catchment and was introduced in 2012. It intention was to enable volumes stored in dams to supply Victorian Murray water entitlements, and to guarantee that the increasing commitments to meet large volumes of trade between Victoria and the Murray did not adversely impact on storage levels. The IVT stops any allocation trade from Goulburn, Campaspe, Broken and Loddon to the Victorian Murray or to NSW or SA, if a total of 200GL is owed to the Murray downstream. Stakeholders can track the status of the trade limit over the inter-valley trade account, with the IVT opening if less than 200GL is owed to the Murray DELWP (2014).
- *Barmah Choke constraint*: limits water trade between NSW Murray trade zone 10 and 11, and VIC Murray zone 6 and 7. The Barmah Choke constraint is due to a geological formation limiting the maximum flow through the Murray without flooding the surrounding Barmah-Milawa forest. This formation, allows daily flows of 7000 ML/day between the upstream trade zones 6 and 10 to the downstream zones 7 and 11 (MDBA 2019a). Consequently, no water can be traded (including carry-over) from upstream to downstream if the 7000 ML flow threshold has already been reached.
- *The Lower Darling IVT*: This is a special kind of IVT, it is a function of the joint operation of the Menindee Lakes system by NSW and the MDBA under the MDB Agreement. The MDBA manages the lakes if storage volume is above 640 GL. When it falls below 480 GL, NSW takes over management (MDBA 2019b). If the Menindee Lakes are managed by the MDBA, water allocation trade from the Lower Darling (Zone 14) into SA Murray (Zone 12)

is possible, whereas allocation trade is not permissible when NSW manages the lakes (for water storage and water supply to Broken Hill reasons (DEW 2020)).[4]

Figure 1.13 illustrates these IVTs in the southern MDB as at 19th January 2019.

Figure 1.13 Southern MDB Trade limits and IVTs

From ↓ To →	1A	6	7	10	11	12	13	14
1A Greater Goulburn		GOULBURN TO MURRAY LIMIT						
6 VIC Murray - Above Barmah Choke	CHOKE		CHOKE		BARMAH CHOKE LIMIT			INTO LD
7 Vic Murray - Below Barmah Choke								
10 NSW Murr U/S Barmah Choke	CHOKE		CHOKE		BARMAH CHOKE LIMIT			
11 NSW Murr D/S Barmah Choke								
12 SA Murray								
13 Murrumbidgee	OUT OF MURRUMBIDGEE LIMIT							
14 Lower Darling	OUT OF LOWER DARLING LIMIT							

TRADE ALLOWED — TRADE RESTRICTED

Source: MJA (2020, p. 2)

There is some evidence that IVTs can affect major trading zones and exert material influence on water market prices. If IVTs are closed, price differentials form in water allocation markets separated by the restriction, continuously diverging while trade is closed. There may be some evidence that Murray trade zone 7 and zone 11 allocation prices increase when the Goulburn IVT and the Barmah Choke close. The impact of the Murrumbidgee IVT on prices is harder to generalise, as it depends on the balance of in- and out-trade, and also on whether the other two IVTs are open. There is also anecdotal evidence regarding some brokers' ability to use web scraping software to automatically monopolise trade through the Choke (Hunt 2020). Further research would be warranted in this space.

Transmission losses (namely evaporation from surface-water, seepage from the bottom river channels, leakage through river banks or overbank losses during high-flow events) are argued to be one issue associated with water market trade and changing water extraction locations. However, it is important to note that many of these 'losses' are not losses for the environment per se, it depends on if they are losses to a non-recoverable sink or not (Loch et al. 2011; NWC 2012).

Tagged trade

Originally, to address water reallocation issues, exchange rates were applied to water trade issues in the Interstate Pilot Trade Program in 1998 (Bjornlund et al. 2013). As an example, an exchange rate of 1.0 was used on all transfers from NSW to Victoria or SA. However, an exchange rate of 0.9 was used for upstream transfers from SA into NSW, Victoria to counteract reduced supply security (Loch et al. 2013). However, high transaction costs associated with exchange rate trade limited its expansion beyond the pilot interstate trade program.

Tagged trade is where the source water entitlement retains its original access right and extraction conditions but is 'tagged' for use elsewhere. Tagging allows a water user to hold a portfolio of rights with different reliability/risk characteristics but requires reciprocal agreements between states to

[4] There is now a new pipeline supplying water to Broken Hill, from the Murray River near Wentworth (DPI 2016), and the Menindee Lakes Water Savings Project (DPIE 2020), aiming to operate the lakes at low levels to reduce evaporation. Arguably, allocation trade from the Lower Darling into South Australia may be impossible in all but high flood years in the future.

ensure recognition of water access rights and conditions across areas. Overall the lower transaction costs associated with tagged trade has seen its increased use (Loch et al. 2013).

In regards to the relationship between IVTs and tagged trading, allocation deliveries from tagged entitlements are exempt from IVT compliance if: 1) the tag was established prior to 22nd October 2010 (MDBA 2014) ; or 2) they are Victoria based. Contrary to the *Water Act's* intentions, Victoria has implemented tagged entitlements as not subject to IVTs, meaning that water allocations from tagged entitlements can be delivered through the closed Goulburn IVT (DELWP 2018). Indeed, the allocation amount deliverable under a tag is not limited to the nominal entitlement volume, but irrigators can purchase large volumes of Goulburn (cheaper) water allocation and deliver it through the closed IVT to the Murray. Although tagged allocation cannot be on-sold, if stakeholders owned Murray water as well, they could sell their Murray allocation and use their Goulburn tagged allocation, legally arbitraging on the price difference between the trading zones. This led to large volumes of allocation being delivered to the Murray through a closed IVT (120 GL in 2018-19), and prompted Victoria to make all tagged entitlements subject to IVTs, beginning from December 2019 (Neville 2019). This has led to considerable uncertainty within Victorian irrigators, many accustomed and reliant to water supply from their tagged accounts. At time of writing, the Victorian government is engaged in stakeholder consultation regarding proposed changes to the Goulburn-Murray trade rules and tagged accounts (DELWP 2020a). It suggests three options: 1) an annual volumetric limit of water tradeable from the Goulburn to the Murray, 2) a dynamic limit, a hybrid between current rules and the annual volumetric limit; and 3) a seasonally-based rule consisting of two parts: the first part is for spring, late autumn and winter, when it is ecologically beneficial to have high flows and delivery of traded water does not impact the environment. The second part is in summer and early autumn when access is restricted, and operational limits in the lower Goulburn River are applied to protect the environment (DELWP 2020a).

At the moment, tagged entitlements established prior to 22nd October 2010 remain exempt from IVTs. Additionally, price divergence between catchments will continue to occur, with further research needed to assess the impacts that IVTs are having on trading behaviour and prices.

Capacity Sharing

There has been some work on the issues of capacity sharing, which is a way of water sharing and accounting (e.g. ABARES 2013). Truong and Drynan (2013) describe a capacity sharing system as where each water user is allocated with a share in storage capacity and a share in water inflow. Individuals can store water subject to various applicable rules, namely if the sum of water storage and water inflow exceeds the allocated storage capacity, the excess is re-allocated in the same period to other users in proportion to their capacity share sizes (ABARES 2009). An internal spillage is when water is lost to other users when the reservoir does not spill, however given this happens infrequently, internal spill may not cause significant inefficiency.

Truong and Drynan (2013) studied the optimality of water allocation within a capacity sharing system in presence of a spot water market. They found that in the presence of a spot water market with zero transaction cost, an appropriately designed capacity sharing system will result in optimal water allocation.

Summary

The Productivity Commission (2018) summarised the progress on water trading changes under the Basin Plan. It was noted that of the 17 compliance issues raised by the MDBA with states, 11 issues remained unresolved. These areas included issues with: IVTs; interstate trade between ACT and NSW; interstate trade between NSW and QLD on intersecting streams; tagged entitlement and delivery of water; unregulated water limiting future expansion of trade in the Northern Basin; and compliance issues.

1.5 Summary and Key Points

- Water trading occurs in water markets, and can be defined as the process of buying and selling water licences (also called entitlements or rights). Water trading is a demand management water policy instrument. Water markets can be established formally (i.e. through government legislation) or informally, and typically involve water users located in a specific region or sharing a water resource. Informal water trading arrangements includes arrangements between neighbours – and formal water trading arrangements may comprise sanctioned rules, processes, catchment areas managed by governments and/or communities.
- There are three prerequisite institutional factors needed in establishing water markets: (1) enabling institutions (science, economic and social); (2) facilitating gains from trade; and (3) monitoring and enforcement. Only point 2) represents specific institutional factors required for water markets, while points 1) and 3) are needed for any property rights regime, and without enabling institutions there is little hope of establishing effective water markets.
- Today Australia's water market (namely the southern MDB) is mature and, in comparison to many other countries, ranks high in terms of institutional foundations, economic efficiency, and environmental sustainability. In Australia, there have been reports of water being informally traded between irrigators during the World War II drought. Various market trials have also been in place for a number of decades. The southern MDB (sMDB) is one of the most active water trading regions worldwide and the largest water market in Australia in terms of geographic area and volumes/numbers of water entitlements. However, the northern MDB water markets observe lower water-trading volumes/numbers attributed to relative illiquidity (i.e. infrequent trading volumes), less hydrological connectivity and crop diversity coupled with widespread farm water storage and groundwater use. Droughts or other crises have typically been the major catalyst for water policy changes in the MDB, and water markets have also been used as a way to reallocate water from consumptive to environmental use, under the *Water Act 2007* and the Murray-Darling Basin Plan 2012.
- Three broad types of water trading can be defined: i) short-term or temporary transfers of water (known as water allocation trading); ii) medium-term leasing of water allocations to secure access to water for a period of time specified in a contract (known as water leasing); and iii) permanent transfers of water entitlements – the on-going property right to either a proportion or fixed quantity of the available water at a given source (known as water entitlement trading), as well as the right to have water delivered.
- Currently there are over 150 different water entitlement types in the MDB. Other water market products comprise water delivery shares (i.e. right to deliver water in an irrigation system), parking (right to use carry-over space owned by a different entitlement holder), water leases, water forwards and water options.
- States all have their own water registers, where they report water market trades. However, there have been considerable issues with data in water market registers. Water market intermediaries comprise of water brokers and water exchanges. An irrigation infrastructure operator owns or operates water service infrastructure for the objective of delivering water for the primary purpose of irrigation.
- Water trading in the southern MDB is arranged within and between water trading zones. Across the MDB, there are variety of differing rules in regards to carry-over, tagged trade, inter-valley trade restrictions (Murrumbidgee IVT; Goulburn-Murray IVT; Barmah Choke constraint; The Lower Murray IVT). Evidence suggests that in general IVTs all affect major trading zones and exert material influence on water market prices. Further research is required.

2 Understanding who participates in water markets: Evidence at the micro-level

This chapter provides an overview of whom participates in water markets in the MDB, examining this question from the individual stakeholder level. It looks at participation in six main ways: 1) how participation in water markets changed over time; 2) how water market participation differs between the northern and southern Basins; 3) the profile of irrigator buyers and sellers of water allocations versus others; 4) the profile of irrigator buyers and sellers of water entitlements versus others; 5) non-landholder participation; and 6) the participation of environmental water holders, First Nations stakeholders, urban and other sectors in water markets. The final section reviews the literature on water market power and inequality issues.

2.1 Irrigator water market participation over time

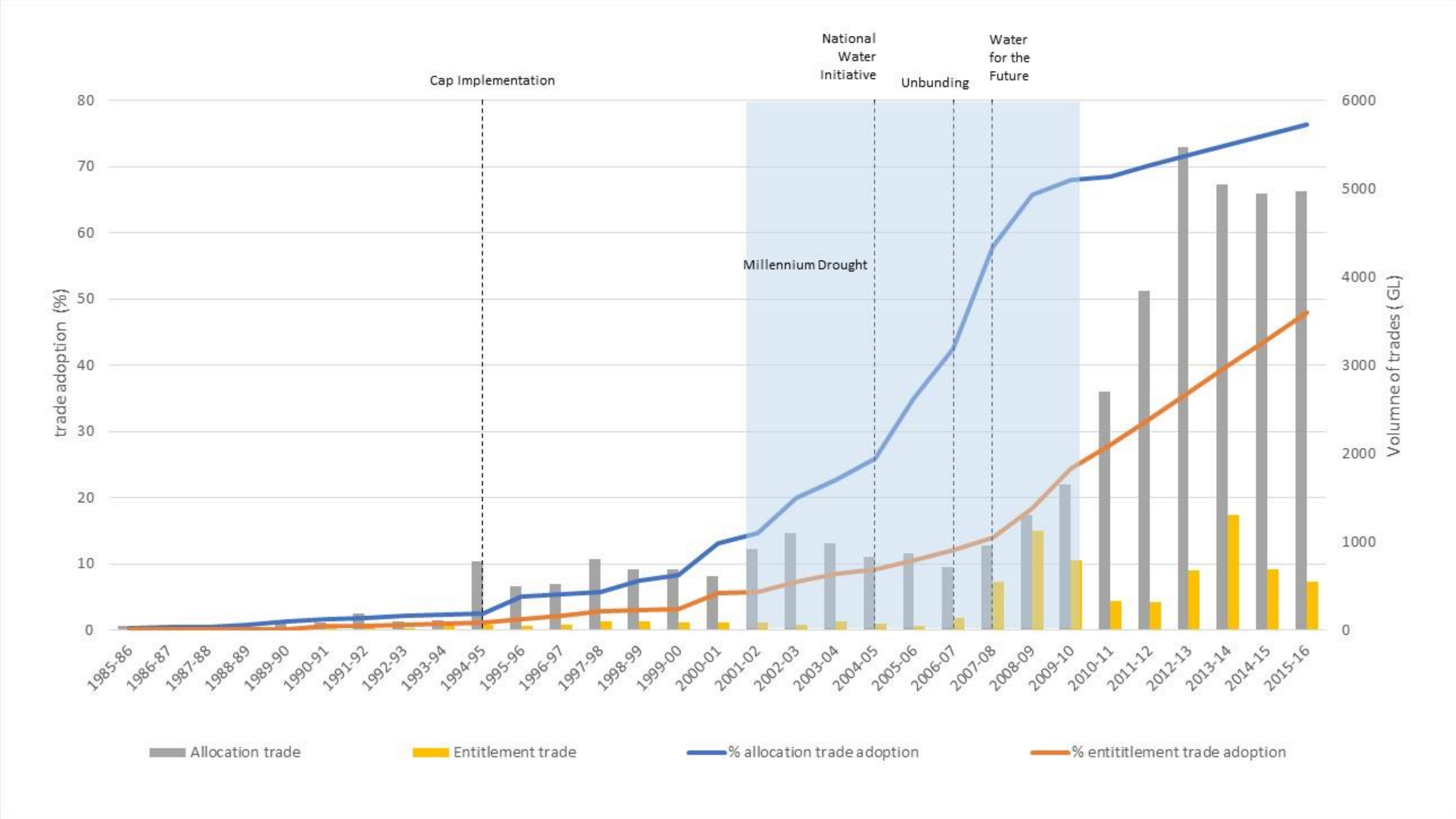
Water market participation can be measured in three different ways: 1) as an individual decision, or as a collective decision across a community/area/district; 2) in temporary or permanent markets; and/or 3) type, volume and method of trade itself, e.g. either as a purchase or a sale (and the subsequent volume of trade), or in an open market or to government. Furthermore, water market participation varies across time and space, particularly so for individual decisions. Hence, when trying to understand participation in a water market, first it is important to understand what sort of water product it is and how that participation varies at different stages of the water market, and the growth of participation over time.

2.1.1 Water market participation in the sMDB

Although fears about water trading has been widely expressed since their introduction (Bjornlund 2002; Bjornlund & McKay 1999; Edwards et al. 2008a; Edwards et al. 2009; Edwards et al. 2008b; Fenton 2006; Productivity Commission 2010), what is also true is that irrigator views towards trading have become more accepting over time (with users of water markets much more accepting than non-users, and also sellers are more likely to be more accepting than buyers). In the MDB, it has been found that irrigators become more favourably disposed to water trading from the 1990s to 2010. In particular, irrigators and communities in the MDB have been especially more accepting of water allocation trading, whilst restrained about water entitlement trade (Bjornlund et al. 2011). The past literature surveying attitudes of irrigators has consistently found that irrigators recognise the beneficial impacts of water trading on their farm businesses, with the greatest concerns related to possible negative community impacts of entitlement sales (see the later part of this chapter for more comment). However, the analysis of the latest sMDB attitudinal survey data in 2015-16 indicates that irrigator attitudes to trade may be hardening and becoming more negative. Chapter 6 provides more comment on this.

Figure 2.1 illustrates how water market participation has changed over time in the sMDB showing the percentage of irrigators that have conducted at least one water market trade over time. The columns represent the volume of trade within the sMDB market. By 2000, even though water markets had been in operation for almost two decades, less than 10% of irrigators had conducted a water market trade, although the implementation of the cap on total water resources lead to a spike in temporary trade in the early 1990s/2000s (Bjornlund et al. 2013; Wheeler 2014). By 2010-11, 86% of NSW, 77% of Victoria and 63% of irrigators in SA had undertaken at least one temporary or permanent water trade (Wheeler et al. 2014a). By 2015, around half of all irrigators in the sMDB had made at least one water entitlement trade, while 78% had conducted at least one water allocation trade. Figure 2.1 shows how the adoption of temporary trade accelerated after the introduction of major water reforms (e.g. NWI) from 2004 onwards, and the adoption of permanent trade took off after the *Water for the Future* program (water buyback scheme) was implemented in 2007-08.

Figure 2.1 Cumulative adoption (and trade volumes) of temporary and permanent markets in the southern Basin from 1985-86 to 2015-16



<u>Sources</u>: Adapted from Grafton and Wheeler (2018) and Wheeler and Garrick (2020). Graph constructed using historical irrigator survey datasets and various state water market registries

Over 80% of the total water market trading in Australia is undertaken in the southern MDB (and more so in temporary than permanent water trade). Stakeholder payments (Leonard et al. 2019) are a key reason for a high water trading adoption and originate from the unbundling of water from land which created considerable financial assets for irrigators (thereby increasing the acceptability of water reform and markets overall). With the advent of the government into the water market during the buyback scheme, permanent water market participation increased substantially from 2007-08 onwards.

An early study analysed water trading data during the first 13 years (1991-92 to 2003-04) of trading in the Goulburn-Murray Irrigation District, using the entitlement register as at 30 June 2004 and the trading registers for the thirteen years previously (based on 10,011 farm businesses with a tradable water entitlement) (Bjornlund 2006b). Figure 2.2 illustrate the percentage of irrigation businesses engaging in allocation trade (by buying and selling and doing both), while the bottom panel provides the percentage engaging in entitlement trade.

Figure 2.2 Yearly adoption of temporary and permanent markets in the GMID from 1991-92 to 2003-04

Source: Bjornlund (2006b)

The previous discussion focussed on the cumulative adoption of the water market over time. Wheeler et al. (2014c) provides information on the question of the cross-sectional engagement by irrigation industries in the water market. This study used 3,428 irrigator survey records by ABARES and provided estimates of the percentage of irrigators (within the horticulture, broadacre and dairy industries in the southern MDB) and the northern MDB (total) use of the water allocation (purchase and sale) and entitlement (purchase and sale) markets from 2006-07 to 2010-11. Key points from Table 2.1 include:

(i) water allocation trade was used by irrigators much more than entitlement trade;
(ii) irrigators in the sMDB trade much more than nMDB irrigators;
(iii) there are more water allocation purchasers than water allocation sellers (hence sellers in general trade larger parcels of water);
(iv) there are more water entitlement sellers than water entitlement purchasers (which is explained by the fact many sellers are selling to the Commonwealth from 2008-09 onwards);
(v) horticultural irrigators purchase more (sell less) water allocations in times of drought than dairy or broadacre irrigators; and
(vi) all water trade strategies are used less in times of water abundance.

Table 2.1 Irrigators trade activity (%) in the MDB from 2006-07 to 2010-11

			Southern MDB (%)			***Northern MDB (%)***
			Horticulture	*Broadacre*	*Dairy*	
Water allocations	Purchase	2006-07	29[a]	25	39	12
		2007-08	59	14	25	8
		2008-09	50	11	37	12
		2009-10	34	14	20	9
		2010-11	8	11	15	7
	Sell	2006-07	23	22	16	6
		2007-08	14	47	29	7
		2008-09	16	54	15	9
		2009-10	12	32	9	8
		2010-11	8	9	3	4
Water entitlements	Purchase	2006-07	2	1	4	2
		2007-08	3	4	2	0
		2008-09	2	5	4	1
		2009-10	1	2	1	0
		2010-11	0	7	2	2
	Sell	2006-07	1	1	3	2
		2007-08	1	2	5	1
		2008-09	4	6	8	4
		2009-10	5	11	14	3
		2010-11	8	8	8	3

a. Indicates that 29% of farmers in the horticultural industry purchased water allocations in 2006-07.
Source: Wheeler et al. (2014c)

Tables 2.2 and 2.3 provide a breakdown of the water extractions used by irrigators as a percentage of the water they received in water allocations (Table 2.2) and as a percentage of their water entitlement ownership overall (Table 2.3), broken down by the type of water market participant. They illustrate that in the time-period of 2006-07 to 2010-11, irrigators used 72% of the allocations they received, while water extraction represented 45% of their water entitlements owned. The highest percentage use of water entitlements is by horticulture, then dairy and then broadacre. Unsurprisingly, water buyers used a much higher percentage of their water received (and owned) than water sellers.

Table 2.2 Water extraction as a percentage of water received (taking entitlement reliability and yearly allocations into account) in the sMDB (%)

		All year ave.	2006-07	2007-08	2008-09	2009-10	2010-2011
All	Hort	81	82	88	88	78	69
	Broadacre	48	87	31	39	41	44
	Dairy	78	91	77	73	76	69
	All	72	84	74	69	65	61
Allocation buyer	Hort	96	92	97	98	95	97
	Broadacre	72	93	47	69	71	67
	Dairy	92	97	89	86	100	86
	All	92	93	92	92	91	85
Allocation seller	Hort	64	63	62	67	66	62
	Broadacre	35	74	30	35	28	25
	Dairy	61	98	50	52	20	-
	All	52	69	48	47	40	50
Entitlement buyer	Hort	88	-	-	-	-	-
	Broadacre	53	-	-	-	-	-
	Dairy	88	-	-	-	-	-
	All	73	95	74	68	-	62
Entitlement seller	Hort	75	-	-	-	-	69
	Broadacre	47	-	-	-	47	-
	Dairy	73	-	-	-	66	-
	All	65	61	-	75	59	66
(yellow)	Observation numbers are smaller than 30						
-	Observation numbers are smaller than 10, hence not reported.						

Note: ABARES irrigation survey data (2006-07 to 2010-11), n=2,961
Source: Wheeler et al. (2014b)

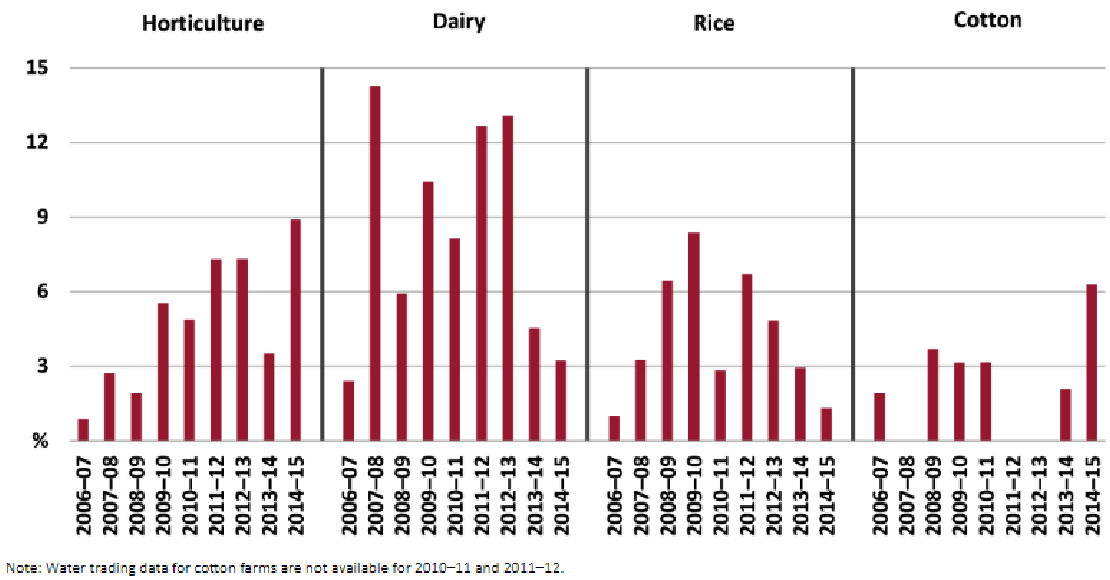
Table 2.3 Water extraction as a percentage of water entitlements owned in the sMDB (%)

		All years ave.	2006-07	2007-08	2008-09	2009-10	2010-11
All	Hort	57	62	53	57	59	53
	Broadacre	23	38	11	15	19	34
	Dairy	45	66	40	35	38	46
	All	45	58	40	40	42	46
Allocation buyer	Hort	68	78	60	67	72	86
	Broadacre	38	45	14	36	35	63
	Dairy	61	77	61	47	61	62
	All	62	71	57	59	63	70
Allocation seller	Hort	48	51	41	50	53	47
	Broadacre	17	33	13	15	15	17
	Dairy	30	64	27	16	20	-
	All	31	49	25	25	27	34
Entitlement buyer	Hort	64	-	-	-	-	-
	Broadacre	30	-	-	-	-	-
	Dairy	60	-	-	-	-	-
	All	50	80	40	39	-	51
Entitlement seller	Hort	59	-	-	58	58	60
	Broadacre	26	-	-	-	16	46
	Dairy	39	-	-	49	38	44
	All	42	41	26	47	35	52
(yellow)	Observation numbers are smaller than 30						
-	Observation numbers are smaller than 10, hence not reported.						

Note: ABARES irrigation survey data (2006-07 to 2010-11), n=2,961
Source: Wheeler et al. (2014b)

Figure 2.3 provides an overview of the proportion of farms selling permanent water entitlements in the MDB from 2006-07 to 2014-15, broken down into more specific industry groups than the data presented above.

Figure 2.3 Proportion of irrigation farms selling water entitlements in the MDB, 2006-07 to 2014-15



Source: ABARES at https://www.agriculture.gov.au/abares/research-topics/surveys/irrigation/overview

2.1.2 Comparing water market participation in the Southern and Northern Basins of the MDB

Following on from Wheeler et al. (2014a), Wheeler and Garrick (2020) provide insights into why water markets have been much more successful in the sMDB as compared to the northern MDB (nMDB). Given that water market trade in the sMDB represents over 80% of the total water market in Australia (and more so in temporary than permanent trade), the study found that irrigation businesses in the sMDB were 4.8 times more likely to have conducted a temporary water trade, and 7.9 times more likely to have conducted a permanent water trade than in the nMDB. Wheeler and Garrick (2020) identified eight main reasons that drive this divergence in water market participation:

1. Far greater hydrological connectivity (and public storage) in the southern than the northern MDB
2. Far greater amount of unregulated water entitlements in the northern (32% of water entitlements), versus southern (4% of permanent water in the southern MDB are unregulated) MDB
3. Far greater reliance on groundwater as an irrigation source in the northern than southern MDB (17% versus 10% respectively), plus greater use of on-farm irrigation storage (32% versus 3% respectively) from flood harvesting.
4. Much higher water usage charges paid in the southern (133% higher per megalitre extracted) versus the northern MDB
5. Far more irrigators in the southern (3.6 times more) than northern MDB
6. Lower average irrigated area per business in the southern (a third less) than the northern MDB
7. Higher monitoring of water extractions in the southern MDB (77-84% of water extractions are monitored) versus northern MDB (25-51% extractions are monitored)
8. Far larger water use homogeneity in the northern (cotton industry uses on average 79% of extractable water) than southern MDB (cereals/rice, pasture and fruit/nut/vegetables all extract around a third each of the total water) (Wheeler and Garrick 2020).

Table 2.4 provides more exact detail on these key institutional and demographic factors across the two Basins, and Figure 2.4 provides an overview of water extractions by industry in the MDB.

Table 2.4 A comparison of key factors influencing water market participation in the northern and southern MDB, for various time-periods between 2006-07 and 2017-18

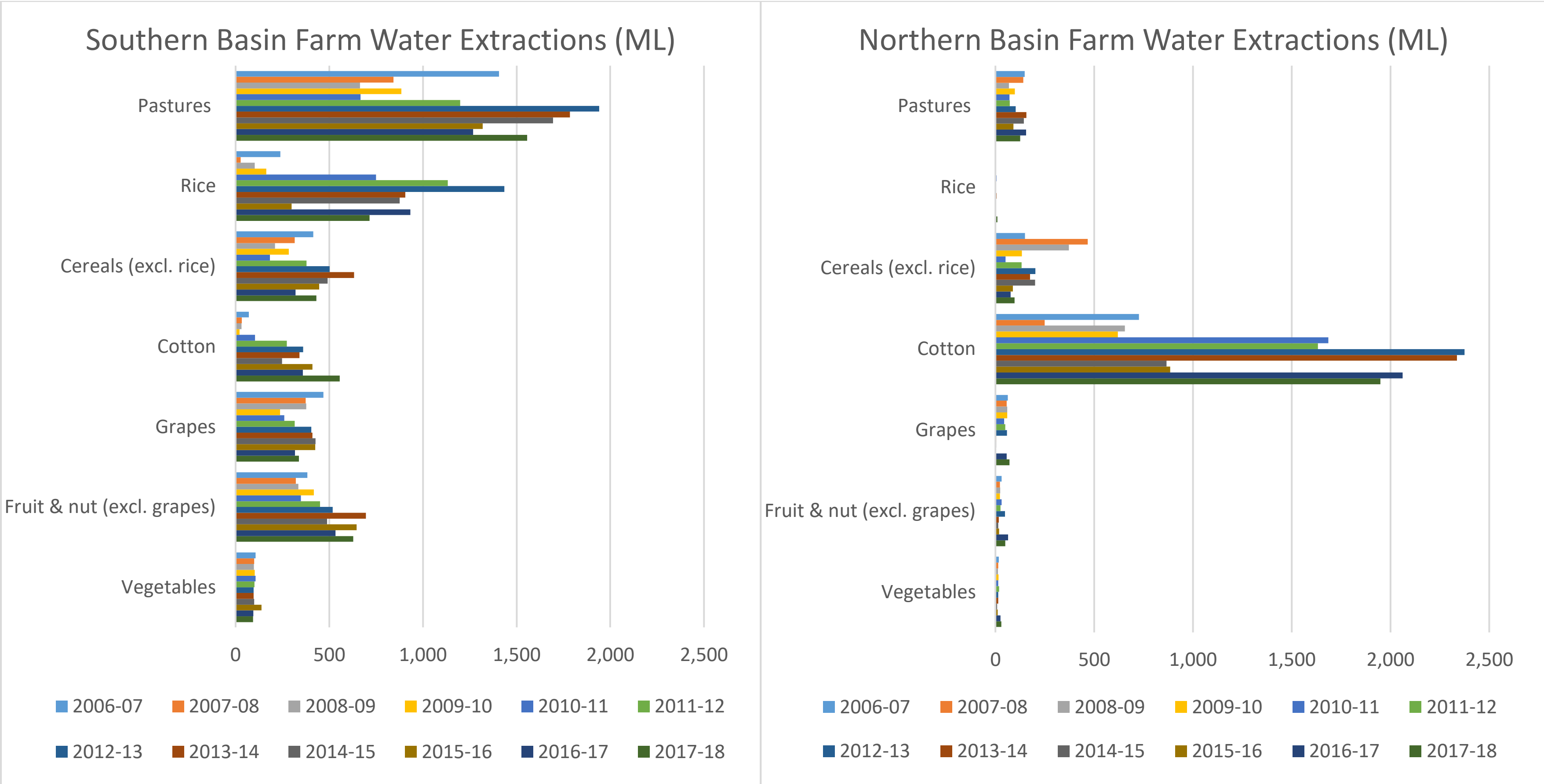
Various Descriptive Statistics and Means	***Northern***	***Southern***
Regulated Entitlements on issue (% of total entitlements on issue)	53%	85%
Unregulated Entitlements on issue (% of total entitlements on issue)	32%	4%
Groundwater Entitlements on issue (% of total entitlements on issue)	15%	11%
Share of groundwater of total farm water extractions* (%)	17%	10%
Share of on-farm dam storage (floodplain harvesting) of total farm water extractions (%)	32%	3%
Share of irrigation channels of total farm water extractions (%)	12%	64%
Share of surface-water of total farm water extractions (%)	44%	25%
Number of irrigators	3039	10898
Annual irrigation water volumetric/usage charges per ML extracted	$12/ML	$28/ML
Area irrigated per business (ha)	124	84
Surface-water extraction monitored	25-51%	77-84%
Cotton industry use of water extracted (%)	79%	6%
Cereals/rice industry use of water extracted (%)	13%	34%
Pasture industry use of water (%)	6%	32%
Fruit/nut/vegetables industry use of water (%)	1%	28%
Annual average allocation trade rate per business**	0.4	2
Average entitlement trade rate per business**	0.26	0.51

Source: Adapted from Wheeler and Garrick (2020), based on means of a variety of years, depending on data available from ABS water use on farms and BOM data. See Wheeler and Garrick (2020) for exact time-periods, data sources and also definitions used for the northern and southern MDB.
Notes: * Shares of groundwater/on-farm storage/irrigation channels/surface-water are based on the total water extracted by the farm, not on the entitlement ownership. Hence, it is possible to make direct comparisons of share of use across regions.
** Trade rate includes buying and selling.

A comparison of the southern and northern MDB confirms three key drivers of greater water market participation, namely: 1) robust government regulation (market design, scientific hydrological knowledge and regulated property rights matter significantly); 2) low transaction costs (water register and market information, monitoring and compliance enforcement, number of market participants); and 3) homogeneous marketable products (e.g. regulated water products, need full information about connectivity and long-term average annual yield issues) but heterogeneous water users (e.g. in industry, size, technology and demographics).

Wheeler (2014) emphasised how adaptive capacity of the irrigation industry was significantly enhanced because of the diversity of different types of agricultural production in the MDB, and, in particular, by the presence of opportunistic annual crops (e.g. cotton and rice) in the MDB. Although it is often argued that Australia should not be growing cotton or rice due to their high water extractions, this ignores the adaptability of such crops in dry and wet conditions, and the role that many of those farmers play in providing water to more permanent crop irrigators in times of drought (albeit, this happens more in the sMDB than the nMDB). Hence, adaptation of farmers is most enhanced in situations where there is diversity of production, secure and monitored property rights in water, ability to trade water, and an ability to choose different forms of production or crop choice (Wheeler 2014).

Figure 2.4 ABS Water Extraction on Australian Farms



Source: adapted from Wheeler and Garrick (2020)

2.2 Irrigator temporary water market participation characteristics in the sMDB

This section 2.2 provides first an overview of the lessons learned from the agricultural economic adoption literature that have relevance for understanding water market adoption characteristics. It then describes in depth the characteristics of those irrigators who participate in water allocation markets.

2.2.1 Agricultural economics adoption literature lessons for water market studies

Agricultural economics has a long history in modelling the characteristics associated with adoption of various technologies in agriculture. Studies on agricultural adoption behaviour generally associate innovation adoption with higher relative advantage, trialability, larger farm sizes, extension, distance to other adopters, (younger) age and education (Pannell et al. 2006; Wheeler et al. 2017c). Some studies also discuss adoption behaviour for different types of innovation, for example for 'hard' technologies (e.g. infrastructure adoption) and 'softer' management technologies (e.g. soil agro-ecology methods), the latter requiring a change in skills and management (Wheeler & Marning 2019). Insights from the agricultural adoption behaviour literature are relevant to water markets in trying to understand who has adopted water market trading, and why. The following sections review the studies that have been conducted on: a) temporary water market; and b) the permanent water market. It is important to note the difference between temporary and permanent water trading behaviour. Temporary trading generally is more trialable with lower transaction costs (e.g. see Loch et al. (2018) and ACCC (2019b)) than permanent water trading. That is one of the main reasons why temporary water trading was adopted earlier than permanent water trading (see Figure 2.1). Studies mainly associate temporary water trading with short-term considerations in response to seasonal fluctuations of prices or water availability (to manage risk and uncertainty within and between seasons) and personal characteristics (e.g. Loch et al. 2012; Nauges et al. 2016; Wheeler et al. 2010b; Zuo et al. 2015a). Conversely, permanent water trading is more linked to long-term factors mostly concerning farm and environmental/spatial characteristics (e.g. investment in farm technology) (e.g. Bjornlund 2006a; Haensch et al. 2019; Haensch et al. 2016; Wheeler et al. 2010b; Wheeler et al. 2012b). Also, different types of water markets (e.g. surface and groundwater, temporary and permanent) are interlinked (e.g. Wheeler et al. 2020a). This means, if water trading participation changes in one market, participation in another market is also influenced.

2.2.2 Temporary water market irrigator participation characteristics

This section focuses on the early literature of studying the characteristics of water allocation traders; the literature on characteristics post the Millennium drought; marginal returns to water allocation trading; and evidence that water allocation is used as a risk management strategy.

Early studies of water allocation irrigator trading characteristics (up to the Millennium drought)

Most of the early MDB literature has focussed upon participation in surface-water temporary trade. The first few years of participation in formal water markets in Australia were assessed by Alankarage et al. (2002); Bjornlund (2004, 2006a, 2006b, 2007); Bjornlund and McKay (1995, 1996) and Young et al. (2000). The early studies provide ground-laying insights into irrigators' water trading behaviour in Australia using non-econometric approaches. Some insights from this literature include that annual cropping farmers were most likely to trade temporary water, whereas most of the temporary water buyers were dairy farmers and most of the temporary water sellers were cropping and grazing farmers. Contrary to permanent water traders (see section 2.3), temporary water buyers could be clearly distinguished from temporary water sellers according to their efficiency level or any environmental or resource related factors, and no specific spatial movement of temporary water was found (Alankarage et al. 2002; Bjornlund 2004, 2006a; Young et al. 2000).

Bjornlund's (2006b) entitlement and trading register early simple descriptive data analysis (1991-92 to 2003-04) in the Goulburn-Murray Irrigation District (GMID) studied water allocation trade participation at an aggregated level across different regions, and between private and IIO irrigators. Its findings suggested that the Goulburn West (which had lower productivity through poor soils, high salinity) had a higher tendency to trade than the Goulburn East, followed by the Goulburn Murray and then private diverters.

Another early study by Young et al. (2000) using descriptive analysis only suggested that temporary and permanent water trading were linked by the following factors: price differential and price variations, resource constraints, tax laws, fines for exceeding water allocations, transaction costs, output prices, and water and land management practices.

One of the first studies to model irrigators' water allocation trading decision-making empirically was Wheeler et al. (2009). The study analysed interview data of 191 water allocation traders (94 buyers and 97 sellers) and 94 non-traders from 1998-99 within the GMID in the southern MDB, using multinomial and binary logit modelling to investigate the characteristics of early adopters of water allocation trading. Overall, results showed partly that the adoption of water trading is similar to the adoption of general agricultural innovations and was influenced by demographic, socioeconomic, attitudinal, and physical factors. Comparing buyers with non-traders, buyers were more likely (e.g. was statistically significant at least at the 0.10 level) to be: older; female; not have an agricultural qualification; live in the region of Pyramid Hill; have a higher operational surplus; have a higher total farm water entitlement; have a larger irrigated area; have a less favourable opinion about the need to specifically allocate water to the environment; and have a higher percentage of irrigated area for dairy cattle and for cropping. Comparing water allocation sellers with non-traders, sellers were more likely to be: older; newer to farming; have a higher education than Year 10; live in the region of Pyramid Hill; have a larger water entitlement; have a higher operating surplus; think their farm has lower productivity; have a lower percentage of irrigated area used for cattle and a higher percentage in crops; and have a smaller percentage of irrigated area connected to a reuse system. And finally, comparing water allocation sellers with buyers, sellers were more likely to have: agricultural qualifications; a smaller irrigated area; a smaller percentage of their irrigated land in dairy; a smaller percentage of irrigated area connected to a reuse system; and a more favourable opinion about specifically allocating water to the environment. Furthermore, results provided only weak evidence to suggest that water moved from lower value uses to higher value uses, which means the water allocation market initially had limited efficiency.

Wheeler et al. (2010b) builds upon Wheeler et al. (2009) using the described dataset from 1998-99 within the GMID, along with further survey data of the three farming seasons from 2003-04 to 2005-06. Using binary logit, multinomial logit and OLS regression models, the study analysed the changing profile of water allocation (n=628) and entitlement traders (n=316). Generally, results showed that the profile of water allocation traders in the early and mature stages of the water allocation market differ greatly, with education being the only common characteristic among both markets (i.e. low education levels were associated with less trade). Results showed that water allocation traders were more statistically significantly distinguishable from non-traders in the early market than in the mature market as common factors in the early year (i.e. being older, having a higher farm operational surplus, less years in farming, lower farm productivity level, larger farm size and farmers' water management attitudes (less favourable opinion about the need to specifically allocate water to the environment)) did not statistically significantly differentiate water allocation traders and non-traders during 2003–06. Furthermore, having a whole farm plan was linked with water allocation trading in the early years and with non-trading in later years, and a higher percentage of irrigated land connected with surface drains, a lower percentage of irrigated land with off-farm drainage and a more positive attitude towards water trading were associated with water allocation trading in the later years. Moreover, the study showed that there are significant differences in the profile of allocation and entitlement traders. Water allocation trading decisions were more likely to be linked with farmers' socio-economic characteristics and the type of farm (i.e. higher education level, larger irrigated area, having a whole farm plan, etc.).

Later studies of water allocation trading characteristics

From 2009-10 onwards, in particular, temporary water traders became more advanced in their use of market information for water trading decisions (NWC 2012). Qualitative interviews and five focus groups (n=74 across the sMDB) with irrigators in Loch et al. (2012) explored why irrigators participate in water allocation trade (particularly at different times within the season), and highlighted the increasing sophistication of allocation trading in particular. Loch et al. (2012) described the influence of attitude to risk, institutional/policy changes and deriving an income out of trading and found that predominantly perennial irrigators buy allocation to keep crops alive in seasons with low water availability and drought, whereas annual producers were able to achieve higher income from selling allocation to perennial production than from growing a crop. Trading allocation early in the season was used as a strategy to mitigate the risk of developing water scarcity and higher prices later in the year. Allocation trade allowed sMDB irrigators to adjust to seasonal fluctuations in commodity prices, precipitation, evaporation and water allocation levels, especially during prolonged drought, with irrigators experiencing higher variability in profit and increased downside risk, purchasing more allocation (Loch et al. 2012; Zuo et al. 2015a).

Marginal returns to water allocation trading

Wheeler et al. (2014c) used actual water allocation market data and farms' financial return data from ABARES surveys from 2006-07 to 2010-11 and found that the marginal impact of one additional ML of water allocation sale for horticulture, broadacre, and dairy industries, respectively, was $632, $465, and $219. Estimates of the cost of one more ML of water allocation purchase were $240, $125, and $81 for the horticulture, broadacre, and dairy industries, respectively. The value of foregone production (and additional production) from one unit of water sale (purchase) was the highest for perennial crops and lowest for annual crops (i.e., pasture, rice, and cotton). Such results partly reflect the fact that annual producers' use of irrigation water is more flexible (in terms of substituting other inputs for water use, such as feeding cows barley instead of watering pasture, and broadacre farmers can choose to not produce and sell their water allocations) versus perennial crops that are high value and permanent and take time to change production systems.

Water allocation trading as a risk management strategy

There is much evidence to suggest that irrigators use water markets as a risk management strategy (early evidence was provided in Bjornlund 2002, 2004, 2006b).

Zuo et al. (2015) modelled irrigator ABARES surveys from 2006-07 to 2009-10 (n=1232 in the sMDB) confirming the risk-reducing effect of buying temporary water, particularly for horticultural farmers. The study found that farmers experiencing higher variability in profit and facing more downside risk, purchased greater volumes of temporary water. Therefore, it was a risk-reducing strategy to purchase temporary water on the market, especially for horticultural farmers. Adding to this, but using ABARES survey data from 2006-07 to 2011-12, Nauges et al. (2016) modelled irrigator ABARES surveys for horticultural (n=963) and broadacre farms (n=543) in the sMDB and found that horticultural irrigators used temporary water trading because they are averse to the risk of large losses (downside risk) while broadacre irrigators use water trading as they are averse to the variability (variance) of profit. This confirms that water trading was used by irrigators as a risk-management strategy. The study emphasised the importance of the continuance of the development of Australian water market as an adaptation tool to help manage risk. Suggestions also included the development of models that would better predict the quantity of water available and hence expected future allocations, greater information provision or the development of secondary markets, such as options.

Allocation trading provides significant drought mitigation benefits: for example in the Millennium drought dairy producers were able to sell allocation and buy fodder, generating good returns from water sales while also avoiding the need to destock (Kirby et al. 2014). In particular, Kirby et al. (2014, table 1, p. 157) compared actual farming outcomes in the MDB from 2000–2001 to 2007–2008 and found that the real adjusted gross value of irrigated production fell by just 10%, despite a 70% decline in irrigated surface-water use, again highlighting the importance of trading in dealing with water scarcity.

Finally, studies have also looked at Australian irrigators' willingness to donate seasonal water allocations to the environment. Wheeler et al. (2014d) found that in a 2010–11 survey of GMID irrigators, 1 in 10 irrigators agreed that they would be willing to donate some seasonal water allocations to the environment. The study concluded that such donations are more likely to occur when water prices are lower, and that there are significant costs involved for irrigators to donate their water, hence there needs to be consideration about how to best manage and encourage this further, as well as how to carry-over and manage this water in readiness for its use as environmental flows.

2.3 Drivers of water market participation in permanent trade by irrigators

This section 2.3 provides an overview of the profile of permanent water market traders. It looks at the literature findings pre and post Millennium drought, as well as the literature focussing on the characteristics of irrigators who have sold permanent water to the government.

2.3.1 Early literature on the characteristics of irrigators who sold permanent water – pre Millennium Drought

Until 1994, permanent water was primarily traded out of regions undergoing environmental issues (i.e. regarding the level of water table, water supply, or water/soil quality) (Bjornlund & McKay 1995) and away from low efficiency technology irrigators (Bjornlund & McKay 1996). A large volume of unused water (i.e. 'sleeper' water) was sold into active production, mostly into the then high-value dairy industry in VIC (Bjornlund & McKay 1995). In SA, permanent water was primarily traded out of pasture, broadacre and non-farming uses into horticulture, viticulture and vegetable production (Bjornlund & McKay 1996). Correspondingly, studies often conclude that permanent water buyers were more likely to be cultivating permanent crops (e.g. citrus, grapes) to secure long-term water security (Young et al. 2000; Bjornlund and McKay 1995; 1996). Generally, water has moved to higher value (or more efficient) uses and provided incentives to increase irrigators' water-use efficiency. Thus, water trading increases the overall water allocation efficiency and water is sold by less-efficient users to high water efficient users (e.g. better soil quality or irrigation infrastructure) (e.g. Bjornlund & McKay 1995; Young et al. 2000).

More specifically, studies found that permanent water buyers were younger, had higher education levels, were actively participating in training sessions, used fertilised pasture area and grain for supplementary feeding, had larger investments in infrastructure (e.g. used irrigation scheduling aid), a whole farm plan, larger entitlement holdings, access to alternative water use (groundwater), on-farm water storage facilities, fewer environmental problems (regarding soil degradation and soil salinity), higher gross margins of water use and larger/more viable units (Alankarage et al. 2002; Bjornlund 2004, 2007). All these characteristics indicate higher efficiency levels. In addition, permanent water buyers cultivated on more loamy soils, whereas permanent water sellers were established on more sandy and clay soils (Alankarage et al. 2002).

Generally, permanent water trading was driven by the aim of long-term structural changes on the farm to control long-term risk exposure, e.g. to secure a particular level of water availability, or change farm location or type, which may be followed by the use of the temporary water market to adjust for the new risk position (Alankarage et al. 2002; Bjornlund 2006a; Turral et al. 2005).

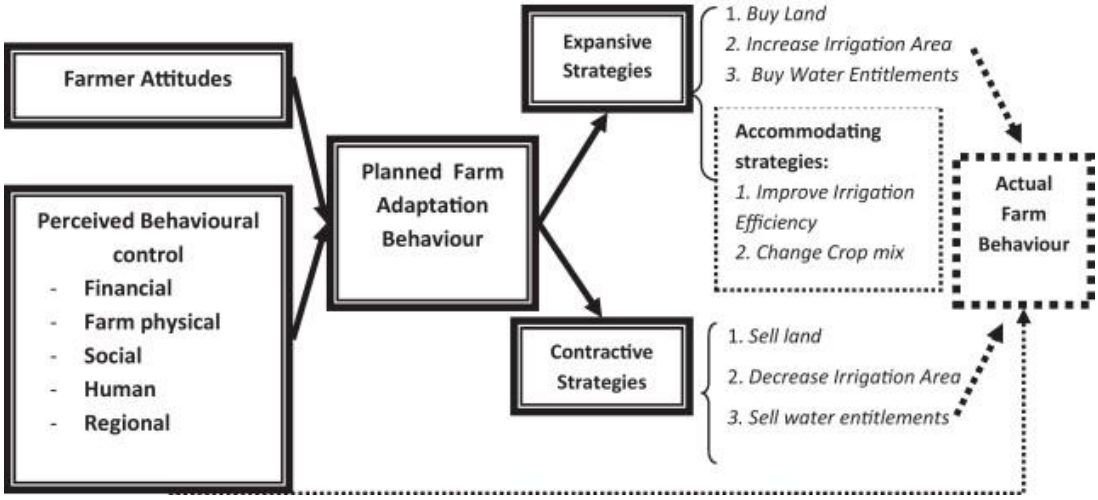
NWC (2012) further showed that individual industry developments (e.g. the expanding almond industry, economic decline for wine grape growers and dairy farmers) prompted large permanent water purchases or sales. The primary reason for permanent water sales was to generate cash (69%), followed by ceasing irrigation farming (24%), decreasing farm production and switching to rely on the temporary water market (especially in the dairy and broadacre industries where farm production is more flexible). Some farmers also bought permanent water 'locally' after selling their water to the buy-back program. Additionally, it was shown that many irrigators decided to retain their water delivery rights/access to irrigation infrastructure after selling permanent water entitlements (60%), e.g. to be able to sell the property with the delivery share attached.

Wheeler et al. (2010b) used a dataset from 1998-99 and 2003-04 to 2005-06 in the GMID to model the changing profile of water allocation (n=628) and entitlement traders (n=316). Specific results for water allocation trading have already been discussed, and while it was found that water allocation trading decisions were more likely to be linked with farmers' socio-economic characteristics and the type of farm (i.e. higher education level, larger irrigated area, having a whole farm plan, etc.), on the other hand water entitlement trading decisions were more likely to be associated with the extent of existing farm infrastructure (e.g. the percentage of the farm attached to off-farm drainage and reuse systems) and farm productivity. In particular, influences on water entitlement trading for 2003-2006 included a negative seasonal/climatic effect (year dummy for 2003/04) in all entitlement models; the presence of farm parents with a negative effect in the buyer vs. non-trader model, farm productivity with a negative effect in the seller vs. non-trader model, the percentage of land use as dairy, cattle and crop with a negative effect in almost all entitlement models but the buyer vs. seller model, percentage of property with access to off-farm drainage with a positive effect in the seller vs. non-trader model and percentage of property with reuse system with a negative effect in the seller vs. non-trader model. Furthermore, the study found that overall there are different factors associated with participation in the water market compared to those associated with how much water is traded. Also there were only two common variables with the same influence on volumes of water allocations/entitlements sold/bought: Increased entitlements owned were associated with increased volume of allocation or entitlements sold, while the presence of off-farm income was a negative influence on the volume of water allocations and entitlements purchased. The following influences were positively statistically significantly associated with both the allocation purchase volume decision and the decision to buy allocations: not having an agricultural qualification, having a higher farm operating surplus, and having a larger percentage of the farm attached to a reuse system. Having a larger percentage of the farm in dairy production and horticulture was negatively associated with both the water allocation sale decision and the volume sale decision. The study found less congruence between the factors associated with deciding whether to trade entitlements and how much volume to trade. Farm's productivity development level was the only common factor which was significantly negatively linked to the entitlement sale and volume sold decision. Wheeler et al. (2010b) also provided evidence that trading in the water allocation market has become more efficient over time, however the same could not be shown conclusively for the water entitlement market.

2.3.2 Later literature on the characteristics of irrigators who sold permanent water

Wheeler et al. (2013b) analysed 2010-11 irrigator survey data (n=642) from the southern MDB, comparing irrigators' planned and actual farm adjustment strategies to climate change over the past fifteen years (see Figure 2.5 for an overview of farm adaptation behaviour and adjustment strategies). Possible farm adjustment strategies include expansive and accommodating responses (e.g. buying land and permanent water, increasing irrigated area, changing crop mix and adopting efficient infrastructure) and contractive strategies (e.g. selling land and permanent water, and decreasing irrigated area).

Figure 2.5 Modelling irrigators' farm behaviour



Source: Wheeler et al. (2013b, p. 540)

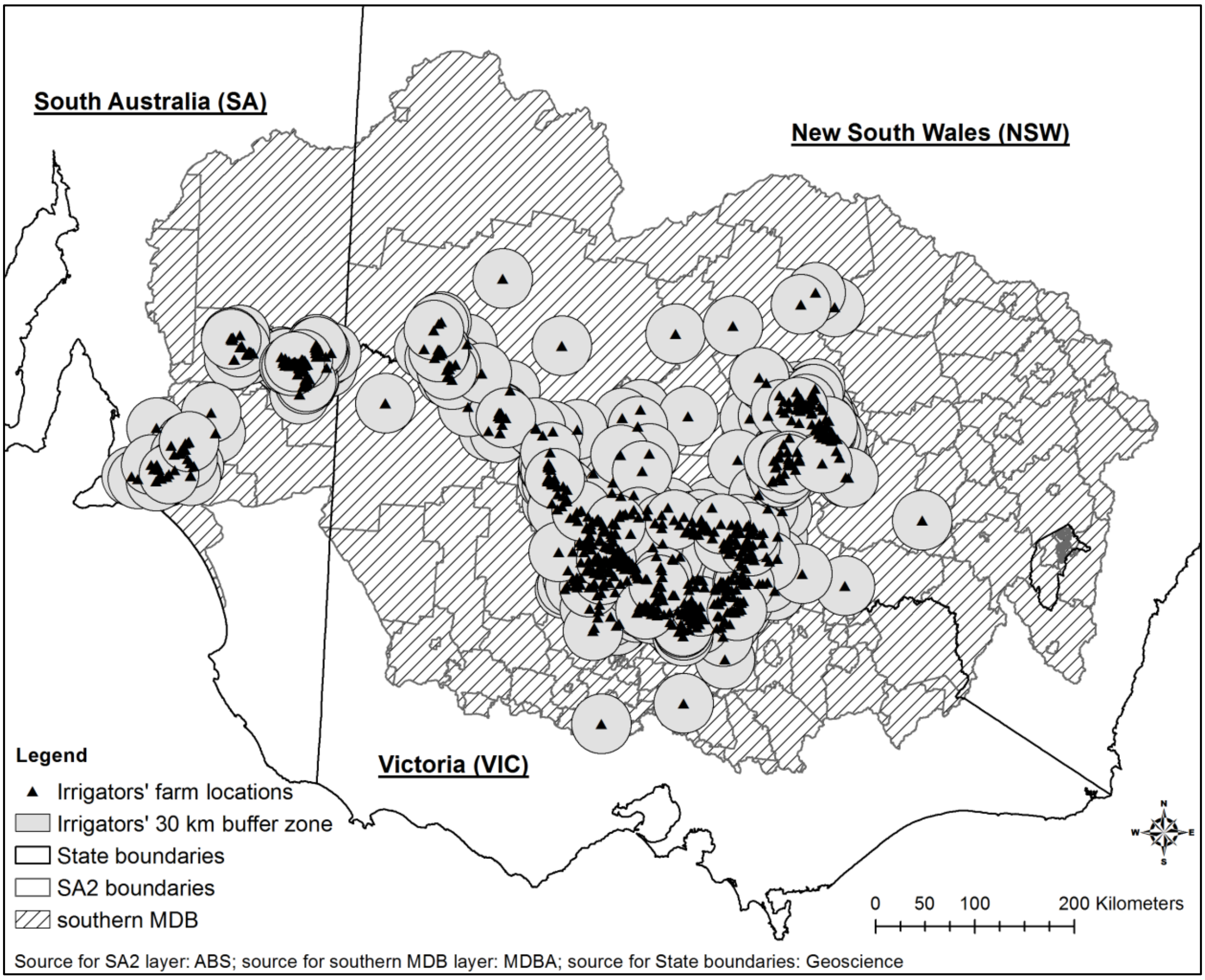
The study created an overall index of adaptability and estimated OLS regression models to explore influences associated with farm adjustment strategies. The index is the sum of all strategies, with a maximum of five (undertaking all five expansive but no contractive strategies) and a minimum of minus three (undertaking all of the three contractive but no other strategies). Overall, incremental adaptation is statistically significantly positively linked with younger (and healthier) farmers, farms that have identified successors, more productive farms, and more innovative, traditional and/or environmentally focused farmers. Furthermore, farmers believing in climate change were more likely to plan accommodating, but not expansive, strategies. Wheeler et al. (2013b) also modelled each farm strategy (namely whether irrigators planned to undertake various farm strategies in the next five years) separately, using bivariate and binary probit modelling. Drivers of planned permanent water purchases included: being younger, female, having spent less years farming, having a farm successor, being an annual cropper, being in horticulture, having purchased water entitlements in the past five years, having a larger reuse area, having experience greater productivity change on the farm. Drivers of planned permanent water sales included: not having a 'traditional' attitude to farming, being more risk adverse, having worse health, having spent more years farming, being an annual cropper, having sold water in the past five years, having received a higher volume of water that season and had received more net rainfall, and obtained information from government sources. These findings suggest that climate variability across the Basin has caused farmers who have experienced greater stress through lower water allocations and higher net evaporation to be more likely to plan contractive, or diversified, strategies. It was found that farmers who believe in climate change plan to implement more accommodating strategies. The results suggested that, as well as attitudes influencing behaviour, adaptation behaviour can influence attitudes, and this loop is most likely to occur for true water risk management strategies. Results also show there is an element of path dependence in farmer behaviour. Once farmers are on a certain track of expansionary or contractive behaviour, this will continue to influence planned behaviour.

2.3.3 Drivers of selling permanent water to the government

Studies relating to differences between open markets or government water market participation are relatively scarce. Wheeler et al. (2012b) analysed 1,570 surveys from two years (2008-09 and 2010-11) to investigate a) irrigators' intentions to sell water to the government in the future; and b) those who had actually sold permanent water to the government in the sMDB. Ordered and binary probit regression analysis showed that irrigators primarily decided to sell out of 'last resort' circumstances, i.e. debt, death, and divorce, or for strategic reasons (e.g. following farm investment plans, water surpluses). Overall, results suggested that non-traditional farmers, with higher debt, lower farm income, larger high security water entitlements, lower water allocations over the past 5 years, and those who have been net sellers of water allocations were more likely to have sold water or are thinking of selling water to the government. Overall, irrigators' permanent water selling behaviour can be different across regions and multifaceted (i.e. depending on various factors, such as financial, farm, institutional, social and regional). More specifically, the following influences were statistically significantly associated with actual water entitlement sales: being younger, lower education levels, having non-traditional attitudes, higher number of children, not using governmental information sources, being net sellers of water allocations, having a whole farm plan, land use (lower percentage of annual and permanent crops), lower operating surplus, higher debt, lower allocation level, and the location (VIC or SA). A slight difference between 2008/09 and 2010/11 sellers was identified: age, education, number of children, information source, having a whole farm plan, farm operating surplus and the location only had an influence on sales in 2010/11 and percentage of the farm area under horticulture and the level of debt only had an influence on sales in 2008/09. In contrast to the actual sales models, irrigators' willingness to sell was influenced by gender (male), lower number of years farmed, other attitudes (commercial and environment orientated farmers but not succession orientated), having past water entitlement sales experience, the cap had prevented previous water entitlement trade, lower number of full-time equivalent employees, and larger farm size. Permanent crop irrigators were less willing to sell water entitlements in 2008/09 since permanent cropping allows less flexibility and a higher reliance on secure resources. But in 2010/11 permanent crop irrigators were more willing to sell potentially due to decreasing prices for wine grapes (and citrus). Generally, financial factors played a more important role in the actual sales models, whereas attitudinal and regional/institutional factors had a higher influence in willingness to sell models. The difference between 2008/09 and 2010/11 models can largely be explained by the effect that drought and non-drought years can have on the decision to sell water entitlements, as well as by the different characteristics of the survey regions.

Haensch et al. (2019) also studied permanent water entitlement selling decisions at the individual farmer level using survey data of water entitlements sold to the government's buyback program in 2009/10 and 2010/11 in the southern MBD (n=1,462). Irrigators' locations were geocoded and locational characteristics were linked to the survey data using a GIS system. Results of several binary probit regression models and a censored tobit model showed there was a significant farmer neighbourhood effect, i.e. irrigators were influenced by their neighbours' decision to sell permanent water to the government (higher likelihood of permanent water sales occurring in areas where more neighbours had sold permanent water). Using Anselin's Local Moran's I measure the study identified that water entitlement sales were spatially clustered at 40km and 90km, which means farmers' neighbourhood size may vary across the regions in the southern MDB). Figure 2.6 illustrates the spatial location of irrigators who had sold water to the government, as at 2012 (using data from all information on who had sold water to the Commonwealth by 2012 in the sMDB).

Figure 2.6 Irrigator locations and spatial units in the southern MDB



Source: Haensch et al. (2019)

Zuo et al. (2016) used sMDB survey records (n=535), along with a contingent ranking experiment (that generated up to 4,300 records for analysis) and revealed actual data from the Restoring the Balance program (data from all irrigators who sold and offered water to the Restoring the Balance program) as to how irrigators in the southern MDB may buy and sell water entitlements in response to different prices. A high security water entitlement demand elasticity of -0.57 was estimated, along with a supply elasticity of 0.42. The relative inelastic demand supported the need for multiple tenders over time.

Given that current water supply in permanent water markets is very small compared to total water ownership and permanent market participation has been increasing over time since 2006, it is also important to understand the impact of water recovery in permanent water market dynamics where demand is inelastic (e.g. Zuo et al. 2016). The exact impact may also depend on the extent to which the permanent or temporary market plays a price leadership role.

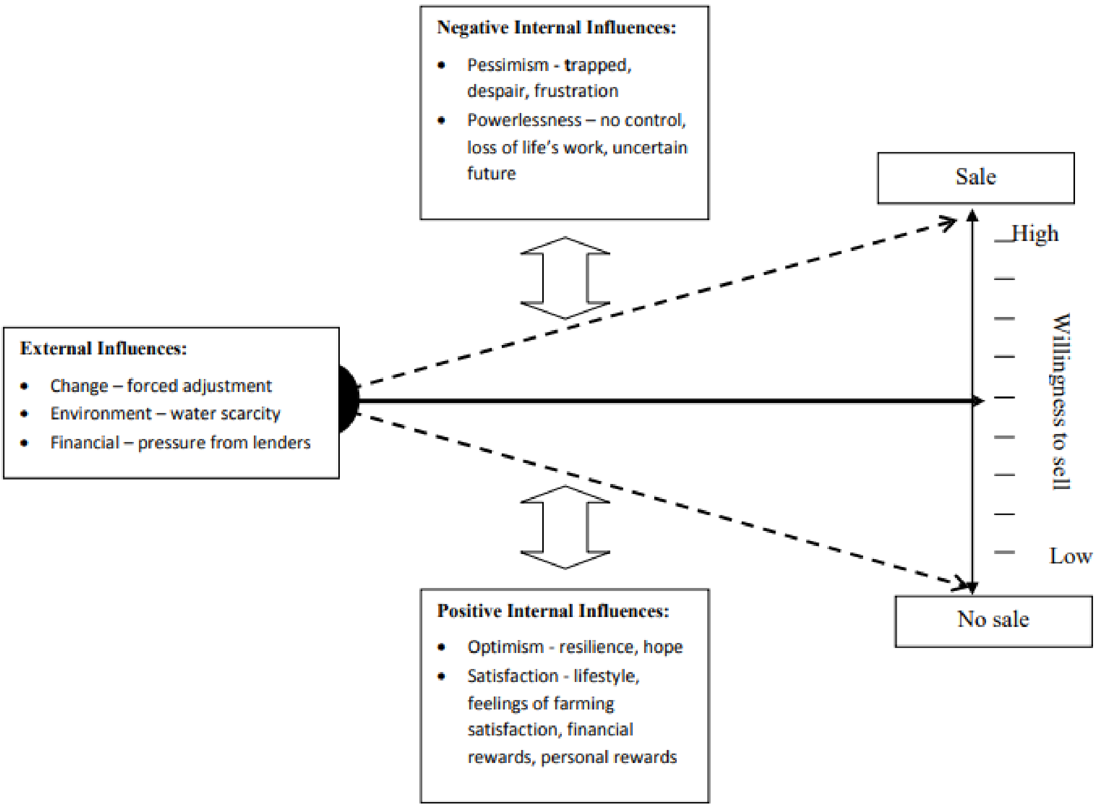
Regression model results in Haensch et al. (2019) also confirmed associations of irrigators selling permanent water to the government with lower education levels, having a whole farm plan, not using government agencies as an information source, owning larger volumes of water entitlements, and having previous lower seasonal water allocation levels. Also smaller farm sizes and carrying over lower volumes of water from the previous season were linked with water entitlement sales. Furthermore, sellers' characteristics may change over the years as models by year showed that being younger, lower educated and a net seller of water allocations and having a higher percentage of income from off-farm work increased the likelihood of selling in 2009/10 but not in 2010/11. Models also suggested that irrigators' located further away from cities were more likely to sell their water (at a decreasing rate) and confirmed the positive relationship with dryland salinity. Moreover, a higher likelihood of permanent water sales was shown for irrigators located closer to the downstream area (closer to key environmental issues) confirming previous findings that SA and VIC irrigators were more likely to sell water entitlements to the government.

Qualitative studies (i.e. farmer interview based) found similar influences. For example, Thampapillai (2009) suggested that irrigators in financial hardship, close to retiring, with off-farm income availability, and having no successor were more likely to sell permanent water to the government. Murrumbidgee (NSW) irrigators were unwilling to sell water separate to the land because permanent water were still considered as being part of the land and an integral farm asset. Irrigators from the Goulburn-Broken (VIC) region were worried about the future and security of food production. In general, irrigators not willing to sell expressed concerns about the rural viability, rising costs of the irrigation infrastructure system, government management of environmental water and transparency of the government's buy-back program. Section 6 provides more overview of irrigators' changing views towards water trade issues over time.

Schirmer (2016) reported on the Regional Wellbeing Survey results of 833 MDB irrigators in 2015 using descriptive statistics, and showed that many irrigators answered that selling permanent water had had a positive impact on their farm, particularly in relation to reducing debt, reducing stress levels, and improving their life, finances and farm enterprise as a whole. Irrigators were slightly more likely to rate better outcomes on-farm for transfers of water entitlements for irrigation infrastructure upgrades. Schirmer (2017) found that MDB irrigators who received an infrastructure grant were significantly more likely to: increase irrigated, farm areas and irrigation efficiency; purchase new land and intensify production. They were more likely to experience negative impacts such as increased farm debt and electricity/power costs from modernisation; and experience a loss in the last year (and over the previous three years).

Kuehne et al. (2010) conducted a mailout survey of irrigators in the Riverland in 2008-09 (n=291) and performed simple descriptive statistical analysis to suggest the relevance of non-profit maximising values for the decision to sell water to the government, such as plans for staying in farming, years left to retirement, succession arrangements, being full-/part-time or hobby farmer, future employability, whether the water sale included the land, conditions of the farm exit grant package, and the price on offer. A more pessimistic attitude towards the future was associated with a higher probability of water sales (illustrated in Figure 2.7).

Figure 2.7 Attitudinal influences on willingness to sell permanent water



Source: Kuehne et al. (2010; p. 102)

Whilst confirming debt as a dominant reason for selling permanent water, Bjornlund et al. (2011) likewise emphasised the role of irrigators' values, attitudes and wellbeing (financial security is only one driver of wellbeing).

Furthermore, using simple statistical comparisons a report found that program participants in an early government buy-back program in NSW (n=63) were primarily using less efficient technology, owned a large proportion of permanent water, were older, better educated, had a high gross income (with the majority earned on-farm) and were primarily selling because of financial planning (Walpole et al. 2010). Another report similarly suggested that the two most important motivations for water sales were based on financial reasons (retiring debt) and re-investment in the farm (Hyder Consulting 2008). Consistent findings were reported by Wheeler and Cheesman (2013). This study (which is the largest ever survey of sellers to the Restoring the Balance program to date –520 sellers surveyed) found that 70% of the survey participants remained in farming, after they had sold parts (60%) or all (10%) of their permanent water, and 30% exited farming after they had sold all of their permanent water. Thus, exiting farming was not a major driver for the decision to sell permanent water to the government. Dominant reasons for selling were debt (30%) and cash flow (30%). The cash flow was mainly used to support farm income and increase viability (22%) and also to fund on-farm investment (8%). Other reasons for water sales were farm exit (15%), having surplus water (9%), age, and death/divorce. Also, few participants responded with environmental reasons, family support, frustration with local IIO or the government, channel upgrades, unbundling of land and water as well as decreased water quality levels.

TC&A and Frontier Economics (2017) reported the results of an analysis by DELWP of 11% of Victorian irrigators who had sold water entitlements to the Commonwealth across three years: 2008-09 to 2010-11, but continued to irrigate. They found that:

- 37-49% of irrigators purchased new entitlements correspondingly;
- 61-74% only sold part of their entitlement, and continued to receive water allocations; and
- The proportion of net purchasers of water allocations increased.

Increased demand from permanent horticulture during periods of water scarcity can increase water prices, which impacts negatively on those irrigators who rely on the temporary market. This was said to impact broadacre, dairy and younger irrigators the most (NWC 2012).

Drivers of irrigators' preferences for water recovery in the MDB

Using a mail-out survey in the southern MDB in 2011, Loch et al. (2014a) and Loch et al. (2016) analysed irrigators' preferences to allocate federal water recovery budget funds in the sMDB (n=535), including market-based water policy programs. These market-based water policy programs included water entitlement purchasing, temporary water market products and exit-based packages to recover water, and were compared against irrigation infrastructure on and off-farm programs. Table 2.5 shows irrigator preferences for government expenditure on market-based programs to reallocate water toward environmental uses. Overall, irrigator preferences were 56% for infrastructure and 44% for all types of water market purchases.

Table 2.5 Water recovery irrigator budget expenditure preferences in the sMDB in 2011/12

Policy Options	Mean percentage[c]				One-way ANOVA F-test
	NSW (n=176)	SA (n=205)	VIC (n=154)	Weighted Average	
Upgrading on-farm irrigation infrastructure	<u>32</u>[b]	21	<u>34</u>	31	17.44***
Upgrading off-farm irrigation infrastructure	<u>28</u>	<u>23</u>	<u>25</u>	26	2.09[a]
Water entitlement purchases	<u>18</u>	34	<u>19</u>	21	21.71***
Water Allocations/Entitlement leases/option contracts	<u>12</u>	6	<u>11</u>	10	3.95**
Exit Packages & revegetation payments	<u>6</u>	11	<u>7</u>	7	4.69**
Standard Exit Packages	<u>5</u>	<u>5</u>	<u>5</u>	5	0.42[a]

<u>Notes</u>: a Represents the robust test of equality of means (Welch) due to heterogeneous variances, and *p-value<.1; **p-value<.05; ***p-value<.01.
b Underlined state mean percentages indicate they are not significantly different at p<0.05 using Bonferroni post-hoc comparisons.
c Calculations do not include 'no answer' responses.

<u>Source</u>: Loch et al. (2014a, p. 400)

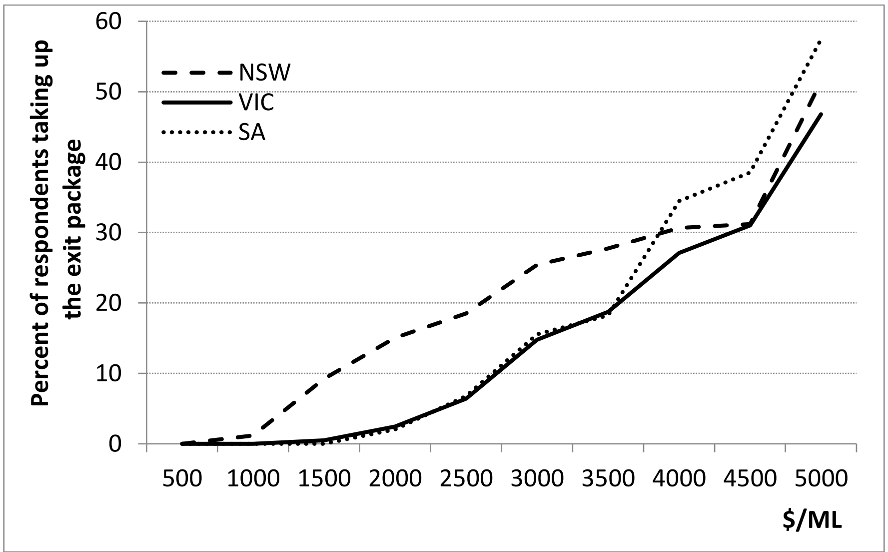
Overall, Loch et al. (2014a) suggested that irrigators marginally prefer infrastructure expenditure above market-based options (i.e. water entitlement purchasing, temporary water market products and exit-based packages). The study's descriptive analysis showed distinctive differences across responses by state. For example, SA irrigators were significantly different in their preferences to NSW/Victorian irrigators in most water recovery options. Specifically, SA irrigators favoured higher spending on water entitlements and exit packages compared with NSW or Victorian irrigators, and less spending towards on-farm infrastructure. Irrigators' main reason for their budget preferences was the need to improve irrigation efficiency (49%). Irrigators preferring trade and exit packages (15%) were driven by various policy options, or the belief that policy needed to be more flexible. Irrigators favouring water markets were more likely to be interested in retirement options and to indicate environmental water needs as a reason (as a more cost-effective option).

In Loch et al. (2016), a zero-one inflated beta regression analysis, using the same survey data as Loch et al. (2014a), identified variables that increase engagement with market-based programs, which were state regional influences, the type of farm production and recent stress that the farmer has incurred (i.e. debt, low income, or low water allocations). In particular, NSW irrigators (primarily annual cotton and rice farmers) prefer farming over water trade, whereas perennial viticultural and horticultural farmers show positive engagement with market-based programs. Also, SA irrigators were linked with moderate preferences for market-based options. Broadacre and dairy cropping farmers were associated with moderate lower proportional preference outcomes (dairy farmers are more flexible with risk management and thus less reliant on market mechanisms). Furthermore, increased farm debt and water extraction levels as well as higher holdings of high security water entitlements showed decreased preferences for market-based programs. Farm income variables (both on- and off-farm) showed positive associations with proportional preferences. Price variables appeared to be less relevant but higher water entitlement prices paid in 2010/11 prompted irrigators toward positive proportional water market preference outcomes.

Drivers of irrigators' preferences for farm exit in the MDB

Zuo et al. (2015b) used mail-out survey data (n=535) to examine the various factors that would influence exit package take-up across the different sMDB states. The results found that around one-fifth of farmers in the sMDB would require a price premium of around $1,600/ML over the current water entitlement market price (representing 174, 81 and 89% over the water entitlement market price at the time in NSW, Victoria and SA, respectively) to take up an exit package. Price elasticity estimates of exit package take-up in all states were elastic at most price levels. Figure 2.8 illustrates the percentage of irrigators stating they would take up an exit package in the three sMDB states for certain water entitlement prices.

Figure 2.8 Predicted exit package take-up in the sMDB



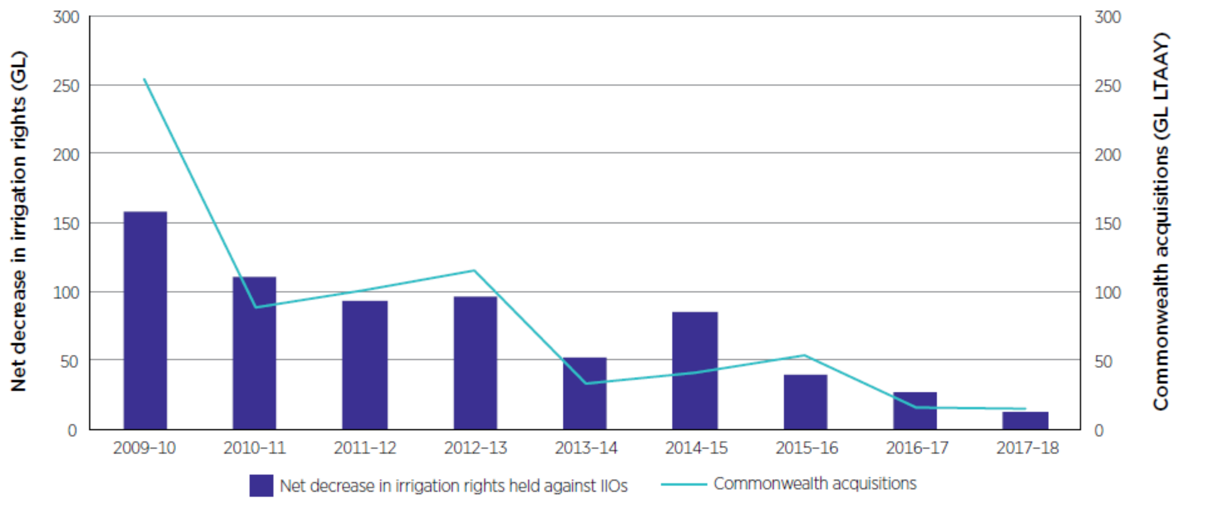
<u>Source:</u> Zuo et al. (2015b)

Potential Implications for IIOs delivery and operating impacts

An issue that is commonly raised in relation to the implications of irrigators' selling water entitlements out of IIOs is the potential creation of stranded assets and/or redundant infrastructure. A stranded asset is any component of the water delivery system (e.g. meter, off-take wheel, channel diversion box etc.) that reduces in value on the market as compared to its value on a balance sheet because it has become obsolete (or unused) before being fully depreciated by an IIO. In irrigation areas, when there is a permanent decrease in the demand for water delivery services the assets of IIO can become unused or underused (or stranded). This is also known as the 'swiss-cheese' effect from infrastructure removal and the spreading of operational costs across a reduced irrigator membership (Loch et al. 2014b; Walsh 2012). Empirical evidence from Wheeler and Cheesman (2013) – the largest survey of water entitlement sellers conducted - found that of the farmers who owned water in irrigation areas, 60% of them kept their delivery rights, while 94% of those who stayed farming after selling water kept their delivery rights. IIO areas now impose termination or exit fees to cover the ongoing costs associated with stranded assets. These are a charge imposed on entitlement trade and subsequent loss of a water access entitlement out of an irrigation district or area. These fees are set by the ACCC and charged to maintain the delivery infrastructure or any stranded assets that remain after the water access entitlement has left the area. These results indicate uncertainty about the reality of stranded assets, but at the same time there needs to be a recognition that a severe rationalisation of irrigation areas needs to be considered anyway, with perhaps large amounts of area removed from the system.

Figure 2.9 below illustrates the net decrease in irrigation rights held against IIOs (where terminations were highest in 2009-10), and that terminations have fallen over time, and overall been less than Commonwealth acquisitions.

Figure 2.9 Australian Government environmental water acquisitions and net decrease in irrigation rights, 2009–10 to 2017–18



Source: ACCC (2019b, p. 53)

The ACCC highlights that the largest price increases occur in modernised IIO schemes (e.g. pressurised systems in particular), where infrastructure modernisation impacts upon irrigators' future delivery charges and energy costs (ACCC 2019b).

MJA (2019) discusses how the investment in off-farm irrigation infrastructure is 'gifted' (i.e. the infrastructure is excluded from the regulatory asset base for the duration of its life) in return for water savings. However, operational, maintenance costs and tax on the asset still have to be paid, and therefore impacts on irrigators' delivery and other charges. The exclusion of infrastructure from the regulatory asset base means irrigators are not charged for infrastructure depreciation or financing costs, which will have implications when it needs renewal in the future, causing a range of concerns. In some worked examples of this, MJA (2019) noted that the GMW gravity irrigation business would need to increase prices significantly in real terms to achieve operating and other cost savings, while Murray Irrigation delivery charges would need to rise by at least 30% in real terms over the next decade (in part these price increases are due to the Private Irrigators Infrastructure Operators Program investments). They concluded that irrigation infrastructure subsidisation is currently hiding the real ongoing cost of irrigation upgrades from irrigators.

2.3.4 The link between water trading and farm profitability

In order to understand the link between water trading and farm profitability, we have to understand where water trading is measured in farm accounting. The standard definition of irrigation farm net income includes: total cash receipts (beef cattle receipts, dairy cattle receipts, sheep receipts, other live-stock receipts, transfers of livestock to other properties, off-farm contracts, crop receipts, off-farm share-farming, wool, milk, *water allocation sales*, other farm receipts) minus total cash costs (hired labour, produce purchased, agistment, packing materials, livestock transfers, dairy supplies, fertiliser, fodder, seed, crop and pasture chemicals, fuel, livestock materials, electricity, repairs and maintenance, water for livestock, wool, packs, freight, packing charges, contracts paid, lease payments, administration, insurance, motor vehicles, plant hire, rates, interest, land rent, on-farm sharefarmer payment, *water allocations purchased*, fixed charges for water, other services and materials). The purchase and sale of water entitlements is treated as capital additions or disposals and are included in rate of return or profit at full equity calculations, not farm net income measures (Wheeler et al. 2014b). Wheeler et al. (2014c) analysed 3,428 unit-level farm records held by ABARES over the period 2006-07 to 2010-11 in the MDB, and found that selling a larger volume of water allocations improved farm viability, and that there was no significant impact in the farm's current financial year from selling water entitlements (but a negative impact on current year from buying water entitlements). These results illustrate the positive and negative impacts that arise from the sale of water entitlements in the current year (for example, the reduction in debt and the corresponding reduction in interest payments for net farm income which is counterbalanced by the reduction in production from less water) were generally cancelling each other out in the time-period studied. On the other hand the increase in debt that occurs from buying water entitlements in a given year is not offset at all by any increase in agricultural production that year (probably because of the transaction time involved in buying water entitlements and the need to make longer-term farm plans).

Another study using a University of Adelaide dataset by Wheeler et al. (2014b) used 1,987 irrigator records in the sMDB to investigate whether it could be detected whether irrigation farms who had sold water in the past had an impact on net farm income. There was only weak to no significant evidence found of a delayed impact from selling water entitlements on farms that stayed farming. Hence, the very weak results of the water entitlement sale results in this study is most likely due to the two influences from selling water entitlements for many farmers: a positive (reduction in debt, farm restructure and reinvestment to make it more productive or efficient) and a negative (less water for production and/or higher costs in buying water allocations or bought feed) impact.

Khan et al. (2010a); (2010b) found that water markets could significantly improve farm income, and at lower water allocation prices (<$200/ML) an irrigator could maximise farm income by buying additional water allocations, and at higher water allocation prices, an irrigator was better off reducing the area of irrigated crop and selling water allocations.

2.3.5 The link between water scarcity and farm exit

Wheeler and Zuo (2017) used ABARES irrigation survey data in the sMDB from 2006-07 to 2012-13 (n=2,840) to examine how drought and water scarcity impacted on irrigator exit intentions. They undertook seven sets of probit regression modelling: a) all years in the southern MDB for all industries; b) drought years (2006-07 to 2009-10) for all industries; c) non-drought years (2010-11 to 2012-13) for all industries; and d) all years by industry (horticulture/dairy/broadacre). Positive statistically significant influences on irrigators' intention to exit the farm in the future for the entire time-period included: being older (but this likelihood fell after a certain age threshold – namely aged 80); have sold permanent water entitlements; having less farm debt (but the likelihood increased after a certain debt threshold); having greater off-farm income; having a lower farm rate of return; being in NSW Murray; having less winter rainfall; and not being in the broadacre industry. There was only weak statistically significant evidence to suggest that irrigators' exit intentions were higher in times of drought (from the statistically significant variable of winter rainfall), but there was stronger evidence to support the influence of a lagged water scarcity impact on farm exit intentions during periods of non-drought (from the variable of past water allocations received to water entitlements). In other words irrigators who had experienced more water scarcity in the form of reduced allocations were more likely to intend to exit at times when the property market was less depressed. The key variables linked to exit in drought period times was financial factors (namely rates of return and higher debt over a certain level): these farms were more likely to have exit intentions in drought periods, but not necessarily so in non-drought periods. Wheeler and Zuo (2017) suggest that this is because farms struggling financially are the ones who are forced to leave more in times of debt, while others who can hold on choose to leave in times of non-drought when it is easier to sell farms in the property market.

2.4 Non-Landholder participation in Water Markets

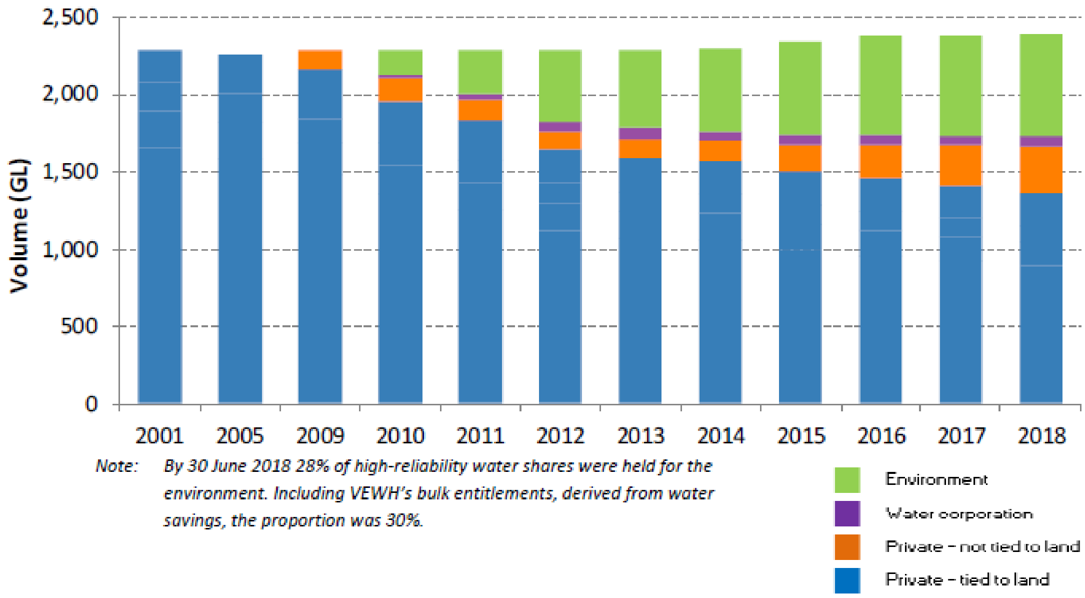
There has been little research to date that has focussed on non-landholders participation in water markets. The separation of land from water allowed for new market participants, such as Environmental Water Holders (EWHs) and non-landholder financial investors (such as superannuation companies and other water market traders who do not own water) to trade water. As already highlighted previously, the reason financial investors have increasingly invested in water is because of the long-term increase in water asset values – to diversify their investment portfolios with water assets which share little correlation with other asset classes (Wheeler et al. 2016), and the fact that variability in water market prices presents significant opportunities for investment trade returns.

Apart from the water entitlements owned by the Commonwealth of Australia, only a small amount is known about the official figures of investment in water entitlements by corporate non-landowners. There is no publicly available register of agri-corporate land and water ownership, apart from what companies publish in their annual financial reports. A crude approximation is the "non-user" group in the Victorian water register (DELWP 2019b). A "non-user" is defined as water entitlements which are not "associated" to land (note this is not describing unbundling, user owned entitlements are fully unbundled), in form of an irrigation or land-use licence. Entitlements not "associated" with land may still be owned and traded by irrigators who own multiple water allocation accounts or have their entitlements as part of their self-managed superannuation accounts.

However, as non-landholder stakeholders by definition do not irrigate themselves, they also would have their entitlements listed in the "non-user" group, enabling crude approximation. Non-user ownership of high-reliability water entitlements increased from 5% in 2009 to 12% in 2018 (DELWP 2019b), see Figure 2.10. While this growth is not directly attributable to a growth in non-landholder ownership, as irrigators may have increased their use of multiple allocation bank accounts or self-managed super funds, anecdotal evidence suggests water entitlements owned by non-landholder investors has increased over time across the MDB.

Concerns have been raised regarding the level of foreign ownership of water entitlements. The latest estimates available suggest that 9% of MDB water entitlements as at mid-2018 were held by companies with some level of foreign ownership (ATO 2019). Information on ownership is difficult to establish without paying for a register search and knowing the water access licence number. This has led some to call for increased public information transparency in regards to water ownership, especially by those who make decisions about water in government.

Figure 2.10 Northern Victorian high-reliability water entitlements by user and non-user group



Source: DELWP (2019b, p. 9)

Because of the lack of public information available on non-landholders involvement in water markets, Seidl et al. (2020b) analysed results from 63 semi-structured interviews undertaken in late 2018: 20 investors and agri-corporates (very large landholders owning and/or trading water but generate their main income from farming); 15 EWH and NGO employees (public or private entities, owning or delivering water entitlements or allocations for environmental purposes); 10 water evaluators (consultants etc. specialised in water valuation); 7 financial investors (non-landholders trading water for financial gain); 6 bankers (employees from financial institutions who were the key individuals responsible for significant lending portfolios in water entitlements); and 5 water brokers (who earn commission-based revenue from water market transactions). Chapter 6 provides more methodological details.

Seidl et al. (2020b) focused mainly on understanding water ownership and market strategies by land-holders versus non-landholders, and it used information from a range of quantitative sources (namely a survey of 1000 sMDB irrigators in 2015-16) plus the interviews with 1) investors and agri-corporates, and 2) EWHs and financial investors.

Table 2.6 illustrates the surface-water entitlement ownership and carry-over for sMDB irrigators from the two sources of information. Key points from this table are that irrigators own less diverse surface-water portfolios (e.g. diverse is the number of surface-water securities held) than agri-corporates, with non-landholder surface-water ownership the most diverse. 67% of Victorian irrigators own a diverse water portfolio of at least two types of entitlements, with diverse ownership less common in NSW (28%) and SA (7%). This is mainly because of historical factors of water ownership by regions within states. In contrast, the interview participants had a much more diverse portfolio ownership, between 58% and 86% having a diverse portfolio across different stakeholder groups.

Table 2.6 Surface-water entitlement ownership and carry-over for MDB irrigators and landholder/non-landholder interview participants

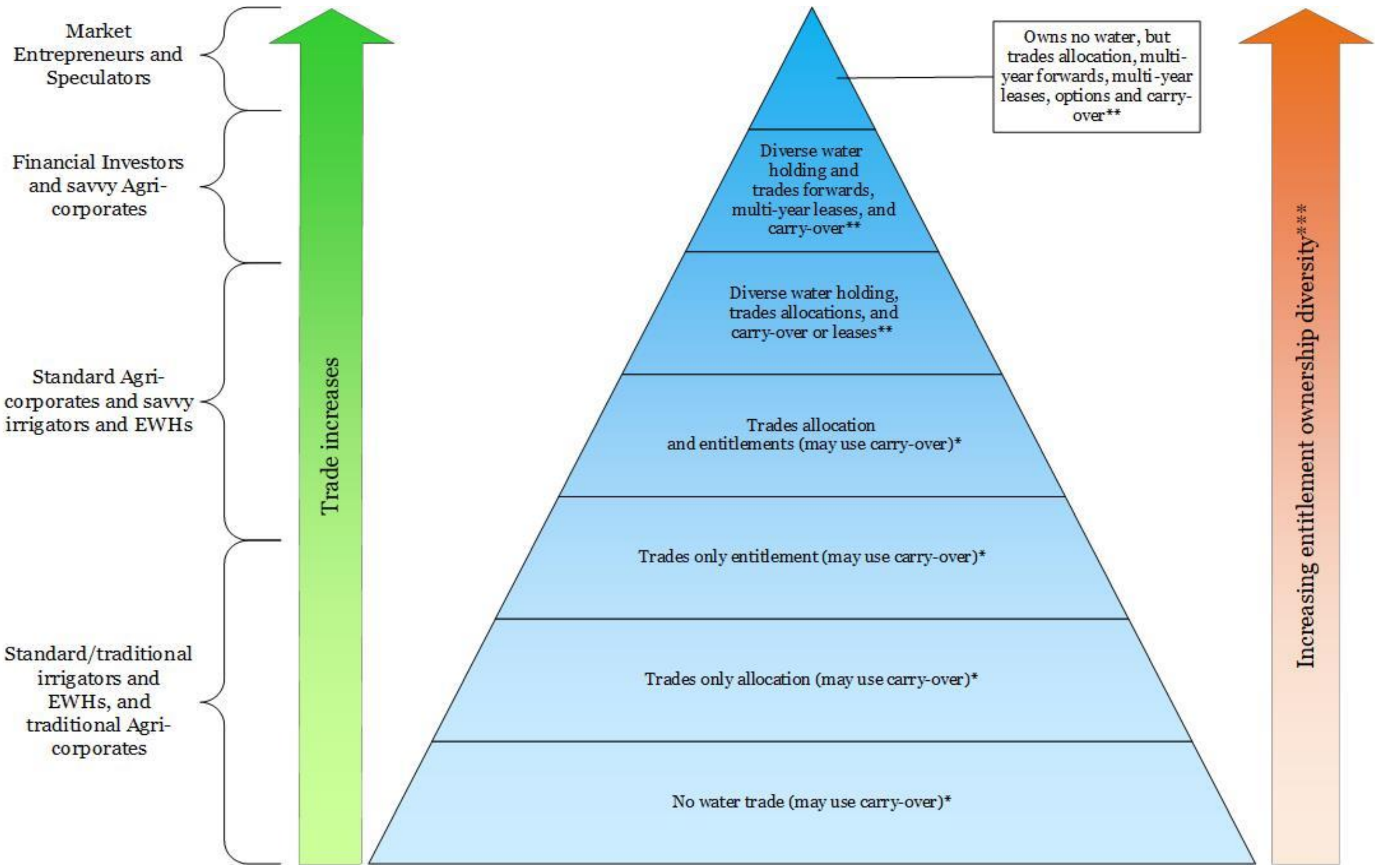
Method	State/ stakeholder	Own surface-water entitlements? (% answering yes)*				Diverse entitlement ownership (% owning more than one security type)**	Used carry-over? (% answering yes)***
		High	General	Low	No ownership		
2015-16 Irrigator survey – southern MDB	NSW (n=419)	37%	65%	12%	4%	28%	67%
	VIC (n=372)	94%	3%	62%	2%	67%	84%
	SA (n=209)	81%	9%	5%	8%	7%	11%
2018-19 landholder and non-landholder interviews	EWHs (n=12)	100%	75%	42%	0%	83%	67%
	Financial Investors (n=7)	86%	86%	72%	14%	86%	78%
	Investors/agri-corporates (n=19)****	95%	26%	37%	0%	58%	39%

Notes: *More than one type of water entitlement can be owned.
**Does not include delivery share ownership
***Question asked for the 2014-15 water season in telephone survey. Carry-over was not available on SA entitlements in 2014-15, but some South Australians own water elsewhere with carry-over availability.
****Investors/agri-corporates own land, EWHs and financial investors generally do not.
Source: Seidl et al. (2020b)

Figure 2.11 illustrates a typology of water market participants (and trade strategies) in the sMDB. Note Seidl et al.'s (2020b) typology relates to water trading and ownership strategy sophistication, is indicative and not to scale. The typology is based on water allocation and entitlement trade results for 1,000 irrigators in the sMDB in the water season 2014-15 and insights from the stakeholder interviews in 2018-19.

A broad classification includes standard/traditional irrigators, EWHs, and traditional agri-corporates tend to rarely to sometimes use trade markets, and they tend to own all or an excess of their water needs under one main form of entitlement. They are most likely to use carry-over as a trade product, and trade allocation to either supplement water supply (or to earn income from surplus water). For example, 38% of them did not conduct water trade in 2014-15 (but they may have used carry-over); while 51% of them traded only water allocations. Moving up the pyramid, more "savvy" irrigators, EWHs, and "standard" agri-corporates own diverse portfolios of entitlements, occasionally trade entitlements, and make regular use of their own carry-over, allocation and lease trading for farming. 7% of our 1000 surveyed sMDB irrigators traded water allocations and entitlements, while only 4% traded water entitlements only. Moving up further again in the pyramid sees "savvy" agri-corporates and financial investors owning diverse entitlement holdings, frequently trading sophisticated temporary products for water supply and price arbitrage differences. This is based on the 38 landholder and non-landholder qualitative interviews: where 55% of them traded carry-over and/or allocations/leases; and 29% of them traded forwards, multi-year leases and carry-over. Finally, at the top of the pyramid there is an even smaller number of highly "sophisticated" market entrepreneurs who, while not owning water, trade and arbitrage daily across the whole diverse range of temporary products, often developing and trading new temporary innovative water products (Seidl et al. 2020b). In the qualitative surveys, only 3% owned no entitlements but traded carry-over, multi-year leases, multi-year forwards, and options.

Figure 2.11 A Typology of MDB Water Ownership and Trading Strategies



Source: Seidl et al. (2020b)

Notes: Diagram is not drawn to scale, and classifications of irrigators into groups (e.g. standard irrigators, standard agri-corporates etc. are approximate only).

*Based on trade results for 1,000 irrigators in the sMDB in 2014-15

**Based on 38 landholder and non-landholder interviews

***The exception to this trend is the top of the pyramid: a very small percentage of financial investors own no water entitlements This group of players are the closest to speculators in the true sense: their revenue stems from 1) arbitrage between markets and seasons; 2) speculation on future price movements; and 3) shouldering risk through contractual arrangements (e.g. selling forwards, but underwriting them with entitlement leases).

Table 2.7 illustrates the reasons why EWHs, Financial investors and investors owned the water portfolio that they held. Rationales for water ownership are classified into eight broad reasons: historic; supply security; asset investment; diversification; proximity to (agricultural) operations; price; deliverability; and liquidity. Rationale for water ownership varies between and within our landholder/non-landholder stakeholder groups.

Table 2.7 Water asset characteristics and rationales for surface-water ownership strategies

Water Asset characteristics	***Sub-total (n=38)***	***EWHs (n=12)***	***Financial Investors (n=7)***	***Investors (n=19)***
Do you view water entitlements primarily as a financial/investment asset? *(% of yes responses)*	79%	75%	100%	74%
How do water entitlements compare to other financial/investment assets? *(% of respondents believing entitlements represented an unique asset)*	50%	33%	57%	58%
Answers to the open-ended question: "Reasons why you own the water portfolio that you do?"*				
Historic (e.g. water bundled with land)	21%	21%	4%	32%
Supply security (e.g. high security)	17%	21%	13%	18%
Strong investment (e.g. expected value appreciation)	16%	13%	25%	12%
Diversification (e.g. different entitlements across regions)	13%	13%	17%	12%
Proximity to operations (e.g. entitlements in the farm region)	12%	13%	8%	15%
Price (e.g. "cheap" purchase price opportunity)	11%	8%	13%	12%
Deliverability (e.g. can trade allocation to most other MDB catchments)	9%	13%	17%	0%
Liquidity (e.g. entitlements in active trading zones)	1%	0%	4%	0%

Note: *Multiple answers were allowed.
Source: Seidl et al. (2020b)

Most respondents interviewed saw water entitlements as an investment asset, with some pointing to the unique characteristics of the asset class. The vast majority seemed to ignore the legal status of water entitlements as a statutory asset, potentially leading to an illusion about water's legal security and protection of water assets in practice (Seidl et al. 2020b).

The interviews in Seidl et al. (2020b) also indicated that non-landholders can be beneficial for the water market: new water market products are often developed/called for and first used by non-landholders, and financial investors and EWHs are major sellers of forward and parking contracts. Investment managers also enter into long-term lease arrangements, and unbundling allowed for an influx of capital into water markets where returns of 6-7% were typically sought. This point has been emphasised by the Australian Water Brokers Association, pointing out that restricting non-landholders in owning and trading water could have detrimental consequences for the water market (Testa 2019). Although the small number of financial investors suggest limited market impact, however this impact is dependent upon: a) the liquidity of the local water market they operate within; and b) the volume of their trade or any insider information (imperfect competition and information asymmetry issues) knowledge. H2OX (2019) also emphasise the important role of investors. They describe the trade behaviour of larger water investors as buying allocation that they forward sell, or buy and sell constantly, taking advantage of inefficiencies in the market and the large "spread" in prices between brokers/intermediaries. These investors settle for smaller gains, rather than holding the water and waiting for higher prices which is seen as a greater risk. It is suggested by H_20X (2019) that market liquidity actually increases with investors, along with the provision of new sophisticated products, and the aggregation of large numbers of small parcels into larger parcels.

Seidl et al. (2020b) suggest that growth in financial investors – namely those who do not own any water entitlements - is likely limited by: a) the required financial investment and trading skills; and consequently b) the opportunity cost of trader involvement given the lower annual turn-over of water markets as compared to financial markets. However, monopolistic concentration of entitlement ownership and market power can lead to price gauging by landholder and non-landholder actors alike, particularly in market power or asymmetric information situations (de Bonviller et al. 2019). For example, some respondents in Seidl et al. (2020b) claimed that information available in regards to regulatory and water delivery consultation (e.g. such as being part of a relevant water steering committee) enables a range of insider trading to take advantage of changed rules.

Apart from emphasising the importance of the continuing fundamental need in the MDB for robust accounting of water extraction and use; independent national departmental water policy decision-making; continual monitoring; compliance and enforcement of water use; and water market institutional conditions (e.g. Grafton and Wheeler 2018; Grafton 2019; Wheeler and Garrick 2020; Wheeler et al. 2020), Seidl et al. (2020b) emphasised the following water reforms were needed:

1) *Data reform*: water register data reform includes the need within registers to identify water forward, lease, option, and parking transactions – including counterparty type – in order to support emerging water market products. Entitlement transactions in conjunction with land must be identified, along with mandatory price reporting and rigorous quality controls of different water register data enforced (MDBA 2019e). Entitlement ownership by stakeholder type data should be analysed at a catchment level to identify and address concerns of market power and monopolistic behaviour. These issues have also been identified as critical by the ACCC and the Victorian government (ACCC 2019a; DELWP 2019c). Also issues with price disclosure in registers, consistency of data information (and timeliness); accuracy of information in registers (especially across states)
2) *Rules and Regulation reform*: improving the transparency around rules and standards for water forwards and options, carry-over access (e.g. investigating removing annual limits on carryover, in place of limits on the volume of unused allocation that can be held at any time, reflective of storage capacity constraints (Hughes et al. 2013)), allocation and IVT determinations would contribute to better decision-making of MDB stakeholders. Need for more research around computerised 'smart markets', blockchains, American style centralised 'water banks', or a review of river operations (e.g. export more water into the Murray through the Snowy Mountains Hydro-electric Scheme to lower the IVT account balance). In absence of clear standards for water forwards and options, product comparability is problematic. A review of tagging and transmission losses through trading should identify and quantify corresponding third party impacts. Conversely, very careful assessment needs to be given to any change in unregulated entitlements to allow trading, such as allowing trading in floodplain water harvesting rights. Legal loopholes enabling stakeholders to bypass trade restrictions and extraction embargoes need to be closed. Membership of consultation bodies, such as water steering committees, and standards for water brokers needs to be fully transparent and publicly declared to avoid rent seeking.
3) *New Institutional Development*: New water market infrastructure, following ASIC market integrity rules, such as a central exchange and clearing house, along with a well-resourced market regulatory agency with competency in secondary or newer innovative water market products that monitor and enforce compliance. Sophisticated water market products require comprehensive spot price data, in this case allocation and entitlement data. Water market

institutions and regulation need to enforce product standards and code of conduct, and limit rent-seeking, as well as having prosecution powers to effectively limit counterparty risk in some of the newer innovative water market products and unlawful intermediary behaviour. Self-regulation of brokers not viable for future.

H_20X (2019) also emphasise the critical importance of a single market and clearing house. They describe the benefits as it: a) makes price and depth discovery easy as every buy and sell order is listed in one place; b) increases the depth of the market making it harder to manipulate, and makes it harder for participants to make large profits by trading on inefficiency; c) makes regulation easier as the exchange ensures participants are complying with rules; d) increases confidence by integrating with existing state registers to ensure all sell orders are placed only once and that buyers are bound to their bids, reducing failed trades; e) allows for trading in real time and decreased transaction costs; f). should increase the number of products available to the market by improving depth and encouraging innovation; g) provides much greater levels of protection for traders; h) eliminates the risk of trader monies being lost through fraud, insolvency, garnishee notices etc.; i) speeds up trading; and j) allows for it to be used to fund improved compliance, insurance, developments to the state registers and other activities through the generation of interest.

In terms of broker reform, H_20X (2019) support regulatory reform. Currently there are no punitive powers in the AWBA Code of Conduct, and they believe regulation and minimum standards would offer a range of improvements; such as 1) requiring all intermediaries to use statutory trust accounts to protect client funds (preferably through a single exchange/clearing house); and 2) enable the development of new water market products.

Seidl et al. (2020b) concluded that given both the identified benefits of non-landholder involvement, and the identified potential limitations, then given the material data challenges for quantifying their water ownership and trading, non-landholder regulation should be delayed until more quantitative evidence (such as linking both ownership and trading register data) has been collected and analysed (Seidl et al. 2020b).

2.4.1 Other relevant insights from literature on non-landholders in commodity markets

The literature on non-landholders (commonly known as speculators in the commodity market literature) is also highly relevant to the question regarding the impact of non-landholders in Australian water markets.

The literature has traditionally defined traders in commodity markets with a commercial interest in, or an exposure to, physical commodities as *hedgers*, while those without a physical position to offset have been deemed *speculators*. However, both groups can take futures positions that are speculative in nature (Büyükşahin & Harris 2011). Quiggin (2019) states that in many cases an active group of speculators in commodity futures markets is required to provide a "thick" market, namely meaning a market where prices are truly informative. Fattouh et al. (2012) point out that the word "speculation" as used in the public debate has a negative connotation because speculation is commonly viewed as being excessive – beyond the level required to satisfy hedging demand, and therefore beyond the level required for properly functioning markets. This is the same situation for Australian water markets. The speculative index developed by Working (1960) is one way to examine the excessiveness of speculation in commodity futures markets. Social welfare is an alternative definition of excess speculation.

The common concern often voiced about commodity markets is that commodity market prices and volatility are increasingly driven higher by speculation rather than by fundamental supply and demand from commercial traders. However, the majority of empirical studies fail to find a significant relationship between commodity index investment and the level of futures prices (e.g. Brunetti &

Büyükşahin 2009; Bryant et al. 2006; Büyükşahin & Harris 2011; Büyükşahin & Robe 2014; Irwin & Sanders 2010; Sanders et al. 2009; Stoll & Whaley 2010; Will et al. 2016). Moreover, many empirical studies find that speculators do not destabilize the commodity market, but instead contribute to lower volatility level and enhanced market quality by improving short-run price efficiency and liquidity (Brunetti & Büyükşahin 2009; Brunetti et al. 2016; Kim 2015). However, there are still some negative views and concerns about excessive speculation (Irwin & Sanders 2010). For instance, Juvenal and Petrella (2015) find an association between short-term spikes with excessive speculative activity in future markets.

Boyd et al. (2018) conclude that although some studies have found short-term effects of speculation in the commodity market literature, there is no evidence that traditional or index speculations drive future prices consistently across time or market. As such, most studies therefore are against market barriers by regulation (Boyd et al. 2018; Irwin & Sanders 2010; Will et al. 2016). Irwin and Sanders (2010) state that proposed regulations to limit speculation have little basis and would be harmful. Pirrong (2008) concluded that regulations would increase input-factor costs that hedgers need to bear. In addition, the position limits and out-right bans of index funds in agricultural futures market are believed to threaten the risk transfer functionality and liquidity of future markets (Pies 2013; Will et al. 2016). Will et al. (2016) emphasised that transection taxes, position limits and prohibitions would damage the functioning of agricultural markets, but the transparency initiatives are informative which can increase market efficiency and are therefore recommended.

It is therefore seen that the impact of speculation on the world commodity markets is complicated and the implications of certain policy intervention(s) need to be carefully analysed on a case by case basis.

The following section continues the discussion of EWHs in water markets.

2.5 Environmental Water Holder participation in water markets

With regulation such as the *Living Murray* and the *Water Act*, the establishment of the Commonwealth Environmental Water Holder (CEWH) and other state-based EWHs, the government is now a significant stakeholder in the water market. Needless to say, the motivations and trading patterns of EWHs are very different to other water market stakeholders.

First of all, it is worth defining the two types of environmental water:

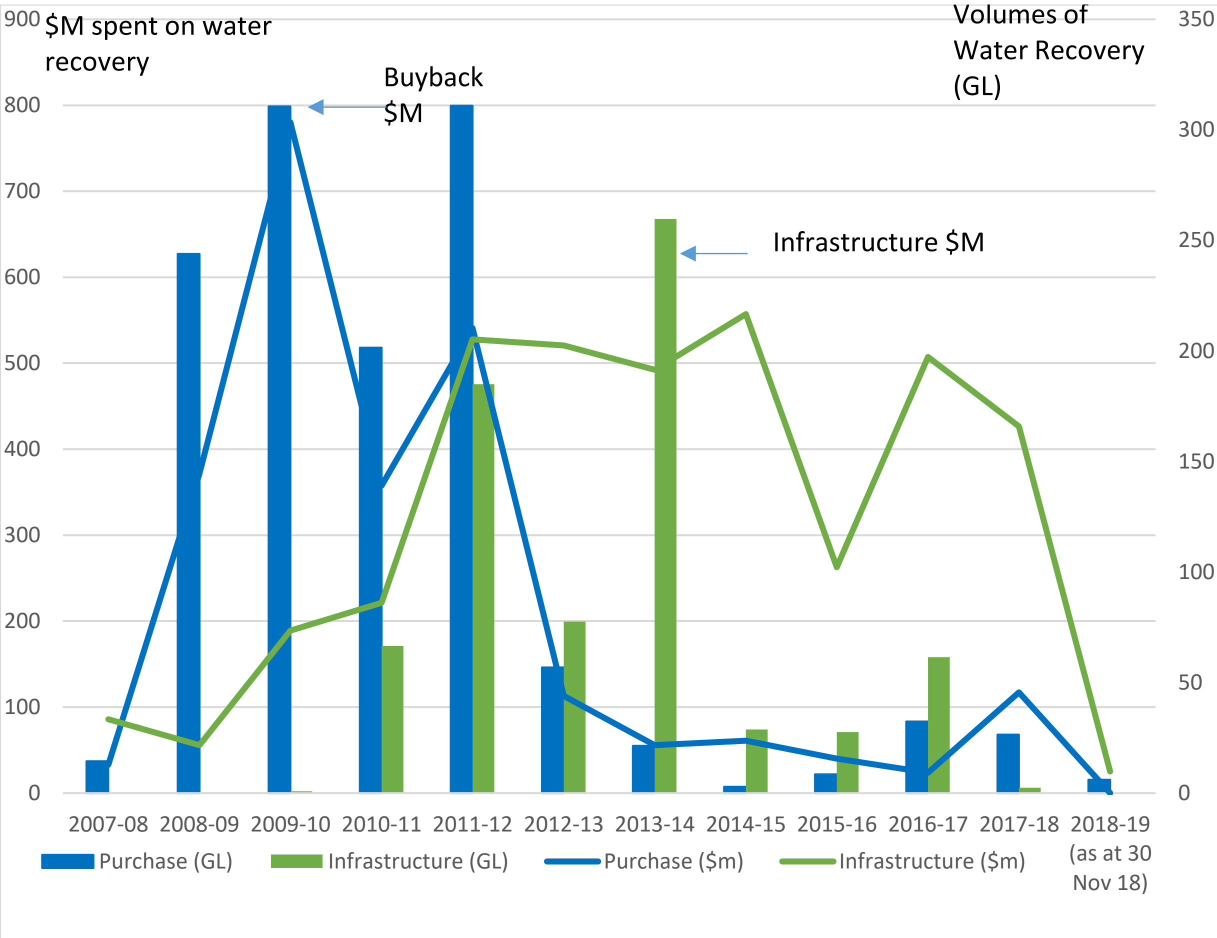
- *Planned environmental water (also called rules-based water):* prescribed under water sharing plans, the Basin Plan or state legislation. In regulated rivers, water sharing plans determine the frequency, volume and timing of water to be released for environmental purposes. In unregulated rivers, planned environmental water can be achieved through water extraction restrictions. Planned environmental water cannot be used for any purpose but environmental watering, and cannot be traded on the market
- *Held environmental water:* water attributed to water entitlements, water delivery or irrigation entitlements and owned (held) by an EWH. Held environmental water retains the characteristics of the underlying water entitlement, and is subject to the same trade restriction, allocation and storage rules.

The Commonwealth currently owned just over 2000 GL of LTAAY of surface-water entitlement as at the end of 2019. 64% of this volume was recovered through buying water directly back, with the remainder through infrastructure and efficiency upgrades (see Figure 1.7) (Wheeler et al. 2020).

EWHs objectives are to maximise environmental outcomes with the water available to them, planned and held. A number of studies have explored the benefits of EWH water market participation and trading as a form of adaptive management (Ancev 2015; Carr et al. 2016; Connor et al. 2013; Kirby et al. 2015; Loch et al. 2011; Settre et al. 2019; Tisdell 2010; Wheeler et al. 2013a).

Tisdell (2010) found that allocating tradeable water to an EWH maximised market efficiency, suggesting that strategies for effectively trading water for environmental use may include opportunistic trading to be cost-effective, including temporarily trading/leasing out when not needed, and buying/leasing in to support environmental flows. Connor et al. (2013) found there was scope for EWHs to improve outcomes through temporary trading, particularly in drought and by increasing the frequency of moderately large floods. Suggesting an environmental trading regime of buying water when prices are low, and selling water when prices are high, there seems to be relatively small impacts from EWH water trading on water market price outcomes (Connor et al. 2013). This strategy of "buying low and selling high" is how Carr et al (2016) described how the MDB Balanced Water Fund achieved its targets of improving environmental health and generating investor returns. Wheeler et al. (2013a) explored alternative water recovery options, such as allocation trade and water leases by the CEWH. Not only was it found that irrigator willingness to participate in selling temporary water to the CEWH was much higher, but also that the CEWH was found to be able to recover more environmental water/deliver more environmental outcomes by employing a mix of entitlement and allocation purchase (Wheeler et al. 2013a).

Figure 2.12 Commonwealth environmental water recovery entitlement volume and expenditure as of 30 Nov 2018



Source: Created from data provided by Department of Agriculture, Water and the Environment

Environmental transfers

Environmental transfers accounted for around 40% of total inter-regional flows of water in 2016–17. Environmental transfers tend to move in a downstream direction, with large volumes flowing into the SA Murray and out of the Goulburn region.

As at March 2020, the CEWH is currently considering purchasing water allocations ($2 million worth) in the nMDB, from Queensland agribusiness Eastern Australia Agriculture (Davies 2020). As far as can be ascertained, this is the first such purchase by the CEWH (they have sold temporary water often). There are arguments that this trade behaviour by the CEWH should become much more usual, as recommended by AAS (2019), and there is available revenue in the CEWH account for such purchases.

2.6 First Nations Water Market Participation

Historically, indigenous water rights were ignored throughout the early period in which water law developed in Australia. This was the case during the late 1800s, and indeed was also the case during the 1990s when the Cap was first implemented (Jackson 2017). Such marginalisation of First People's rights to water has been referred to as 'aqua nullius' (Jackson et al. 2019; Taylor et al. 2016).

The NWI was the first time it was acknowledged the need to take account, include and recognise Indigenous interests in water management. A number of state water laws were amended to improve consultation and access to water for communities, however there still remains strong calls for urgent reform (AAS 2019; Taylor et al. 2016). In mid 2018, there was an announcement of $40 million over four years to support Indigenous Basin communities by investing in cultural and economic water entitlements and associated planning activities. In September, 2019 a bill amending the *Water Act 2007* passed federal parliament for the establishment of an Indigenous position on the MDBA board.

Indeed, Jackson et al. (2019) found in a survey of MDB residents that 70% of respondents supported reallocating 5% of total irrigation entitlements to First Nation communities, with no preference for how that water should be used. Grafton and Wheeler (2018) comment that this may be the next area of water recovery in Australia.

But, to date, there is no evidence that any cultural water has been purchased, despite the promises made. The Independent Panel for the Assessment of Social and Economic Conditions in the Murray–Darling Basin (2020) has indicated that the funds attached to First Nations water was an arbitrary number and will not provide desired outcomes.

2.6.1 The literature on changes needed for more inclusive consultation

A key to community support, and also fair and just outcomes, is to have stakeholder engagement that establishes a flexible planning process. As Nikolakis and Grafton (2014) emphasise, planning should evaluate the trade-offs between consumptive and non-consumptive (cultural, social and ecological) use, actively engage all stakeholders in dialogues, support capacity building and community monitoring and review, and ensure initial allocations, permitted uses and trades promote long-term community benefits.

Wheeler et al. (2017a) found that there is significant peer pressure by irrigators in regards to issues surrounding the MDB plan, and this can stop many stakeholders from being involved in consultation. This can be especially true for First Nations stakeholders.

Wheeler et al. (2017a) outlined guidelines for water governance consultation that allows all stakeholder voices to be heard. Although it is widely recognised that there has been much consultation of and fatigue in basin communities (e.g. see comments by Independent Panel for the Assessment of Social and Economic Conditions in the Murray–Darling Basin (2020)), unfortunately all reviews continue to take consultations in town halls, and do open to all surveys (which result in strategic response bias – as evidenced by Figure 1 in Appendix E in the progress report by the Independent Panel for the Assessment of Social and Economic Conditions in the Murray–Darling Basin (2019)). Wheeler et al. (2017a) made the following consultation recommendations:

(i) conduct smaller focus group consultations and more one-on-one consultations rather than large town-hall meetings, and if you are going to collect irrigator views, conduct randomised, anonymous surveys that have high response rates;
(ii) understand that denial of climate change is one of the main reasons behind a lack of trust and faith in environmental science and the need for more environmental flows;
(iii) understand the crucial importance of local environmental and community groups; and
(iv) understand what areas where the most difficulties will be faced and plan for consultation accordingly.

In addition, for increased indigenous engagement and allocation of rights, insights from Ostrom (1990) can help provide protections to reduce the risk of communities being disassociated from their access or use of water. This includes separating their rights into perpetual shares to a common pool and annual or seasonal water volumes based on the perpetual shares. If community water rights are defined in this way communities can benefit from temporary sales or purchases of seasonal water volumes, but can also retain their permanent control over water entitlements (Nikolakis and Grafton 2014).

2.7 Urban and other inter-sectoral water market participation

A literature review on the status and trends of water reallocation from rural to urban regions across the world was undertaken by Garrick et al. (2019). The review included 97 published studies (academic and policy) and introduced the concept of reallocation 'dyads' (i.e. unit of analysis to describe the pair of a recipient (urban) and donor (rural) region). The study developed a coding framework to classify the drivers, processes and outcomes of water reallocation and identified 69 urban agglomerations receiving water through 103 reallocation projects (dyads). These reallocation projects summed up to 16 billion m^3 of water per year moving almost 13 000 kilometres to urban areas with an estimated population of 383 million (as at 2015). North America and Asia documented the highest concentration of water reallocation dyads. The study concludes that there is a lack of evidence to determine whether a water reallocation project is truly effective, equitable, and sustainable.

In the MDB there has been a very small growing use of water markets by urban and other sectors, such as mining (e.g., DELWP 2019 show an increase from 0% of water entitlements owned by water corporations in Victoria in 2009 to 3% in 2018). Unbundling has allowed for this involvement, however, as NWC (2011c) note, the political, cultural and possible ideological split between rural and urban water remains a very important constraint. For example, the experience (and non-use) of the North-South Pipeline in Victoria (described below) and the fact that rural councils in NSW apply for extra water for town development (rather than having to buy it on the market), which NWC (2011b) argued ultimately reduces the yield and security of entitlements held by irrigators. The Millennium Drought prompted a growing involvement of urban players, for example, SA Water purchased water allocations to boost supply security in Adelaide; Coliban Water and Central Highlands Water in Victoria bought a mix of entitlements and allocations; and there were major water infrastructure investments to link Melbourne and Canberra to the water market in the southern MDB (NWC 2011b).

Crase et al. (2014b) and O'Donnell et al. (2019) reviewed the political decision to limit the use of water that was to have been delivered to Melbourne via the North–South Pipeline (connecting irrigation areas in northern Victoria with metropolitan Melbourne) and the impacts on current water customers. The project was adopted in 2007, completed in 2010, with a one-off delivery of 27Mm3. The North-South Pipeline project, and the associated water savings, cost the Victorian government $700 million, and the water users of Melbourne around $1.05 billion, but resulted in no new water for

Melbourne under the current arrangements (although O'Donnell et al. (2019) note that the infrastructure and entitlements could improve water security in the future if the operating rules change). Crase et al. (2014b) found that the decision to limit access to the pipeline cannot be justified by economic or environmental reasons. For example, urban water utilities faced additional costs for securing water entitlements. Moving forward the study concluded that lacking clarifications of the status of the North–South Pipeline and lacking transparency on these matters, costs cannot be realistically compared across alternatives which undermines future water plans. O'Donnell et al. (2019) suggested four key lessons for rural to urban water transfers: (1) not all irrigators benefit equally from the irrigation efficiency works; (2) clear accounting for water savings and paying for new infrastructure is essential; (3) emergency response (e.g. drought) can drive change; and (4) investment in community engagement is important to establish long-term community support.

Leroux and Crase (2010) provided an analysis of the feasibility of water options contracts in an inter-sectoral setting by considering their introduction to remove urban/industrial water restrictions. The study analysed a case study of the urban community of Wangaratta (Ovens Basin) and upstream agricultural interests to improve the design of water options contracts and to identify settings where water options contracts may provide advantages over the water entitlement trading. The study concluded that options contracts have positive values under a range of scenarios and should be considered alongside other water efficiency policies.

ABS (2018) reports the use of water by mining as remaining relative stable for the six year period to 2016-17, however there is anecdotal evidence of the mining sector increasing its purchasing of groundwater entitlements (Murphy 2019).

2.8 Further Comment on Water Market Stakeholder Participation Power and Inequality issues

2.8.1 Water market stakeholder participation issues

A small literature has documented some power issues in water markets and the welfare consequences associated with market failure. In particular, water market structures can negatively affect market efficiency (Easter et al. 1998). In many cases, water transfers are only possible within each river basin given territory boundaries of river basins, and are dependent on the initial distribution of rights. Palomo-Hierro et al. (2015) present a case study of water markets in Spain, where they suggest that the relatively low size of the Spanish river basins and the high costs associated with water transfers are important barriers to the successful implementation of water markets. Consequently, the water markets are quite narrow given limited numbers of buyers and sellers who gradually become bilateral oligopolies, and water markets are prevented from reaching the maximum allocative efficiency of water use as water prices cannot reflect water resource scarcity.

Bruno and Sexton (2020) developed a theoretical model and applied it to Coachella Valley which is a groundwater-dependent agricultural region in Southern California in the USA. They found that both the magnitude of the efficiency gains from groundwater trade and the distribution of benefits among traders are affected by market power. Results demonstrate that groundwater trade in Coachella Velley can bring about large gains despite the potential for market power and the benefits are up to 36% greater compared with command and control. The same results are also found with exercises using a broad range of alternative model parameters, suggesting that the gains from groundwater trade can be quite large for many groundwater-dependent agricultural regions as Coachella Velley and are robust. It is further seen that, although the efficiency impacts of market power are relatively small even for substantial market power, the distributional impacts are large even for moderate levels of market power.

Ansink and Houba (2012) employ a theoretical economic model to analyse the water market and market power as multi-market Cournot competition (where water suppliers compete on the amount of water they provide, which they decide on independently and simultaneously). They specifically analyse market power in a setting with multiple water suppliers along a river who extract at several locations and sell their water through infrastructure such as pipelines, irrigation canals, water carriers. Four market structures are illustrated, and it is found that competitive equilibrium is not necessarily efficient. Moreover, market power may further decrease efficiency due to the strategic redistribution of water supply. It also demonstrates that the effects of market power on welfare are ambiguous when there is more than one supplier. The interdependencies of suppliers and the delivery infrastructure and its effect on strategic redistributions are two reasons underlying this. Moreover, the effects of market power on pricing do not only depend on the supply infrastructure, but also supply-side interdependencies. In a follow-up analysis, Ansink et al. (2017) further find that water markets may not emerge in river basins where there are numerous agents, as the potential benefits of water trade may not be sufficient to offset transaction costs and to make agents cooperate.

2.8.2 The literature on water participation inequality issues

As mentioned in Chapter 1, water market failures are at times closely intertwined with inequality issues in water access on both demand and supply sides. While inequality in water access is usually a concern in urban utility markets (e.g. López Rivera 2013), inequality associated with water allocation is increasingly studied among irrigators in different parts of the world. For instance, Livingston (1995) notes that the withdrawal, consumption and return flows by one individual inevitably affects the quality, quantity ad timing of supply for individuals downstream. Therefore, the water users' costs are usually not born by users themselves and thereby leading to distortions in allocation. For this reason, there is a need for institutional efforts to yield efficient water allocation and use, including a secure and flexible system of water rights. Grafton et al. (2018) also notes issues associate with return flows.

Ravnborg (2016) presents a case study of Nicaragua where a new water rights regime was introduced as part of its water governance reform. It is found that, while the reform aims to provide water security for all, it could indeed result in the concentration of enforceable water rights in the hands of the few, due to selective and partial implementation of the reform, thereby exacerbating inequality among farmers.

In a broader context, inequality in water markets exists with not only poorly designed reforms but also a variety of reasons. In studying the Indian water sector, Kumar and Saleth (2018) characterize water access inequality in several dimensions, including inequality in accessing common pool groundwater resources (both inter-generational and intra-generational inequality); inequality caused by monopolistic groundwater markets; inequality in accessing common property water from river catchments; inequality in accessing subsidized water from public irrigation schemes; and inequality in accessing water from municipal water supply systems. These water access inequalities are further linked with a variety of consequences including income differentials.

Geographical and spatial features are another important predictor of inequality. Garg et al. (2013) aimed to understand the differential impact of an irrigation canal in its head reach and tail-end communities in Uttar Pradesh, India. Using regional-level panel data, they find that farmers in its head reach (the first 76km of canal) always get sufficient water while those living in the tail end (beyond 340km from the canal head) almost never receive sufficient water. Moreover, proximity to the canal results in lower cost and higher cropping density for farmers, those differences being statistically significant. Manero et al. (2019) also found that location (namely downstream) within a smallholder irrigation scheme in Tanzania had a significant negative impact on yields and incomes.

As already discussed in section 2.6, in Australia water distribution inequality has been an ongoing concern for First Nations stakeholders. While inequality in water access is usually the focus, associated income inequality is largely unknown. Intuitively, inequalities in water access can lead to income differentials, as a few studies have already pointed out (Garg et al. 2013), though further understanding is urgently needed given potential impact heterogeneity across study contexts. In all the studies, institutional efforts are sought to address such inequality and eliminate welfare differentials among farmers.

2.9 Summary and Key Points

Overview of Participation in Water Markets

- In the MDB, the literature highlights that irrigators become more favourably disposed to water trading from the 1990s to 2010. Historically, irrigators and communities in the MDB have been more accepting of water allocation trading than water entitlement trade. However, by 2015-16 attitudes seemed to have worsened towards water trade (more in Chapter 6).
- By 2000, even though water markets had been in operation for almost two decades, less than 10% of irrigators had conducted a water market trade, although the implementation of the cap on total water resources lead to a spike in temporary trade in the early 1990s. By 2010-11, it was estimated that 86% of NSW, 77% of Victoria and 63% of irrigators in SA had undertaken at least one temporary or permanent water trade. Adoption of temporary trade accelerated after the introduction of major water reforms from 2004 onwards, and the adoption of permanent trade took off after the beginning of the Millennium Drought and the introduction of water recovery.
- Water market participation can be measured in three different ways: 1) as an individual decision, or as a collective decision across a community/area/district; 2) in temporary or permanent markets; and/or 3) type, volume and method of trade itself, e.g. either as a buy or a sale (and the subsequent volume of trade), or in an open market or to government. Furthermore, water market participation varies across time and space, particularly so for individual decisions. Temporary trading generally is more trialable with lower transaction costs than permanent water trading which is why it was adopted far earlier.
- A comparison of the southern and northern MDB confirms three key drivers of greater water market participation, namely: 1) robust government regulation (market design, scientific hydrological knowledge and regulated property rights matter significantly); 2) low transaction costs (water register and market information, monitoring and compliance enforcement, number of market participants); and 3) homogeneous marketable products (e.g. regulated water products, need full information about connectivity and long-term average annual yield issues) but heterogeneous water users (e.g. in industry, size, technology and demographics).

Irrigator Participation in Temporary and Permanent Water Markets

- Studies mainly associate temporary water trading with short-term considerations in response to seasonal fluctuations of prices or water availability (to manage risk and uncertainty within and between seasons) and personal characteristics. Conversely, permanent water trading is more associated with long-term factors mostly concerning farm and environmental/spatial characteristics. Also, different types of water markets (e.g. surface and groundwater, temporary and permanent) are interlinked, hence if water trading participation changes in one market, participation in another market is also influenced.
- Generally, permanent water trading is driven by the aim of long-term structural changes on the farm to either exit, or control long-term risk exposure, e.g. to secure a particular level of water availability, or change farm location or type, which may be followed by the use of the temporary water market to adjust for the new risk position. The following factors predicted permanent water sales the most successfully: older age, less education, traditional attitude to farming, larger number of children, used government as an information source, have

previously sold water allocations, had a farm plan, had larger water entitlement holdings, land use (lower percentage of annual and permanent crops), lower farm net operating surplus, higher debt, lower allocation levels, and the location (VIC and SA were more likely to have sold). It has also been found that a decision to sell permanent water is influenced by neighbours' selling decisions, and that the majority of permanent water sellers remained in farming, after they had sold a part of their water. Dominant reasons for selling permanent water were debt and cash flow.

Non-landholder Participation in Water Markets

- The literature on non-landholders in commodity markets sheds some light on the question regarding the impact of non-landholders in Australian water markets. There has historically been widespread concern that commodity market prices and volatility have been increasingly driven higher by speculation rather than by fundamental supply and demand from commercial traders. However, this topic has been studied widely, and the majority of empirical studies fail to consistently find a statistically significant relationship between commodity index investment and the level of futures prices. Moreover, many empirical studies find that commodity market speculators do not destabilise the commodity market, but instead contribute to lower volatility level and enhanced market quality by improving short-run price efficiency and liquidity, although some studies have found short-term effects of speculation. This implies that the impact of speculations on the markets are complicated and the implications of certain policy intervention(s) need to be carefully analysed on a case by case basis.
- Overall there has been little research to date that has focussed on non-landholders participation in water markets. The literature highlights that non-stakeholders have increasingly invested in water is because of the long-term increase in water asset values; the diversification against other assets and the fact that variability in water market prices presents significant opportunities for investment trade returns. There is no publicly available register of agri-corporate land and water ownership, apart from what companies publish in their annual financial reports. In Victoria 'non-user' water ownership was estimated at around 12% in some areas in 2018.
- Concerns have also been raised regarding the level of foreign ownership of water entitlements, with the latest estimates suggesting that 9% of MDB water entitlements as at mid-2018 were held by companies with some level of foreign ownership (ATO 2019). This has led some to call for increased public information transparency in regards to water ownership, especially by those who make decisions about water in government.
- A typology of sMDB water trading and ownership strategy sophistication has found that standard/traditional irrigators, EWHs, and traditional agri-corporates tend to rarely to sometimes use water trade markets within a given season. They also tend to own all or an excess of their water needs under one main form of entitlement. They are most likely to use carry-over as a trade product, and trade allocation to either supplement water supply (or to earn income from surplus water). The next group is more "savvy" irrigators, EWHs, and "standard" agri-corporates who own diverse portfolios of entitlements, occasionally trade entitlements, and make regular use of their own carry-over, allocation and lease trading for farming. The next group are "savvy" agri-corporates and financial investors owning diverse entitlement holdings, frequently trading sophisticated temporary products for water supply and price arbitrage differences. Finally, there is an even smaller number of highly "sophisticated" market entrepreneurs who, while not owning water, trade and arbitrage daily across the whole diverse range of temporary products, often developing and trading new temporary innovative water market products such as forwards and options.

- It is suggested that the current small number of water market non-landholders trading water probably have limited market impact overall, however this impact is dependent upon: a) the liquidity of the local water market they operate within; and b) the volume of their trade or any insider information (imperfect competition and asymmetric information issues) knowledge. Growth in the water market non-landholder financial investor area (such as trading without owning water at all) is also likely to be limited by the substantial financial investment and trading skills required, and also the fact that these traders have choices open to them to also trade on other stock markets (with greater turnover possibilities).

EWH, Urban, First Nations and Others Participation in Water Markets

- The Commonwealth Environmental Water Holder (CEWH) is the largest water entitlement owner in the MDB, and has strict rules regarding its involvement in water markets. It has sold water allocations in the market previously, and for the first time in 2020 is considering buying water allocations, which many support as a further adaptation tool for the CEWH to maximise environmental watering benefits.
- There is a history of First Nations rights to water being ignored in Australia. The NWI was the first time water policy acknowledged the need to take into account, include and recognise Indigenous interests in water management, however there still remains a strong call for urgent reform. Even though the Federal Government allocated $40 million in mid-2018 to support First Nations Basin communities by investing in cultural and economic water entitlements, to date there is no evidence that any cultural water has been purchased. Further research and need for improvement in this space is critical.
- In the MDB there has been a small, yet growing, use of water markets by urban and other sectors, such as mining (mining tends to be most concentrated within groundwater entitlements). For example, DELWP (2019) highlight an increase from a 0% share of water entitlements owned by water corporations in Victoria in 2009 to 3% in 2018. The Millennium Drought in particular prompted a growing involvement of urban players, for example, SA Water purchased water allocations; Coliban Water and Central Highlands Water in Victoria bought a mix of entitlements and allocations; and major water infrastructure investments linked Melbourne and Canberra to the water market in the MDB. However, many of these infrastructure investments have had very limited use to date due to political reasons.

3 What drives movements in water market volumes and prices? Evidence at the macro-level

The previous section concentrated on the characteristics of whom is participating in what types of water markets, and how participation in water markets has changed over time. Hence, the majority of the literature described in Chapter 2 used cross-sectional analysis, from irrigator surveys (either large-scale quantitative survey work or qualitative interviews). Chapter 3's objective is to understand the trends over time, influences on, and impacts of, water markets. As such, the literature in this section is based on actual water market trading data over time, using information from water registers and water brokers and generally employing time-series modelling (albeit some studies use simulations or CGE modelling). This chapter first provides an overview of what the overall demand and supply factors on water markets are, and then describes specific influences for both a) water allocation trade; and b) water entitlement trade.

3.1 Key driver results in the water market literature

As has already been commented on extensively in Chapter One, there are extensive institutional and policy related factors that influence the extent water market participation (in both purchasing and selling temporary and permanent water), these include: the establishment of property rights and resource caps, trade barriers, the provision of information and trade registries, electronic platforms for trade, policies that reduce market and processing transaction costs, heterogeneity of users, and water scarcity (NWC 2011a, 2012; Wheeler et al. 2014a). Those external drivers influence the costs and benefits as well as the type of participation. We build on the demand and supply factors noted in ABARES (2016) here:

Supply

- *Water allocations*: the percentage of water allocations received by water entitlements seasonally (updated fortnightly) is a function of storage volumes (which in turn is a function of current inflows and rainfall), state water sharing plans and some expectations about future inflows and rainfalls.
- *Environmental water*: water entitlements transferred to environmental agencies remove water entitlements from the consumptive pool.
- *Carryover*: decisions by individual water right holders to hold water allocations in storage within or between years (rather than using or selling). This can be influenced by utilisation of existing entitlements
- *Water trading rules*: any binding constraints on trade affects water supply on markets in different zones and can lead to differences in prices between regions.
- *Infrastructure investment*: government and private on and off-farm infrastructure programmes can both increase and decrease the effective supply of surface-water. Where it reduces consumptive non-recoverable losses, supply can increase, but where it leads to a reduction in recoverable losses, this can impact on both inflows into storages and also environmental water in general.

Demand

- *Rainfall and soil moisture*: rainfall is a substitute for irrigation water. When rainfall increases, irrigation water demand decreases.
- *Temporal factors:* demand for irrigation water can be quite different within the season, and rely on various expectations (early, middle and later season behaviour)
- *Groundwater availability and quality:* groundwater can be a substitute for surface-water, where it is available via bores and of sufficient quality.

- *Commodity prices and input prices*: market prices of major irrigation commodities influence irrigation water demand, plus key input prices (e.g. feed barley is often used as a partial substitution for watering pasture in dairy and diesel prices can influence groundwater pumping) influence water demand.
- *Land Quality and Regional factors:* Regional factors (such as other income opportunities, unemployment etc.) and land quality factors (e.g. dryland salinity, soil quality) influence the opportunity cost of water and irrigation demand.
- *On-farm infrastructure investment (public or private):* expansion or rationalisation of irrigation areas, changes in the mix of irrigation activities or investments in on-farm water use efficiency all influence demand for water allocations. This includes the existence of the rebound effect, explained previously in Section 2.4.

The following sections focus on the literature that has explored: 1) the key drivers of water markets (temporary versus permanent); 2) the impact of water recovery (through buyback and irrigation infrastructure) on water markets; 3) future impacts of water scarcity on the Basin and on water markets; 4) various theoretical water models that have modelled macro dollar societal benefits from water markets; and 5) environmental impacts (negative and positive) of water markets.

3.2 Key driver results in temporary water markets

The short-term perspective of temporary water traders to adjust for seasonal price or water supply issues was also found in subsequent studies emphasising the market's ability to provide for risk and uncertainty adjustments within and between seasons (Brennan 2006; Loch et al. 2012; Shanahan et al. 2010; Zuo et al. 2015a). Studies have found that seasonal factors, such as water allocations, drought and low water storages, are the main drivers (e.g. have the largest impact and are the most statistically significant) of temporary water prices (e.g. ABARES 2016; Wheeler et al. 2008). Water market studies on the relationship between price and volume have focused mainly on estimating the price elasticity of demand or supply (Brooks & Harris 2008; Wheeler et al. 2008; Zuo et al. 2016). Seasonal factors matter, especially prior to carryover, where prices were higher at the start of the season and lower at the end. Carry-over also reduced buy and sell offers in the Goulburn from 2001-2010 (Wheeler et al. 2008; Wheeler et al. 2010b).

An early study by Zaman et al. (2005) analysed water exchange data from Watermove in the GMID to illustrate the seasonal pattern of water trade. Wheeler et al. (2008) analysed the influences on temporary and permanent water prices in the GMID from 1993-2007 and found that the temporary price was most influenced by short-term water scarcity factors (e.g. drought and water allocations).

Nguyen-ky et al. (2018) forecast monthly NSW Murray Irrigation Area temporary water prices from 1999–2015, using Artificial Neural Network (ANN) and hybrid Artificial Neural Network-based Bayesian (ANN-B) modelling approaches. The results found that while ANN models accurately predicted water allocation prices with a less than 5% error margin, the hybrid ANN-B model provided greater consistency between actual and forecast prices. Similar to other studies, the results indicated that current water allocation prices, general water security volumetric allocations and commodity price data of cereal and meat prices were significant determinants of future water temporary prices. Errors were greater in periods of high uncertainty (e.g. Millennium Drought).

ABARES (2016) simulated the effects on water market prices from IVTs limits. They suggest that the limits have led to increased prices in the Murray trading zone and lowered prices in the Murrumbidgee.

Plummer and Schreider (2015) develop a climate driven regression model to estimate the effects of volume of water in storage and winter rainfall on water allocation price jumps in Northern Victoria between irrigation seasons, from 2002 to 2010. It suggests that both seasonal rainfall and volume in storage can significantly influence the price jumps between irrigation seasons. Besides, the recent policy innovations such as carry-over policy and reserve policy are found as good measures to smooth prices and reduce the jump in prices between irrigation seasons. These findings relieve the inter-seasonal price jumps as a serious impediment to the introduction of options.

de Bonviller et al. (2020) was the first study that we know to estimate groundwater temporary water price elasticity, analysing 10 years of monthly surface and groundwater temporary market data (July 2008- April 2018) within the Murrumbidgee catchment in the MDB to explore a) the lead-lag relationship between surface and groundwater markets; and b) the price elasticity of groundwater demand. They used two-stage least square regression estimates and found a close to unit price elasticity (-1.05) – namely increases in groundwater temporary prices led to almost very similar decreases in groundwater temporary market demand. De Bonviller et al. (2020) also found a significant price leadership phenomenon from surface-water allocation markets to groundwater allocation markets.

3.2.1 Financial quantitative analysis of temporary water markets

There is a small, but growing, literature that is applying financial techniques traditionally only used in stock markets to water markets. Such a trend will continue as data from available water registers increases. Some of this financial literature has considered whether water markets exhibit characteristics similar to other financial markets (e.g. market depth in Brooks et al. (2009); price clustering was found in the GMID by Brooks et al. (2013) and Zuo et al. (2014); and price leadership was shown by two water trading zones in the GMID in Brooks and Harris (2014)).

In particular, Zuo et al. (2014) explored the reasons for price clustering (e.g. water market bids clustering around particular numbers, for example, those with either “zero” or “five”) in the GMID, in both buyer and seller water allocation market behaviour. Empirical studies in the finance literature find that the degree of clustering in any market is a function of market structure, uncertainty, resolution costs and human preferences (known as the negotiation hypothesis; the price resolution hypothesis (uncertainty); the attraction hypothesis and strategic behaviour hypothesis). Zuo et al. (2014) found that buyer-clustering behaviour in the GMID was mainly explained by the price resolution hypothesis—where uncertainty tends to increase risks and decrease rounding costs. The cost of precision valuation increases when water allocation prices are volatile. For buyers, times of severe climate conditions (e.g., hotter and drier conditions), commodity price volatility, and government policy introduction increases their risk and consequently their price-clustering behaviour. On the other hand, sellers’ clustering behaviour reflected more strategic behaviour than uncertainty. The results suggested that water market sellers were acting in a more sophisticated manner in water markets than water buyers, and most of the costs of clustering are therefore borne by buyers.

de Bonviller et al. (2019) studied daily water allocation price and volume data (2008–2017) to identify abnormal price movements preceding water allocation announcements in the Greater Goulburn trading zone in the southern MDB, with the purpose of trying to investigate the presence of insider trading. This study provided the first systematic, comprehensive analysis of the occurrence of insider trading in water markets, and there was also a natural experiment within the data that allowed the time-period to be split into two periods: before 2014 and after 2014. Water market rules were introduced in 2014 in the MDB that officially regulated insider trading. Data represented 28,983 transactions and were collected from the BOM. The study estimated moving average time-series regression models and controlled for known water allocation market influences, such as commodity input and output prices; water storage levels, rainfall, temperature, allocation announcements and percentages and other macroeconomic variables. Results found that scarcity and seasonal factors are the most important influences of water allocation market price movements. Specifically, daily water allocation trade amount and total storage in major dams were negatively statistically significantly associated with water allocation prices. Furthermore, a commodity price index received by irrigators showed a statistically significant positive impact on water allocation prices after 2014, as higher commodity prices tended to increase irrigation water demand. In particular, there was evidence of abnormal price movements (in the hypothesised direction) preceding water allocation announcements was found, suggesting the presence of insider trading, especially before 2014. There is also some evidence that the new water trading rules introduced in 2014 may have decreased (or eliminated) the incidence of such abnormal price movements, although there is still some very weak evidence of abnormal price movements post-2014. Overall, the study suggested that water allocation market traders are becoming more sophisticated and speculative.

A recent working paper by Klein (2020) that has not been peer-reviewed nor published formally, used financial market methods to investigate whether there was any evidence of the existence of price bubbles in the GMID water allocation and entitlement market, using monthly data from 2008 to 2019. Using a GSADF approach, four episodes of explosive autocorrelation in water prices on the allocation market were identified, confirming that recent peaks in prices can be attributed to a rational bubble phenomenon. However, the market for water entitlement did not show any pattern of price explosiveness. Exploring the causes of bubbles on the allocation market, it was found that water scarcity issues, as well as commodities prices explain the emergence of price bubbles (and fuel its boom phase). But, a large share of price movements during a bubble could not be predicted by a model including these variables, in line with a decorrelation with market fundamentals. This implies that water is subject to financial market imperfections, with asset water price bubbles artificially increasing the price of the water and its volatility. The issues with this paper are that it used average not median water prices, it had a very small time-series of data and did not include particular areas of time in the Millennium Drought where there were other potential bubbles.

3.3 Key drivers of permanent water markets

Total water market trade volumes are dominated by temporary trade (see trade volumes in Section 1) and a relatively smaller amount of permanent trade is conducted in the MDB. The fact that there is less permanent water market data available has correspondingly meant there has been less work in this area than temporary water markets. Some of the work has considered both water entitlement and allocation markets together. For example, an early analysis of the water entitlement market by Shanahan et al. (2010) analysed both allocations and entitlements water trade in the GMID using water register data from 1993 to 2007. Unlike the seasonality impact on water allocation prices, water entitlements were most statistically significantly influenced by current prices of water allocations and government water policy.

As highlighted in the previous section, in general it has been found that permanent water trading is more related to long-term considerations, such as farm and environmental/spatial characteristics, and that participation in permanent trade has increased gradually over time, especially from 2006 onwards (e.g. Shanahan et al. 2010; Zuo et al. 2016; Grafton and Wheeler 2018).

More recent studies looking at movements of water over time have found that larger volumes of permanent water were likely to be sold from regions with higher dryland salinity in soils and lower groundwater salinity issues. The latter result showed that groundwater entitlements may act as substitutes for surface-water entitlements in recent years (where they are viable substitutes) (Haensch et al. 2016). Haensch et al. (2016) analysed water broker volume data at the postcode level from 2003-04 to 2013-14 in the southern MDB to model (using a random-effects panel model) influences on water entitlement trade over time. Areas in the MDB that suffered from higher dryland salinity sold larger volumes of water entitlements. Findings suggested that regions suffering from higher dryland salinity levels were more likely to be selling their water entitlements, as the comparative return on their land is lower, compared to other regions. Increases in groundwater salinity was found to be negatively associated with regions selling larger volumes of water entitlements, providing some evidence of the substitutability of groundwater for surface-water. There was a lack of evidence for surface-water salinity, though there is some very weak evidence that areas with high surface-water salinity have sold more water entitlements. Other statistically significant influences on the total amount of water entitlements sold over time by river valley included: greater water entitlement ownership; higher water entitlement prices; less dairy; and less net rainfall.

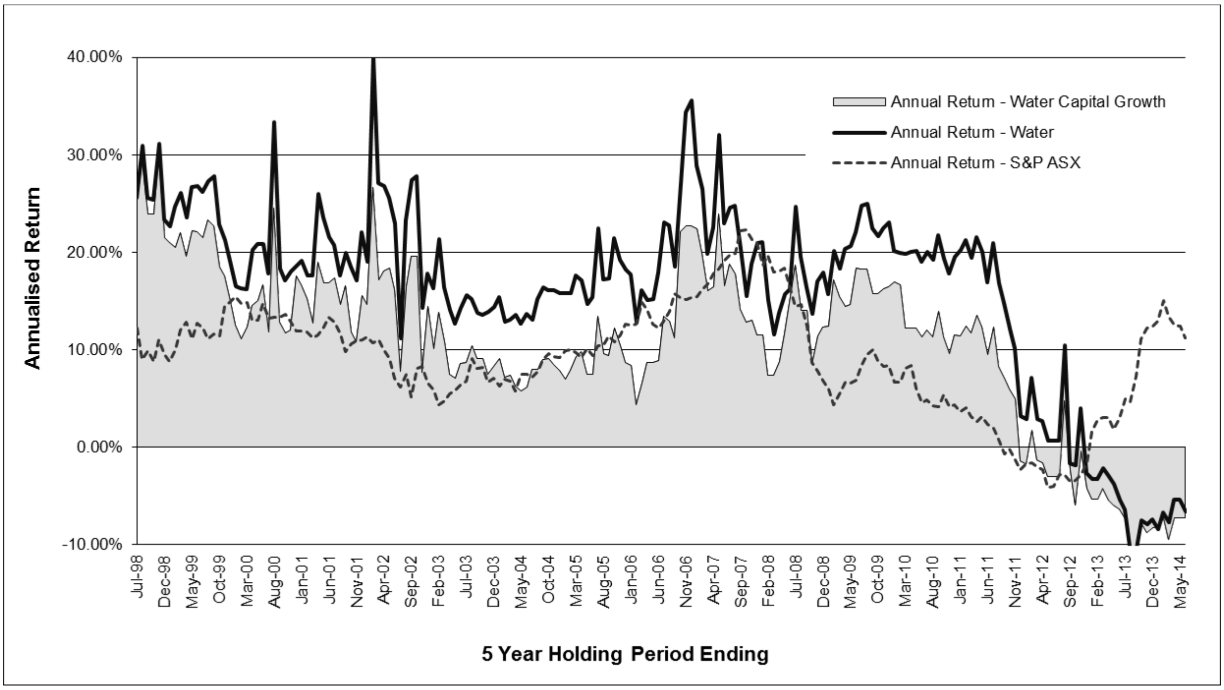
Furthermore, Haensch et al. (2020) (unpublished and not peer reviewed) suggest there is little evidence that rural community decline measures (i.e. disadvantaged communities) are associated with higher permanent water sales. Haensch et al. (2020) studied the influences on the volume of water entitlement and allocation trading data by postcode area from 2010-11 to 2013-14 from a leading private water broker at this time (Waterfind) for the southern MDB, using random-effects tobit panel models. Overall, key spatial influences such as net rainfall, groundwater use and dryland salinity, were determining influences on the volumes of water entitlement sold, while water entitlement purchase volumes were much more likely to be associated with water market prices, location and soil productivity. On the other hand, no statistically significant relationship was found between very remote areas and areas with lower socio-economic classifications with higher volumes of water entitlements sold. However, there did seem to be a link between more disadvantaged areas and higher volumes of water entitlements purchased. Water allocation trading was more associated with water scarcity factors, confirming that water markets provide an important adaptive tool for irrigators in response to unfavourable conditions. The results also suggested irrigators switched between groundwater and surface water use.

3.3.1 Total return from holding water entitlements

Unbundling water from land has allowed water to be invested in by non-landholders. This has many implications, not least for the changing nature of water as an asset. Bjornlund and Rossini (2007) and Wheeler et al. (2016) compared the return on investment in an Australian water entitlement market (namely the Goulburn) with that of the share market. Wheeler et al. (2016) compared the returns under different investment and cash flow scenarios over 1998 to 2014.

Figure 3.1 shows the breakdown of the total return from a five year holding period of water entitlements in the Goulburn between capital growth and annual return and also provides a comparison to a five year holding period in the Australian share market (based on the S&P/ASX 200 accumulation index).

Figure 3.1 Total water market return, capital growth and the S&P ASX accumulation index



Source: Wheeler et al. (2016)

It was found that in the early market (for example, pre 2003), the majority of the returns from a five year hold in water entitlements was derived from capital growth. From 2003-2011, total return became more balanced between annual return from selling water allocations and capital growth. This reflects a maturing market with assets more suitable for inclusion in broader asset portfolios.

Capital growth was the major source of return until 2008, with it stablising for a few years, and then dropping after 2012. Until late 2012 investments in the water market outperformed share market investments quite significantly. Since 2012 to 2015 the share market outperformed the water market with a substantial margin, and if this analyis was run again to 2020, it is likely that the water market is now outperforming the share market once again. Both markets are to some extent counter cyclical, which indicates why investing in both may be useful in a portfolio situation.

As such, the presence of water markets has significantly increased the asset value of water entitlements held by irrigators.

3.3.2 Impact of government water recovery via buybacks on permanent and temporary water markets

MJA's (2019) literature review for the Independent Panel for the Assessment of Social and Economic Conditions in the Murray–Darling Basin (2020) stated that there was 'consensus that environmental water recovery and water reforms have put upward pressure on permanent and temporary market prices' [citing ABARES (2016), Aither (2017), MJA (2017) and some other consultancies]. However, recent findings in the academic literature contradict this. It is important to highlight/explain some theoretical insights which are unique about the demand and supply in water markets. Permanent water bought back by the government or recovered through irrigation infrastructure upgrades reduce the amount of permanent water owned in an area. Although the law of demand and supply suggests that prices in a water market should increase over time if the water supply goes down in an area, there are a number of considerations that need to be taken into account.

First, there is a difference between: a) water entitlement's (permanent water) long-term average annual yield (LTAAY) owned by stakeholders in a region at particular points in time (highest ML); b) water allocations (temporary water) received annually by the region for the entitlements they own; and c) water allocations/extractions used in a region by stakeholders (typically lower than b) depending on carry-over and water trade movements, also fluctuating widely as shown previously by Figure 1.7). As a consequence, total volume of water supplied in temporary water markets in a region varies with: i) water allocations; ii) total portfolio of permanent water in the region and iii) sellers' willingness/ability (willingness is an irrigators' choice to enter and sell a volume of water, and ability to do so is dependent upon trade restrictions – such as IVTs or caps - at any point in time) to sell water. As discussed earlier, entitlements receive annual water allocations which can range from 0% to 100% within a water season subject to local water availabilities. That is why annual water extractions vary considerably year by year (Figure 1.7).

Furthermore, water demand in the market is also not linear because of adaptation, carry-over, substitution and underutilisation issues. Wheeler et al. (2014b) showed that historically irrigators in the MDB have only used around 70% of their water allocations they receive. Therefore, even if the consumptive pool for water diversions are reduced, and irrigators have sold water entitlements back to government, irrigators may not correspondingly increase their demand for temporary water in the market (because they increase their utilisation of existing consumptive permanent water entitlements, or adapt to less water). The issue is further complicated by increased utilisation of permanent water entitlements leads to both less water in storages and rivers, and has an impact on future water allocations, which is a significant driver of water market demand.

Hence, it is potentially hard to theoretically predict the impact of government programs on local water markets. As noted by MJA (2017), precise analysis of the regional economic effects from water recovery programs is confounded by numerous dynamic influences that affect water market performance and prices, and regional economic performance. As Zuo et al. (2019) outline, water supply ownership by irrigators is likely to change but impacts on water market prices and dynamics will depend critically on how much demand and supply in the markets are affected and not on how much water ownership varies because the studied market can be a fraction of total water ownership. There are further other important influences on water market outcomes, such as the links/substitution between both permanent and temporary surface-water and groundwater utilisation, storages, allocations and markets, and farmer adaptation to less water availability. Higher water market prices are not necessarily linked to decreased net social welfare, because water sellers receive higher prices, while water buyers are paying higher prices (the concept of the pecuniary externality as discussed in Chapter One). Higher water prices also increase irrigators' innovation and adaptation activities which is illustrated by the evaluation of the net social welfare change in Australia from the implementation of water recovery in the MDB (Grafton 2019).

A number of studies have commented on the impact of the government's buyback program on water markets: McColl and Young (2006) first suggested an increase in permanent water market prices; ABARE (2010) estimated an increase of 17.5% in permanent prices; ABARES (2016) suggest a 39% increase in annual water allocations prices between 2012-13 to 2014-15; Aither (2016) undertook a regression on 17 observations and suggested that buybacks cause a quarter of the increase in temporary water prices (with climatic factors being the main driver of variability); MJA (2017) found the economic effect of the purchase (buy-back) program on the MIA is very small if not neutral because the water was purchased at the prevailing market price; while RMCG (2016, p. 41) suggested a doubling of temporary water prices and a significant increase in long-term permanent prices in the Goulburn area. TC&A and Frontier Economics (2017) estimated a counterfactual of the foregone milk production due to environmental water recovery in Victoria, and predicted that milk production would have been 30% higher than was observed (but note: this was not modelled and did not account for any change in any other influences on milk production).

However, there are limitations with existing studies, for example, the studies do not always carefully consider the difference between water market supply and water entitlement ownership, and are significantly constrained by methodology, data availability and assumptions used, as well as only focused on the impact on levels of price and volume without considering volatility impacts. Wheeler et al. (2018a) provided a review of some issues.

ABARES (2016) used a simulated model of the water market to model a 'without environmental recovery scenario' where environmental purchases were ignored. The model was run annually, for the main regions in the trading zone of the southern MDB, from 2000-01 to 2014-15, hence the regressions had a very small sample size. The variables in the model included: allocation, rainfall, with the dependent variable water allocation price. ABARES (2018b) presented an econometric partial equilibrium model of water trade and irrigation combining econometric estimation of water demand with bio-economic optimisation models. Variables of commodity prices, water prices, rainfall and time were included in yearly models from 2002-03 to 2016-17 in NRM areas in the sMDB (nine regions), by industry. It was found that in general, total area of irrigation contracts as water prices increase, with higher value activities less sensitive to changes in price in comparison with lower value activities like pasture.

ABARES (2020) built upon the model in ABARES (2018b) and modelled a series of forward looking scenarios for the sMDB water market (namely, 1) *current irrigation development* (horticultural plantings), current water recovery under the Basin Plan, current trade rules and commodity prices; 2) *Future market*: Full maturity of recently established almond plantings, and future water recovery to meet Basin Plan requirements (3,200 GL target) via on-farm infrastructure upgrades; and 3) *Future market (dry):* as in the future market scenario, but with an 11% reduction in water supply and a 3% reduction in rainfall), examining future water prices, trade flows and irrigation outcomes. Its key findings included:

- *Higher water prices*: a significant increase in average water allocation market prices is estimated across the sMDB, with a 28% (50% increase in allocation prices in the future market scenario (future market (dry) scenario).
- *Inter-regional trade limits impact*: growth in water demand in the lower Murray due to maturing Almonds trees (particularly in NSW and SA Murray), leads to greater pressure for inter-regional water trade, more frequently binding trade limits and large differences in prices between regions.
- *Growing demand from horticultural plantings in dry years*: Water supply (including both surface water and other sources such as groundwater) is predicted as sufficient to meet estimated demand from horticultural plantings (fruits, nuts and grapevines) in all scenarios, but some supply shortfalls will persist. Horticultural plantings are estimated to use around 1276 GL on average each year in the 'future scenarios'.
- *Reductions in water use and GVIAP in traditional irrigation sectors and regions*: water use in the dairy and rice sectors predicted to decrease 14-15% in the future market scenario and up to 55 and 32 per cent respectively in dry year, with less decrease in GVIAP expected, with the decrease in other sectors partially offset by an increase in farm productivity and input substitution. Overall, the total GVIAP across all sectors is modelled to increase by 0.8% (4.1%) in the future market scenario (future market (dry) scenario) (ABARES 2020; pp. v-vi).

As noted in the report by ABARES (2020), the limitations of the analysis includes that it uses current capital and technology, commodity prices and trade rules/limits and recovery amounts, and does not allow for long-term adaptation or structural adjustment; climate change patterns may change; results are for scenarios only, it is not predictions; and it does not include consideration of potential benefits from environmental water recovery to the irrigation sector or to the Australian public. It also does not allow for any groundwater substitution.

MJA (2017) used two approaches to estimate the impact of water recovery in the MIA: a static approach (disaggregating water recovery expenditures and identifying those which contribute to value added) and a 'dynamic' approach involves the use of a general equilibrium dynamic and multi-period model which solves for both price and quantity, which was conducted using the VU TERM CGE (computable general equilibrium) model by Victoria University. They found the economic effect of the purchase (buy-back) program on the MIA is very small if not neutral because the water was purchased at the prevailing market price.

The key issues with much of the water market econometric time-series modelling done so far includes: 1) small sample sizes and no use of time-series econometrics (OLS regressions on very small time-series of data (e.g. less than 20 observations) has significant problems and results are likely spurious (see Enders 1995, pp. 166-195; Granger & Newbold 1974); 2) use of annual median/average prices: considering the wide fluctuations of water allocation price within and across seasons, investigating the price dynamics on a weekly or monthly basis is much more desirable method to generate robust results; and 3) causal policy impacts: methods used to estimate the impact of Commonwealth purchases on water allocation prices cannot provide a causal impact because there was not a proper model for the counter-factual. To be able to derive a causal impact, because the water allocation price model should be estimated based on the period without Commonwealth purchases, which can be used to predict the price for the period with Commonwealth purchases (see Baerenklau et al. (2014) for an example in another setting). The difference between the predicted price and observed price for the period with Commonwealth purchases can provide one strong indication of the impact of Commonwealth purchases, controlling for all other important influences. However, to be able to use this approach, sufficient data are needed to generate a robust prediction model for the period without Commonwealth purchases and small sample size observations mean this is impossible.

The only empirical econometric study to date that has utilised appropriate methodology and a long time-series of data to empirically investigate the causal question of buyback of water entitlements on the water market was Zuo et al. (2019). This study used VARX-BEKK-GARCH time-series regression to model Goulburn water market dynamics of monthly permanent (HS) and temporary water market trade from 1997-2017 (n=227). Key findings included:

- Volatility in the permanent water market was less than the temporary market, while persistency in volatility only exists in permanent markets;
- Unidirectional transmission spillovers exists in both markets from prices to volumes;
- The main drivers of temporary water prices were water scarcity related, while permanent prices were most significantly influenced by previous permanent water prices and current temporary water market prices;
- A statistically significant negative impact on temporary volume-traded from government water recovery (e.g. a 1% increase in water recovery resulted in a 0.14% reduction in water volume-traded) was found, but no significant impact was found on temporary water prices, nor on permanent market prices and volumes; and
- Government water recovery increased the volatility of temporary market prices and volumes, signalling increased issues of risk and uncertainty for irrigators engaging in temporary water markets.

Further research is warranted in this time-series space, as a number of questions remain. In particular, impacts of recovery on permanent prices (and allocation shares) of low and general security entitlements in different regions would be beneficial.

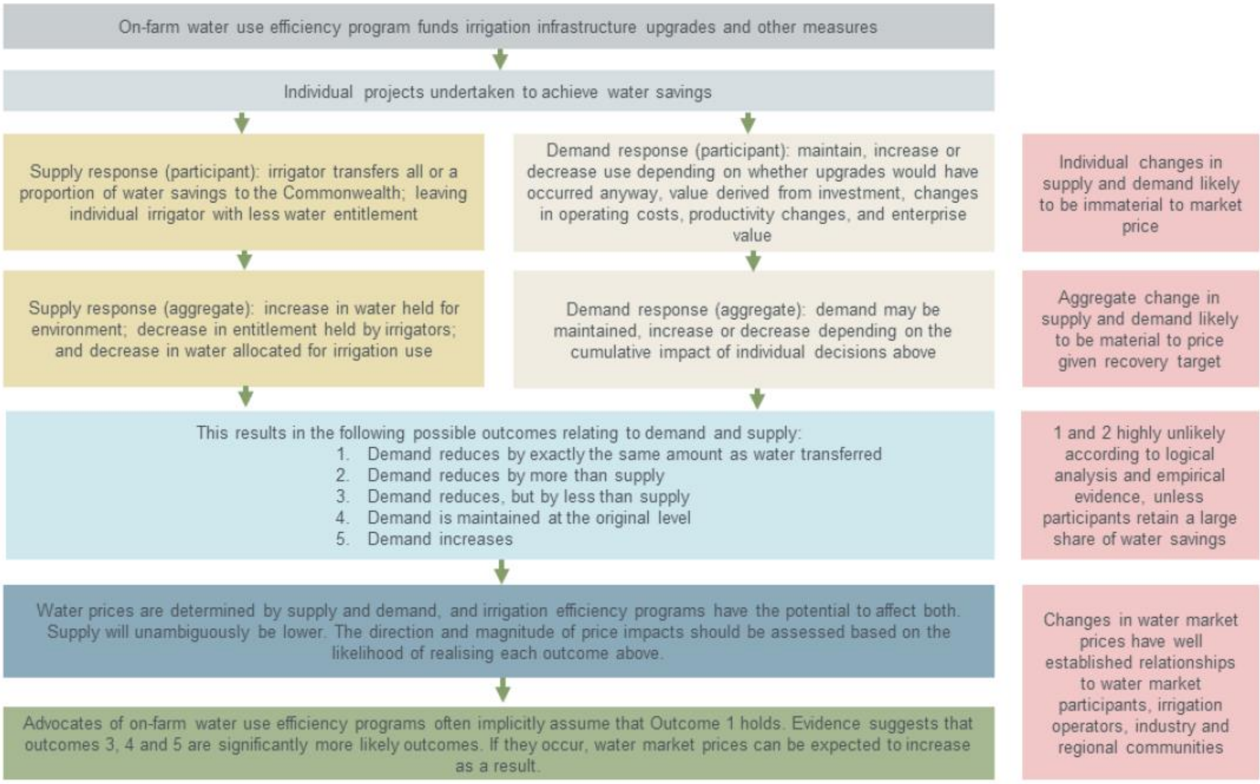
3.3.3 Impact of government water recovery via irrigation infrastructure on permanent and temporary water markets

It is first worthwhile to understand what the key differences between government recovery via buyback versus irrigation infrastructure, before we turn to the specific impacts on water markets. There are a number of impacts associated with subsidising irrigation infrastructure. The positive impacts include reducing any negative water quality impacts from saline return flows and increasing private farm productivity (Schirmer 2017). Wheeler et al. (2020) summarised the negative impacts as:

(1) cost: subsidies cost at least three times more per dollars per megalitre (ML or million litres) of water acquired for the environment than buyback partly because of the increased transaction costs of subsidy programs;
(2) governance: the program has been plagued with a lack of transparency, with some schemes subject to corruption charges;
(3) return flows: reduces seepage into groundwater and flows to streams and rivers (water quantity issue);
(4) rebound effect: increases the area of land under irrigation or the area of land growing crops, potentially increasing water extractions;
(5) utilisation: increases utilisation of water entitlements and allocations;
(6) substitution: groundwater substituted for surface-water;
(7) equity: benefits are not evenly spread, with large corporate entities having a much higher probability of securing irrigation subsidies over family farms (which is of importance if there is existence of imperfect competition and asymmetric information);
(8) floodplain harvesting: the program funds new dams that can increase floodplain harvesting and divert water that may have been returned to streams and rivers; and
(9) resilience: encourages substitution to permanent crops, increasing both electricity costs and demand for water during drought and reduces community resilience.

Now, the rebound effect occurs when the increase in water demand from the increased productive value of water outweighs the reduced demand from the technical efficiency shift and the variable cost increase (Adamson & Loch 2014; Loch & Adamson 2015). Aither (2017) provide one way of assessing the impacts of water recovery (focussing particularly on irrigation infrastructure) on water markets (Figure 3.2).

Figure 3.2 Framework of impacts of water recovery



Source: Aither (2017; p. 9)

The issues with increasing water demand is associated with the tradeoffs between technical efficiency improvements, increases in variable costs of inputs and productive value changes (Wheeler et al. 2020). Now, improvements in efficiencies (driven by all farmers, not just those who participated in water recovery programs), can lead to an increase in water demanded, and corresponding have an impact on water markets. Using the same model as described in Aither (2016), Aither (2017) modelled the predicted 450GL of water recovery through on-farm WUE programs and suggested that this would lead to a $13-18 per ML increase in water allocation prices to irrigators in northern Victoria. They expected that this increase would flow-on to increased entitlement prices.

Irrigation infrastructure subsidies can incentivise irrigators to adopt perennial production systems, to maximise the benefit from more efficient infrastructure. While accelerating agricultural systems change (e.g. towards almonds) and thus potentially contributing to higher water prices based on crop output prices, this also leads to inflexibility in production systems, as perennial producers cannot easily change production systems without loss of capital. This leads to a hardening of water demand, and the fact that producers are willing to stave off catastrophic loss of capital in drought or periods of water scarcity, through paying high allocation prices, above the level of generating operational losses (short-term choke price) (Adamson et al. 2017). It may also lead to increased water entitlement demand, especially if they are risk averse. Further research on the changing nature of crops within the MDB on water markets is warranted.

Wheeler et al. (2020) estimated the rebound effect on water extraction from subsidising irrigation infrastructure. They found the rebound effect has occurred on a farm-level in the sMDB, with water extractions increasing up to 21-28% more than for those who received a subsidy grant than those that did not. Irrigators increased water extractions by increasing their water utilisation of existing entitlements, changing crop mix, and being more likely to buy water entitlements and allocations on the market. The study also provided a broad critique and overview of two water accounting methods used to estimate changes in MDBA diversions. Although it is unknown to what extent the rebound effect impacts on overall Basin-wide extraction, it was argued that the transitional SDL data is still subject to considerable underestimation due to five water governance challenges, which include: floodplain harvesting, other interceptions of stream-flows, lack of measurement of stock and domestic extractions (i.e. basic rights), water modelling and accounting issues and also illegal extractions. Governance and auditing of the Cap water extraction data was also a significant issue, which calls into question whether extractions have decreased by the same amount as the water returned to the environment (Wheeler et al. 2020).

3.4 Modelling future water scarcity on water markets

There has been some work in the literature that has focussed on trying to understand what might happen in the future with a) increased water scarcity and b) changed patterns of land use across the Basin. Such scenario work is critically hard to do, given the difficulties in modelling what has happened, let alone predicting what might happen in the future.

Aither (2019b) used a scenario approach to estimate how the consumptive water supply in the southern MDB in any given future year that will be required by permanent irrigated horticulture and the 'headroom' above that (namely the amount available to other industries). Their conclusions were that existing permanent horticulture in the connected Murray region is growing, and will grow from their estimated 1230 GL per annum to 1400 GL at full maturity. The issues surrounding such a question are highly complex, and indeed, Aither (2019b) state their assumptions included:

- No use of various trade products such as carryover or other new trade products
- Assumption of perfect rationality in regards to trade patterns and choices
- No adaptation to water scarcity is built into the model – such as deficit irrigation, improved watering and measurement, mulching, pulling old stock etc. (e.g. adaptation measures identified in Table 1.5).
- Lack of information on groundwater extraction and substitution – very little information is available on full estimates of groundwater use given monitoring issues (e.g. Nelson 2019; Holley et al. 2020). Report assumes that groundwater sources do not overlap with existing and projected growth of permanent horticultural demand in Lower Murray.
- Lower Murray part of the model allows for no water allocations to be traded into it.

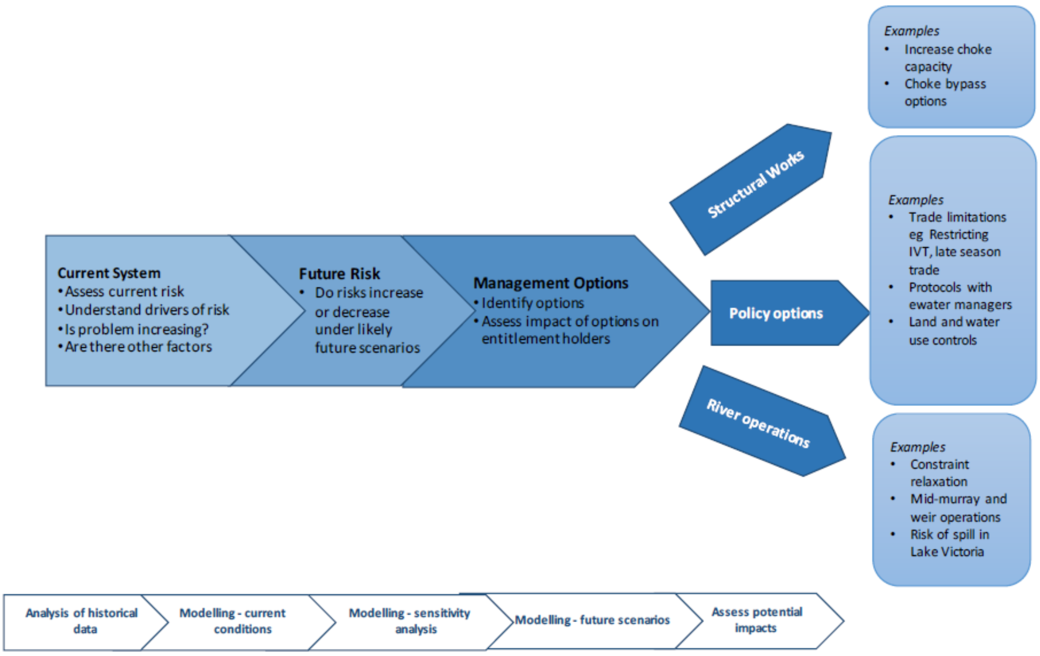
Loch et al. (2019) and Adamson and Loch (2019) also modelled scenarios of water use in the MDB. In particular the paper studied the current modelling of uncertainty with respect to investment choices (e.g. technology adoption to improve water use efficiency). They recommend a joining of cost-benefit analysis to state contingent analysis, and to model uncertainty as alternative states of nature. They model water inputs as two categories: (g) water that is required to keep capital (e.g. tree-crops) alive, and (h) water that allows for productive crop yields (where annual crops do not require (g) water, as all inputs are used to create productive yields). They find that systems with greater rates of (g) water input requirements are at far greater risk of exceeding tipping points, raising questions about who is accountable for those losses, and who subsequently pays? They then argue there is a critical need to quantify those (g) requirements and to assess proximity to tipping points. Adamson and Loch (2019) focus on an example of the almond industry in California and find: i) water use efficiency is typically not economically attractive to private investors due to relatively low savings; ii) subsidies are needed to incentivise uptake; but iii) risk remains high and both public and private exposure increases as a result of the co-investment choices. Indeed, in scenarios with severe future climate drought regimes they find that expected returns are completely insufficient for investors to recoup expenses involved.

Following on from the above, concerns over the River Murray's ability to meet water allocation delivery demand, fuelled by increased areas of horticultural planting downstream of the Barmah Choke, led to the commissioning of a review of capacity issues by Doolan et al. (2019). They assessed MDBA's current development of a modelling tool under the *Capacity and Delivery Shortfall Project* (representing consumptive and environmental water demand, and River Murray capacity to deliver water to satisfy this demand). Water supply shortfall was defined as the inability to provide entitlement holders with their allocation when and where they want, with two dimensions:

1) **system shortfall**: the system cannot deliver water flow requirements for the whole season; and
2) **short-term delivery shortfall**: a spike in short-term demand exceeds the water physically available in the Murray River for a period of time (Doolan et al. 2019).

A long-term daily simulation model of the River Murray is being developed by the MDBA, based on 125 years of hydrological data and the National Hydrological Modelling Platform, also known as the Source Murray Model (SMM). The SMM was configured to closely represent 2018-19 water demand and trading conditions (including water policy and IVTs) as the reference scenario, and is intended to allow for the simulation of future water demand and River Murray flow capacity under different scenarios, identifying water supply shortfall, associated drivers, and their development over time. It is also intended to quantify the impact of three different categories of shortfall management options, structural works, policy options and river operations (see Figure 3.3).

Figure 3.3 Conceptual decision-making model on delivery shortfall risks



Source: Doolan et al. (2019, p. 9)

While Doolan et al. (2019) find that the MDBA modelling project is appropriately designed and focused to identify factors affecting delivery failure. However, to identify and quantify management options further, they suggest that risk of delivery shortfall to regions downstream of the Barmah Choke will increase over time, given: 1) increased areas of horticultural plantings in the Murray Valley; 2) increasing water demand of maturing existing horticultural plantings; 3) environmental water delivery requirements under the Basin Plan; and 4) a drying future climate. While the SMM is equipped for comparative analysis of sensitivity to risk factors, it is not suitable for determining absolute risk levels of water supply shortfall, given its long-term timeframe.

Doolan et al. (2019) made thirteen recommendations to improve the *Capacity and Delivery Shortfall Project* (see Table 3.1), falling into seven broader categories: 1) understanding the current system, 2) understanding risk under future scenarios, 3) understanding implications for entitlement holders 4) assessing management options, 5) model capability, 6) timelines, review and resourcing and 7) governance and communication.

Table 3.1 Independent Panel for Capacity Project Review recommendations

	Recommendations
Understanding the current system	• Incorporate detailed planting and irrigation-method data from SA • Request Victoria and New South Wales to investigate the significance of environmental issues in the Lower Goulburn and Murrumbidgee Rivers and their implications for system capacity
Understanding risk under future scenarios	• Undertake two additional future modelling scenarios: o Examining the impacts of climate change, including both inflows and increased temperature. o Examining the impact of constraint relaxation proposals currently under consideration by governments
Understanding implications for entitlement holders	• Undertake work on impacts and duration of water deficits at different points in the growing season for a variety of crops • Develop indicators of environmental delivery shortfalls • Undertake work to understand the implications of shortfalls for environmental watering events under different climate sequences and their impacts on environmental outcomes
Assessing management options	• Jurisdictions should develop a contingency decision-making framework on how shortfalls will be managed, including consideration of environmental delivery shortfalls • Revisit work on Barmah Choke bypass options and undertake feasibility analysis by mid-2020 • Determine rate of sedimentation of Barmah Choke & feasibility of extraction
Model capability	• Improve the representation of environmental watering demands, and the ability to indicate when environmental water orders are not able to be met • Undertake general model improvements: better representation of VIC allocation policies, Goulburn and Murrumbidgee inflows, Lake Victoria operating levels, transmission losses in the Barmah Choke and VIC Goulburn interim operational measures Goulburn • Review potential for operational analysis to inform interpretation of delivery shortfalls
Timelines, review and resourcing	• Extend the timeline for the project until at least June 2021 • Regular 6-9 monthly reviews of the project outputs and planned activities • Maintain at least current levels of project resourcing
Governance and Communication	• Ensure that project members have the skills, authority and time available to properly manage the project • Develop shared proactive communication strategy and clear pathway for stakeholder engagement

Source**:** Adapted from Doolan et al. (2019)

We would also suggest that the SMM model needs improvements in terms of how it incorporates irrigator behaviour, return flow impacts from both water recovery and irrigation infrastructure upgrades (private and public), price impacts in water markets and substitutability between different water types.

Given recent concern about water supply shortfall in the River Murray, HARC (2020) were commissioned to examine water use patterns and area planted to different crop in the region from the Barmah Choke to SA from 1993-2018. The report used two data sets: 1) SunRISE crop area data (http://www.sunrisemapping.org.au/) for NSW, SA and VIC; and 2) water extraction data from MDBA account sheets.

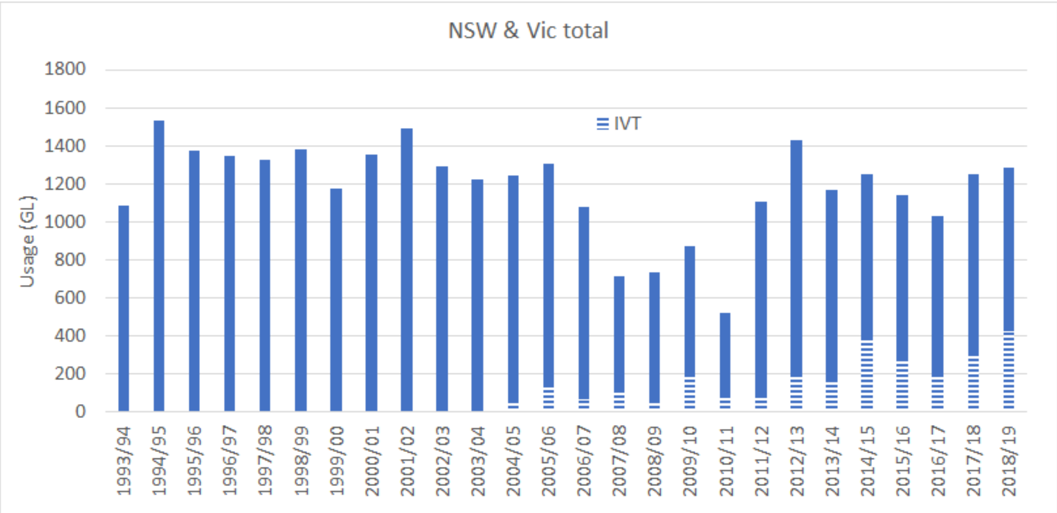
They found there has been an increase in planted areas in the Lower Murray, driven by an increase in permanent plantings, with the area of seasonal crops almost identical in 2003 and 2018. Although grape vines remain the dominant horticultural crop by area, with just over 50,000 ha in 2018/19, vine planted area has steadily fallen over time, coinciding with large increases in areas planted to nut trees, particularly in Sunraysia (VIC) where they are now the dominant horticultural crop.

Annual consumptive use in the Lower Murray has been relatively static over time, as a decrease of water extractions between Barmah and Wakool Junction is offset by a slight increase in extractions between Wakool junction and the SA border. Water extraction patterns within the water year have also not materially changed over time.

An examination of peak water demand has also revealed no material changes in peak demand volume in the Lower Murray. However, environmental water recovery and subsequent delivery to SA has increased the combined consumptive and environmental peak volume at the SA border, with the peak occurring earlier in the year, coinciding with environmental water delivery. However, as environmental watering occurs in spring and early summer, targeting over banks flows, this is not competing with peak consumptive demand by irrigation.

The water volume recovered for the environment in the Lower Murray has reduced the availability of allocation from Lower Murray licences. With consumption remaining largely unchanged, the balance has been supplied by increased inter-valley water trading, mainly from the VIC Goulburn and the Murrumbidgee (Figure 3.4).

Figure 3.4 Total Barmah to SA water usage and inter-valley trade balance over time



Source: HARC (2020, p. viii)

In recent years, environmental water used to deliver additional environmental flows to SA, with water supplied from environmental water entitlements held in the Murray, Murrumbidgee or Goulburn systems, and significant environmental entitlement volumes held below the Barmah Choke. Environmental deliveries each year are largest over the May to December period and smaller during the peak consumptive demand period of January to April. Apart from avoiding the peak demand period, this timing also coincides with the timing of environmental watering requirements and follows the good neighbour policy assumed by environmental water holders in order to not adversely affect irrigators (HARC 2020).

Since 2010-11, environmental water holders have consistently delivered environmental water to South Australia during early summer. Although this might appear to be a conflict for channel capacity with consumptive users, HARC (2020) shows that this environmental supply has been met by environmental entitlements held below the Barmah Choke and therefore does not influence the Barmah Choke constraint. It is important to note that the report by HARC (2020) has only focused on the changes in demand in the Lower Murray. It did not consider supply and flow conditions from other catchments, such as the Murrumbidgee and the Goulburn, nor their water demand and trade restrictions. The report clearly acknowledges this short-coming.

Additionally, water diversions is estimated by the MDBA and General Purpose Water Accounting conventions in that extraction equals use. This has been widely challenged in the peer-reviewed literature, as it ignores the impact of return flows (e.g. Grafton 2019). There are also significant limitations in the water extractions that are measured in the MDB, as documented in Wheeler et al. (2020). Given the documented increase in perennial nut plantings, likely under drip irrigation, this is a material limitation. HARC (2020) represents environmental water in a narrow understanding of held environmental water only. This creates the impression that environmental water contributes to higher flows at the SA border due to environmental releases. It is debatable whether the increase in held environmental water was off-set or countered by a decrease in water yield from rules-based environmental water. In essence, the overall environmental water flowing into SA, held and rules based may have decreased over time, which adds another layer of complexity to the issue.

Finally, HARC (2020) focuses on nominal extraction in mega/gigalitres, rather than percentage use of total water available. This is likely explained by it not exploring water supply data. However, using volumes rather than fractions somewhat masks the distributional effects of increased permanent plantings. For example, it is likely that in dry years a larger percentage of extraction falls towards permanent plantings as compared to annual plantings, even within the Lower Murray.

Interim Inspector-General of Murray–Darling Basin Water Resources (2020) provides more comment on conveyance and delivery issues in the Basin.

3.5 Water trade models of efficiency benefits from trade

3.5.1 Theoretical modelling studies

The previous sections analysed models of water trade movements, and influences on prices, volumes and land use. This section reviews the literature on the overall net welfare gain to society from the introduction of water markets in Australia, using the application of theoretical studies. This question has been considered in many different studies, via many different methodologies (e.g. see Appendix A for more study specific detail). Some of these studies include computable general equilibrium (CGE), partial equilibrium models; hydro-economic models; and water demand optimisation models. Settre et al. (2017) reviewed all the hydro-economic models that have been conducted of the MDB, and found that water trade issues were considered in about half of them. Key findings from this trade literature are that water trade increases total gross farm margins and increases the volume of water used in high value activities.

Table 3.2 provides a summary of some of the historical key literature in this area that has estimated dollar values of the net benefit of water markets. Although it is difficult to directly compare the dollar values given differing methodologies, time-periods and scenarios modelled, it is clear that economic studies show that there are considerable economic and financial benefits that have been derived from having water markets in place in Australia. See Appendix A for more detail of the majority of the economic studies that have been conducted.

Table 3.2 Overview of Key Historical MDB Water Trade Studies

Study	Methodology	Detail	Estimated Value $ AUD
Peterson et al. (2004)	Computable general equilibrium (CGE) model analysis of the Impacts of reductions of 10, 20 and 30% in water availability in the sMDB under conditions of no trade, intra-regional trade only, and both intra- and interregional trade	The model estimates that moving from no trade to intra- and interregional trade together more than halves the impact of the reductions in water on the gross regional product in sMDB, and moving from no trade to intra-regional trade lessens the impact by 35 to 42%. Including interregional trade reduces it another 22 to 24%. Modelled value of trade from 1997-98 to 2001-02.	$1.4 billion
Qureshi et al. (2009)	Irrigation water demand optimisation model	1) Reduction in water market barriers in the sMDB would increase annual net returns significantly 2) Expanding from intraregional trade to interregional trade	$17 million $88 million
NWC (2010)	CGE model was used to estimate the aggregate economic impacts of water trading at the regional, state, sMDB and national levels	Found water trading in the sMDB increased Australia's gross domestic product in 2008–09	$220 million
Mallawaarachchi et al. (2010)	Partial equilibrium model	Assessed allowing water trade interregions with reallocation of water from consumptive to environment in the MDB allowed increased gross value of production	$91 million
Grafton and Jiang (2011)	Hydro-economic model	Results show with no inter-regional water trade the present value of reduced net profits in the Basin is much less under a reallocation of 3000 GL/year to increased environmental flows	$3.9 billion
ABARES (2011)	Comparative static partial equilibrium model	Simulates water trading both within and between MDB regions, using census data from 2000-01 and 2005-06. Estimated a range of scenarios of water reallocation, before and after interregional trade. For example, Scenario 2 assessed 2800 GL SDL with Cwlth investment in Infrastructure, with and without trade.	$142.3 million
Qureshi and Whitten (2014)	Postive mathematical programming model of climate and adaptation in the sMDB	Examines the difference between the base case and various forms of impact and adaptation. In particular, it compares the net benefit of: (1) full impact scenario with all adaptation options but including trade without water revenues/costs staying in the region. (2) As above, but with water revenues staying in the region	$399 million $665million
NWC (2012)	CGE model	1) Examines aggregate economic effects of water trade on irrigator water	$4.3 billion

	- Modelled without access to water trade in the sMDB. CGE - Modelled expanded intra-and inter regional trade as a consequence of National Water Initiative reforms in the sMDB.	adjustment within and across irrigation regions from 2006/07 to 2010/11. 2) NWI institutional reforms were estimated to have reduced the impact of drought within the sMDB from $11.7 billion to $7 billion over the 2006/07 to 2010/11 period—with higher magnitude benefits being incurred during exceptionally dry years when the need to reallocate water was highest	$4.7 billion

Source: Adapted from Wheeler (2014)

The issues with such studies includes:

- free and open trade of water in hydrologically connected catchments is often a central assumption when modelling water trade between irrigators.
- an additional assumption is profit maximising behaviour at the farm-scale which forms the objective function for many agricultural partial equilibrium optimisation models. Assuming rational profit maximising behaviour and simplification of institutional complexity is necessary considering both the epistemic uncertainty (e.g. incomplete knowledge of farmer motivation) and the natural variability of human behaviour.
- tangible costs such as delivery constraint violations and often environmental impacts (e.g. salinity) are not wholly accounted for when measuring costs and benefits.
- modelling is further subject to the stochastic uncertainty of water and commodity prices, water availability, climate change impacts, government policy and technological change (Settre et al. 2017); and
- equity and distribution issues of initial property rights are not considered.

3.5.2 Applied empirical water studies at the macro-level

Other studies that have looked at the relationship between water availability and gross domestic product in the MDB have found that as little as 0.1% reduction in farm production revenue to around 0.6% for each 1% reduction in water allocations (Kirby et al. 2014).

Wheeler et al. (2020b) analysed farmer exit in the MDB from 1991 to 2011, using specially coded agricultural and population census data from the ABS to constant areas over time (that allowed panel-data regression to be used). To date is the most comprehensive analysis of the drivers of farmer exit over time. They applied spatial regression modelling at the statistical local area level to assess the impact of weather, economic and water factors on net farmer number changes over a twenty-year period from 1991-2011, with climate risk measures using data from 1961 onwards. It found that the direct drivers of farmer exit in local areas were climatic (e.g. increases in maximum temperature and increased drought risk (through decreased long-term precipitation skewness and increased long-term precipitation kurtosis)) and socio-economic (e.g. decreases in commodity output prices, increased urbanisation and higher unemployment). On the other hand, absolute rainfall, changes in irrigation water diversions and water trade movements had no significant impact on MDB farmer exit. This study focussed on total farmers – namely both dryland and irrigated farmers given that when many farmers exit irrigation they often turn to dryland farming instead (Wheeler and Cheesman 2013). This conclusion is very similar to what others have found, namely that the outward trading of water may have had a minor impact on declining productivity during the assessment period but it was small in comparison to the influence of the drought (NWC 2012). Limitations of this dataset is that it is based at the statistical local area, with smaller regional areas that could be used for modelling from 2001 onwards with a more updated dataset.

3.5.3 Socio-economic water impact studies

This literature review's remit is to focus solely on water market and participation issues, hence it does not review the socio-economic literature of the impact of water recovery. Interested readers are referred to Wheeler (2014), EBC et al. (2011), AAS (2019) and Wheeler et al. (2018a) for an overview. Dixon et al. (2009); Wittwer & Griffith (2011); Wittwer & Young (2020) provide various estimates of economic modelling impacts of water recovery.

3.6 Environmental Impacts from Water Markets – macro-evidence

This section provides an overview of the evidence from macro-level studies on the environmental impact of water trade, broken up into two sections: negative and positive.

3.6.1 Environmental negative impacts

There has always been concerns about the potential negative environmental impacts of water markets. Historically, when the cap was introduced, many unused 'sleeper' and 'dozer' licenses were activated through market trade, which resulted in reduced seasonal allocations. A variety of controls have been put in place by state governments to limit further environmental harm from trade, which have increased transaction costs associated with trade. Concern over third party impacts of water trading including surface and groundwater salinity has been the focus of a number of studies (e.g. Haensch et al. 2016; Khan et al. 2009; NWC 2012; Tisdell 2001). Common environmental concerns associated with water trade include that it may result in:

i) concentrating water extraction in areas suffering from high water tables (NWC 2012);
ii) increased salinity in areas that require minimum irrigation intensities and that have experience water entitlement loss (Khan et al. 2009);
iii) moving water into locations where its' extraction might have a negative impact on river water quality (NWC 2012);
iv) increases groundwater substitution (Wheeler and Cheesman 2013; Wheeler et al. 2020), and increased groundwater use can lead to increased salinity problems if saline groundwater flows into rivers due to discharge (Haensch et al. 2016);
v) moving water extraction upstream, thereby resulting in reduced river flow from the new point of extraction to the old point of extraction (NWC 2012); or
vi) activating previously unused water leaving less water in rivers to support ecosystems (NWC 2012; Loch et al. 2013); (plus of course reducing the amount of water in storages which leads to reduced water allocations in future seasons).

Bjornlund (1999) suggested that the impact on surface-water salinity of early water trading moving water from downstream to upstream areas in SA between 1987-1996 may have increased the salinity level at Morgan. Bjornlund and McKay (1995, 1996) and Alankarage et al. (2002) studied regional salinity levels and water trading, using simple descriptive statistics on cross-sectional survey datasets. Bjornlund and McKay (1995) showed that water entitlements in Victoria are traded out of regions affected by high salinity levels into high value producing areas with lower salinity levels. Bjornlund and McKay (1996) showed that early trading in SA moved water from the Lower Lakes in SA at the mouth of the river upstream into Riverland, having a negative impact on surface-water salinity.

Haensch et al. (2016) analysed water broker data at the postcode level from 2003-04 to 2013-14 in the southern MDB to model (using a random-effects panel model) influences on water entitlement trade in broad regions over time. Areas in the MDB that suffered from higher dryland salinity sold larger volumes of water entitlements. Findings suggested that regions suffering from higher dryland salinity levels were more likely to be selling their water entitlements, as the comparative return on their land is lower, compared to other regions. Increases in groundwater salinity was found to be negatively associated with regions selling larger volumes of water entitlements, providing some evidence of the substitutability of groundwater for surface-water. There was a lack of evidence for surface-water salinity, though there is some very weak evidence that areas with high surface-water salinity have sold more water entitlements.

There exists little research about the effect of water markets on groundwater use and the substitutability of surface water and groundwater resources. A current study (not published nor peer-reviewed) finds significant inter-dependencies between ground and surface-water resources in the Goulburn-Murray Irrigation District (Wheeler et al. 2020a): 1) groundwater bores located closer to surface-water sources were associated with more extraction; 2) higher surface-water allocations, an indicator of surface-water availability, was negatively associated with groundwater extraction; 3) an increase in the price of surface-water allocations was associated with an increase in groundwater extraction; and 4) an increase in trading volumes for both water allocations and entitlements in the surface-water market were associated with an increase in groundwater extraction. Such interdependencies need to be further explored and carefully taken into considerations by policy-makers. Another current study confirms the existence of a substitution effect between surface and groundwater (de Bonviller et al. 2020). In particular, this study suggests there is a significant price leadership from surface-water markets to groundwater markets. Results highlight the importance of integrated water policies (applying to both surface and groundwater resources) and the conjunctive management of water resources.

There are current arguments that a number of adverse environmental events (e.g. flooding damage as a result of water movements downstream) have been associated with water trade and environmental water movements (e.g. see claims in RMCG (2019) and submissions to Productivity Commission (2018)). However, there remains a question whether it is more related to water river operations. Indeed, Jody Swirepik's CEWH's recent appearance in the Senate enquiry on March 6, 2020 rejected the claims that environmental watering had caused problems. Future research is required in this space.

3.6.2 Environmental positive impacts

First of all, a benefit of water markets in Australia has meant that it has provided a way for the environment to gain greater rights (for example the Commonwealth Environmental Holder now owns 2104 gigalitres of LTAAY in the MDB). In addition, the literature has highlighted that both community interests and environmental values have been incorporated into market design. Nikolakis et al. (2013) found that if water rights are made to communities rather than individuals, water markets can receive widespread support in Indigenous communities.

Contrary to above, a number of studies have found that water markets can help decrease salinity when water is traded away from high impact areas (Lee et al. 2012; NWC 2012). Providing a large-scale review of the evidence, NWC (2012) concluded that the impacts of increased water trade on salinity appeared inconsequential. Their review found that if water was traded to an identified low salinity impact area, water trading had a positive effect on salinity levels, while when water was traded between areas of similar hydrological and agronomic characteristics, there was not be a deterioration in water quality. This is the same result as Heaney et al. (2006), who suggested the effects of water trading on salinity levels vary with the source and destination of the water that is being traded.

In the southern MDB in particular, the large movements of water via trade downstream is predominantly associated with beneficial ecological impacts. NWC (2012) studied the movement of water in depth, with modelling suggesting that the hydrologic and environmental impacts of water trade between 1998-99 to 2010-11 were small and mostly positive; due to water moving downstream during the drought with no change in winter flow patterns. Negative impacts occurred where water trade resulted in a change to the volume, location and/or timing of water extraction. NWC (2012) suggested that water trade led to improved flow stress ranking scores for the river systems assessed. The findings also concluded that water trade would have beneficial ecological flow impacts under dry conditions compared with wet. Further research in this space is warranted.

3.7 Summary and Key Points

- The supply of surface-water entitlements on the water market is influenced by: water allocations; environmental water; carryover; water trading rules; infrastructure investment; and government policy.
- The demand for surface-water entitlements is influenced by rainfall and soil moisture; temporal factors; groundwater availability and quality; commodity prices and input prices; land quality and regional factors; and on-farm infrastructure investment (public or private):
- Studies have found that seasonal factors, such as water allocations, drought and low water storages, are the main drivers of temporary water prices. Studies also indicated that irrigators can switch between groundwater and surface water use.
- A few studies have examined whether water markets exhibit characteristics similar to other financial markets. Evidence has been found, for example, in some markets showing price leadership, and other studies finding evidence of both price bubbles and insider trading.
- A substantial number of theoretical and empirical models have demonstrated the major economic and financial benefits that have been derived from having water markets in place in Australia.
- One of the most raised questions has been the impact of government water recovery on water markets. A variety of academic and consultancy studies have addressed this. Permanent water bought back by the government or recovered through irrigation infrastructure upgrades reduces the amount of permanent water owned in an area. However, the differences between: a) water entitlement's (permanent water) long-term average annual yield owned by stakeholders in a region at particular points in time (highest ML); b) water allocations (temporary water) received annually by the region for the entitlements they own; and c) water allocations/extractions extracted in a region by stakeholders and the amount supplied/demanded on the market – mean the question of recovery influence is complex and hard to theoretically predict. Studies have ranged from the theoretical (assuming straight changes in supply), to the empirical.
- The only empirical econometric study to date – that has utilised appropriate methodology and a long time-series of data to empirically investigate the causal question of buyback of water entitlements on the water market – found a statistically significant negative impact on temporary volume-traded from government water recovery (i.e. a 1% increase in water recovery resulted in a 0.14% reduction in water volume-traded), but no significant impact was found on temporary water prices, nor on permanent high security market prices and volumes in the GMID. However, government water recovery increased the volatility of temporary market prices and volumes. Further research is needed on the impact of water recovery on allocation shares and permanent prices of low and general security entitlements in the MDB.
- There are numerous negative impacts associated with subsidising irrigation infrastructure as a government policy. Two of these impacts include increasing demand for water and the increased utilisation of water entitlements, therefore increasing water market demand and reducing water market supply, as well as reducing storage volumes and impacting on future water allocations (which correspondingly impact greater on lower reliability entitlements).
- Various studies have used scenario approaches to study how consumptive water supply will change in the southern MDB given future permanent irrigated horticulture demand, as well as MDBA's current development of a modelling tool to assess this. It is expected that risk of delivery shortfall to regions downstream of the Barmah Choke will increase over time, given: 1) increased areas of horticultural plantings in the Murray Valley; 2) increased water demand of maturing existing horticultural plantings; 3) environmental water delivery requirements under the Basin Plan; and 4) a drying future climate. A variety of recommendations were made for improvements to be made.

- Studies indicate that there have been both positive and negative impacts on the environment from the presence of water markets. Negative impacts include: concentrating water use in areas suffering from high water tables; increased salinity in areas that require minimum irrigation intensities and that have experienced water entitlement loss; moving water into locations where its use might have a negative impact on river water quality; increased groundwater substitution, and increased groundwater use can lead to increased salinity problems if saline groundwater flows into rivers due to discharge; moving water use upstream, thereby resulting in reduced river flow from the new point of extraction to the old point of extraction; and activating previously unused water leaving less water in rivers to support ecosystems (plus less water in storages for future water allocations). Positive impacts include: the water market provides a way for the environment to own water entitlements with the same rights and security as consumptive users; water markets can decrease salinity when water is traded away from high impact areas; and changing water use downstream is predominantly associated with beneficial ecological impacts. Further research is warranted in this space.

4 Valuing water assets and implications for water markets

This chapter provides a brief review of the valuation and accounting methods used internationally for water assets, and an overview of the methods applied by current stakeholders in the MDB.

4.1 An Overview of International and National Water Valuation and Accounting Methods

One implication of creating water markets is the need for water as an asset to be valued for a variety of purposes when it is not physically being traded through the market. For example, water assets may need to be valued for banks to lend against it, for the asset to be transferred across generations or for governments to purchase water assets through strategic negotiations.

International valuation methods include *The System of Environmental Economic Accounting for Water* and financial asset valuation tools (namely discounted cash-flows; relative valuation; and option pricing models) (Seidl et al. 2020a).

Australia has employed continuous water accounting since 1983, while from 2004, the National Water Initiative (COAG 2004) required the development of a water accounting framework. The *Australian Water Accounting Standards* for "General Purpose Water Accounting" is currently used around Australia (Water Accounting Standards Board 2012). Its implementation is challenging; definitions are not standardised which lead to inconsistencies across regions. There is also considerable lack of information on water hydrological data, and especially this is the case where it is assumed water extraction equals consumption (ignoring return flows back to the river) (Grafton et al. 2018).

For financial reporting, the Australian Accounting Standards Board (2019) recommends treating (unbundled) water rights as intangible assets with an indefinite lifespan, with three techniques recommended for fair valuation (but does not recommend any method in particular):

1. market (namely relative valuation);
2. replacement cost (amount required to replace the asset); and
3. income (discounted cash-flow).

Similarly, there is also no industry-recommended water valuation method, nor any instructions from governments about how to directly value water. This includes state governments, albeit it seems that the *Victorian Water Act 1989* has addressed financial water valuation the most comprehensively, requiring water entitlements to be valued by a certified valuer (although no guidance on entitlement valuation is provided), and exit fees in irrigation districts should represent the present value of all future fees payable. Seidl et al. (2020a) provides a comprehensive overview of relevant water valuation legislation in its Appendix A2.

4.2 Water Valuation and Accounting Methods used by MDB stakeholders

Given the lack of guidelines regarding water valuation methods used, Seidl et al. (2020a) (this study was described further in Chapter 2) sought to understand further what methods and data stakeholders were employing (Table 4.1 reports the answers from 43 respondents in general across stakeholders such as banks, water brokers/evaluators, investors and environmental water holders).

Table 4.1. Water valuation method and data sources used by MDB relevant stakeholders

Answers to: 1) What method do you use to value water entitlements? and 2) What data sources do you use?		*Banks % (n=6)*	*Evaluators & water brokers % (n=15)*	*Investors % (n=19)*	*Environmental Water Holders % (n=3)*
Methods Used*	Current market price	50	53	16	67
	Volume weighted average	33	27	0	33
	Original purchase price	17	0	0	0
	Other	17	13	32	0
Data sources*	Water registers	67	73	16	67
	Water brokers	67	80	11	33
	Own data	67	20	0	0
	Property sales	0	27	0	0
	Other evaluators	17	7	0	0
	Test listing**	0	7	0	0

Notes: *Multiple mentions of methods and data sources per interview possible.
**Where a water broker offers an entitlement for sale to collect bidding data, but then does not go through with the sale.
Source: Seidl et al. (2020a)

Table 4.1 illustrates that relative valuation methods based on current water market entitlement prices and transaction data were the most commonly used. Other methods included adopting the broker price/purchase price or using volume weighted average prices based on different lengths of data (6-18 months), and 19% of respondents mentioned other valuation methods (e.g. valuation based on historic and future allocation volume; associated production; long-term average annual yield (LTAAY); statistical and time-series analysis; and capital asset pricing type valuation models).

4.2.1 Case study application of implications of various water valuations and methods

Seidl et al. (2020a) also clearly highlighted in a case study looking at the valuation of Kia Ora water purchase by the Commonwealth government (in a strategic negotiated purchase in 2017) how water values can lack transparency. The case study analysis suggested that if the Commonwealth had actually paid the median market price (compared to comparable water market products at the time), the purchase cost should have been around 42-97% less. Hence, valuation of water assets matters. The study also found differences in how water values were treated by different parties. Banks applied extension rates of 50-60% to water valuations, whereas rates between 60-70% apply to agricultural land, for mortgage and security purposes. Financial investors in contrast revalued assets monthly at current market prices. Environmental water holders undertake yearly impairment testing, but do not revalue water portfolios. The difference in accounting leads to a material divergence in reported water portfolio values, plus the predominant use of historical cost accounting by small businesses could disadvantage them in regards to access to capital.

4.2.2 Key findings and recommendations for change in valuation practices

The study's recommendations and conclusions included:

- Water entitlements are more volatile than land, and in many cases extremely liquid, traded routinely in large volumes on active markets.
- There is a need for guidelines on a dedicated water valuation methodology, transparent valuation of water resources should follow a standardised approach in regards to data cleaning, data sources considered and valuation methods employed.
- Problems of valuation are greatest in thin markets, where data scarcity and quality arguably require the use of longer time-periods and multiple data sources. Under the need to recover water by governments, various interests may be able to extract unduly high water entitlement prices and it also provides opportunities for rent-seeking.
- Greater consistency in financial water accounting practice in Australia is required, in particular for water accounting by smaller businesses, who may be at a particular

disadvantage in accessing capital since water is often one of the most important parts of their asset base.

- A lack of consistency in accounting practices is exasperated by poor quality water entitlement ownership data, misreporting the location and security of stakeholders' water entitlement ownership.
- Given the maturity of southern MDB water markets, fair value accounting for water assets is possibly more transparent, more reflective of economic realities, and arguably easier than historical cost accounting.
- More transparent water accounting frameworks, reflecting the current value of water may enable better water management and increased trust.
- Future studies should pay more attention to financial water values and attempt to incorporate these values better into existing accounting frameworks.
- To underpin the hydrological integrity and financial water asset values, physical accounting considering net water consumption on a basin-scale are paramount, along with governance, regulation and addressing corruption and rent-seeking (Seidl et al. 2020).

4.3 Summary and Key Points

- Water markets require water as an asset to be valued for a variety of purposes when it is not physically being traded through the market. For example, water assets may need to be valued for banks to lend against it, for the asset to be transferred across generations or for governments to purchase water assets through strategic negotiations.
- Australia has employed continuous water accounting since 1983, while from 2004, the National Water Initiative required the development of a water accounting framework. The *Australian Water Accounting Standards* for "General Purpose Water Accounting" is currently used around Australia. Its implementation is challenging; definitions are not standardised, which lead to inconsistencies across regions. There is also considerable lack of information on water hydrological data – this is particularly the case where it is assumed water extraction equals consumption (which ignores return flows back to the river).
- For financial reporting, the Australian Accounting Standards Board recommends treating (unbundled) water rights as intangible assets with an indefinite lifespan, with three techniques recommended for fair valuation: market (namely relative valuation); replacement cost (amount required to replace the asset); and income (discounted cash-flow).
- Problems of valuation are greatest in thin markets, where data scarcity and low data quality arguably require the use of longer time-periods and multiple data sources. Under the need to recover water by governments, various interests may be able to extract unduly high water entitlement prices and it also provides opportunities for rent seeking.
- There is a need for guidelines on a dedicated water valuation methodology, and that transparent valuation of water resources should follow a standardised approach in regards to data cleaning, data sources considered and valuation methods employed. A lack of consistency in accounting practices is exasperated by poor quality water entitlement ownership data, misreporting the location and security of stakeholder water entitlement ownership.
- It is suggested that fair value accounting for water assets is possibly more transparent, more reflective of economic realities, and arguably easier than historical cost accounting.

5 Summary of the efficiency benefits of water markets and their identified market failures

This chapter provides a summary overview of the identified efficiency benefits of water markets, especially in the MDB. It also provides a summary of the market failures that have been identified in the literature, and issues associated with pecuniary externalities and distributional issues.

5.1 Efficiency Benefits of Water Markets in Australia

Firstly, water markets in Australia (and particularly the sMDB) have been shown to have: a) allocative efficiency; b) dynamic efficiency; and c) productive efficiency. The overall dollar benefits of this have been shown to be in the billions (e.g. see Table 3.2 in Chapter 3). In particular, the efficiency benefits include:

1) *Allocative efficiency*: Extensive literature has shown that improved water resource short-term decision making reflecting seasonal conditions (e.g. weather, commodity price adjustments, cropping choices) is facilitated by water allocation trade. This has been shown by water allocation trading being a risk management strategy for many irrigators in the literature that has analysed extensive irrigator quantitative and qualitative surveys (e.g. Khan et al. 2010a; 2010b; Nauges et al. 2016; Zuo et al. 2015a; Loch et al. 2012), and the role that water trading played during droughts providing income for annual croppers through selling water allocations to permanent growers to keep their crops alive (e.g. Kirby et al. 2014; Wheeler 2014; Adamson et al. 2017). Other time-series studies critically emphasise the major role that water scarcity plays in water allocation prices and volumes traded on the market (ABARES 2016; Brennan 2006; Brooks & Harris 2008; Loch et al. 2012; Shanahan et al. 2010; Wheeler et al. 2008; Zuo et al. 2015a; Zuo et al. 2016). The introduction of carry-over in the market has also led to decreased uncertainty and volatility of within season prices, and hence improved risk management for many irrigators (Wheeler et al. 2010).
2) *Dynamic efficiency*: the existence of water markets for only willing buyers and sellers of permanent trade allows for structural or long-term decision making, enabling: 1) new investment opportunities, 2) regulatory shifts in access arrangements (e.g. extraction limits or embargos) or 3) personal strategic choices (e.g. retirement). The literature has shown that that the two most important motivations for permanent water sales were a) retiring debt and b) generating cash to support farm income and re-investment in the farm (Hyder Consulting 2008; Wheeler and Cheesman 2013). Wheeler and Cheesman (2013) also found that for those farmers who sold all their entitlement water, a third of them retired. A number of farmers sold water as part of succession plans. There are two influences from selling water entitlements for many farmers: a positive (reduction in debt, farm restructure and reinvestment to make it more productive or efficient) and a negative (less water for production and/or higher costs in buying water allocations or bought feed) impact. Wheeler et al. (2014b) found there was no statistically significant impact on an irrigation farm’s current financial year net income from selling water entitlements – but found a negative impact on current year rate of return from buying water entitlements. Conversely, Wheeler et al. (2014c) found weak statistically significant evidence that selling water in the past may lead to less net farm income in the future.
3) *Productive efficiency*: the existence of water markets where water price changes (both temporary and permanent) offer incentives for the efficient use of water resources as either an investment or input for productive outcomes (Loch et al. 2013). This allows water to be traded to its highest value use, which includes urban, environmental and cultural uses (Grafton and Wheeler 2018). The entrant of new stakeholders into the water market also has the benefit of developing new innovative risk products (Seidl et al. 2020a), which provides greater allocative efficiency. The growing value of water entitlements over time provides a

benefit for existing farmers in terms of superannuation, as an investment or as mortgage property (Seidl et al. 2020b; Wheeler et al. 2016).

5.2 Where is there evidence of water market failure in the MDB?

5.2.1 Institutions and market failure

As outlined in Chapter One, often those who argue against markets do so because they believe markets are a tool of global capitalism resulting in appropriative privatisation, where state or private actors obtain water resources (without meaningful compensation) previously held in common ownership. However, to identify problems with markets, we must first recognise what institutional market failures are.

As highlighted by Wheeler et al. (2017b) and Wheeler and Garrick (2020), it is critical to note that water markets only exist within institutions and structures which allow and govern the transfer of water. If these institutions and structures are corrupted or are missing, then this can result in negative impacts for society. This includes hydrological issues, such understanding and measuring the impact of return flows more (Young et al. 2002; Grafton et al. 2018). A comparison of the water markets in the southern and northern Basins of Australia highlights that greater attention needs to be focussed on ongoing attempts to reform both state water institutions in terms of monitoring and compliance; and water licence conditions through water resource plans, especially in the northern Basin. Greater attention must also be paid to developing strong independent water and governance institutions that can limit (and highlight) rent seeking. Young (2019) also provides additional commentary on how countries can improve methods to share water, with greater emphasis given to 'hands off' water and minimum flows in rivers. Further improvements are needed in providing historical and current water extraction (and consumption) information from satellite and thermal imaging, developing strong and independent state water resource plans, along with increased information and development of water registers, water accounting, water hydrology and connectivity, water pricing and trade products – again, particularly in the northern Basin (see further discussion in Wheeler et al. (2020)). Without these factors, there are serious implications for potential market failure and allowing or encouraging greater trade may have net social costs.

Well-designed marketplace rules and infrastructure will encourage participation, reduce strategic gaming, aggregate information – and improve efficiency, liquidity and equity – which will facilitate more efficient and equitable allocation. Further to the need for carefully designed rules and institutions for water markets that work well, there are also lessons for policy that attempts to use one instrument (e.g. irrigation infrastructure) to achieve two objectives (namely water recovery and jobs) (e.g. see Wittwer and Young (2020) for greater discussion on this).

To summarise, and keeping in mind the issues about the need for monitoring, compliance and review above, findings in the literature highlight the following water market failures:

1) **Imperfect competition:** occurs if markets are not contestable, but nevertheless characterised by monopoly, oligopoly, bilateral monopoly or some other market imperfection. In these cases, the 'invisible hand' may fail to allocate resources efficiently. Multiple factors such as initial endowment of resources, geographic features and government regulation can prevent competition from occurring. In the MDB, there is more evidence of imperfect competition in the northern MDB than the southern MDB, due to both endowment of resources and unregulated property rights (Wheeler and Garrick 2020). Very careful assessment needs to be given to any change in unregulated entitlements to allow trading, such as allowing trading in floodplain water harvesting rights. Legal loopholes enabling stakeholders to bypass trade restrictions and extraction embargoes also need to be closed. Evidence from the operation of some IVTs in the southern MDB is that they do exert material influence on water market prices, and that some brokers have a technical ability and automatically monopolise trade

through the Choke (Hunt 2020). The Productivity Commission (2018) outlined a number of areas of potential non-compliance with Basin Plan trading rules that need addressing. It was noted that 11 compliance issues raised by the MDBA with states remained unresolved. This included issues with: IVTs; interstate trade between ACT and NSW; interstate trade between NSW and QLD on intersecting streams; tagged entitlement and delivery of water; unregulated water limiting future expansion of trade in the Northern Basin; and compliance issues. There also seems to be a need for increased transparency around rules and standards for water forwards and options, carry-over access (e.g. investigating removing annual limits on carry-over, in place of limits on the volume of unused allocation that can be held at any time, reflective of storage capacity constraints (Hughes et al. 2013)). In the absence of clear standards for water forwards and options, product comparability is problematic (Seidl et al. 2020b).

Indeed, the increasing development of new products on the water market means that new water market infrastructure is required, especially given claims of unregulated broker behaviour (Seidl et al. 2020b). Such a body may follow ASIC market integrity rules, such as a central exchange and clearing house, along with a well-resourced market regulatory agency with competency in secondary or derivative products that monitor and enforce compliance. Sophisticated innovative water market products require comprehensive spot price data, in this case allocation and entitlement data. Water market institutions and regulation need to enforce product standards and code of conduct, and limit rent-seeking, as well as having prosecution powers to effectively limit counterparty risk in the newer innovative water market products and unlawful intermediary behaviour. Self-regulation of brokers does not appear viable for the future (Seidl et al. 2020b). Seidl et al. (2020b) suggested that the current small number of water market stakeholders not owning water, yet trading, have probably limited market impact overall, however this impact is dependent upon: a) the liquidity of the local water market they operate within; and b) the volume of their trade or any insider information knowledge (discussed further in the information asymmetry point below). Growth in the water market non-landholder financial investor area is likely to be limited by the substantial financial investment and trading skills required, and also due to the fact potential investors have the option to trade on other financial stock markets (with greater turnover possibilities).

2) **Externalities**: occurs when property rights are not clearly defined, and so costs and/or benefits observe spillovers to others. In this case, discrepancies between private and social benefits and costs will be observed, and the resource allocation generated by markets will not be efficient because market prices do not reflect the ‘full’ or social costs involved. Chapter One described issues associated with tagging and transmission losses through trading, which have potential third party impacts and require further investigation. Another negative externality from government water recovery in water markets was found by Zuo et al. (2019). Statistically significant evidence was found in Goulburn water markets that government water recovery increased the volatility of temporary water market prices and volumes, signalling increased issues of risk and uncertainty for irrigators engaging in temporary water markets. It was also found that a 1% increase in water recovery resulted in a 0.14% reduction in water volume traded, however no significant impact was found by Zuo et al. (2019) on temporary water prices, nor on high security GMID permanent market prices and volumes (although note: impact on prices is not a negative externality or market failure issue, it is a distributional issue – see comments in next section). Nevertheless, further modelling research on the impact of water recovery on low and general security permanent prices and allocation shares in the MDB is warranted.

A potential negative externality impact of increased use of carry-over is that it can lead to less 'socialisation of existing water resources'. Previously, irrigators who did not use/trade all their water allocations forfeited the water, which increased available water in storage (and correspondingly flows in river for some extractors) and allowed an increase in water allocations the following season. The increase in irrigation efficiency across the Basin (private and subsidised) and the reduction of return flows over time has also led to reduced storage capacity. Such a result can mean that owners of lower securities are most affected by reduced allocations. However, as mentioned in the allocative efficiency benefits section, other impacts of carry-over are that it seems to have reduced variability of within season water allocation prices ($H_2$0X 2019; Wheeler et al. 2010a), which reduces price uncertainty and hence can represent a positive externality impact for irrigators.

One of the most cited examples of externalities of Australian water markets is environmental impact. However, there is both evidence that water markets have had both positive and negative impacts on the environment. For example, positive impacts include allowing the environment to acquire equal rights (Grafton and Wheeler 2018); decreased salinity (Lee et al. 2012; NWC 2012); and allowing greater movement of water downstream with beneficial ecological impact (NWC 2012). Negative environmental impacts identified include: increased salinity in areas where water is traded (Bjornlund 1999; Khan et al. 2009); increased groundwater substitution and salinity issues (Wheeler and Cheesman 2013; Haensch et al. 2016; Wheeler et al. 2020a; de Bonviller et al. 2020); activation of sleepers and dozers (NWC 2012); and environmental water causing flooding damage (e.g. RMCG 2019) – note however, many recent claims about environmental water damage have been rejected by the CEWH in the Senate in 2020. In particular water recovery itself (albeit this is an ongoing impact from water trade in general) - through both the buyback of water entitlements and, most notably, through subsidisation of irrigation infrastructure –results in changed incentives for irrigator behaviour. This was discussed at length in Chapter Three, where studies have found that water extractions increased up to 21-28% more at the individual farm level in the sMDB for those who received an irrigation infrastructure subsidy grant versus those who did not. Furthermore, irrigators who received a subsidy were more likely to increase their water utilisation of existing entitlements, change crop mix (to more permanent plantings) and were more likely to enter the market to buy water entitlements and allocations (Wheeler et al. 2020). Other evidence of changed behaviour suggests increased floodplain harvesting and groundwater substitution (Haensch et al. 2016; Wheeler et al. 2020). Hence, negative externalities for the MDB from these effects of changed irrigator behaviour, include: a) the increasing conversion to permanent crops which decreases the flexibility of water extractions to contract in times of scarcity; and b) increased water extractions of a substitute (groundwater) which is poorly monitored (Wheeler et al. 2020). Such a trend in land use change has been detected in the Basin (HARC 2020). However, there is a key difference between behaviour which has been motivated by government intervention and policy (in the case of water efficiency subsidies); and behaviour such as changing land use patterns from irrigators making personal choices from participating in water market trade. Again, it comes back to the issues surrounding the rules and institutions that surround water markets. One implication of the issues associated with changing irrigator trade behaviour is the impact on the reliability of various entitlement securities – and the impact of reduced return flows, increased utilisation, changed trade patterns and conveyance losses all may have implications for entitlement security (especially lower and general entitlement security). Further research is warranted in this space.

Other externalities have also been identified with environmental water transfers. In order to support inter-region environmental transfers, EWHs are required to formally trade water allocations between regions, subject to market trading rules. An alternative is to provide EWHs with some form of return flow right, where environmental releases that flow to the end of a river reach are automatically re-credited to the environment for use downstream. Such arrangements have been developed in northern Victoria (VDEPI 2016), but apparently have not yet been implemented in NSW beyond trials in limited areas. Establishing an equivalent rule across NSW catchments could provide benefits to other users, such as helping to reduce pressure on the Murrumbidgee IVT export limit – which is used by environmental water holders in the absence of return flow arrangements (Seidl et al. 2020b). Again, further research is warranted.

3) Information asymmetry: occurs where one party has better information than the other. In this case, the information-rich agent can behave towards their own benefits at the cost of the information-poor. There have been a number of identified information asymmetries in Australian water markets that hamper decision-making (both irrigator and government policy decision-making). There is a requirement for water register data reform, such as the need within registers to identify water forward, lease, option, and parking transactions – including counterparty type – in order to support emerging innovative water market products. Entitlement transactions in conjunction with land must be identified, along with mandatory price reporting and rigorous quality controls of different water register data enforced. There are ongoing issues with price disclosure in registers, consistency of data information (and timeliness); and accuracy of information in registers (especially across states) (MDBA, 2019e; Seidl et al. 2020b). These issues include measurement of storage, conveyance water, and water extractions across the states. In addition, many stakeholders have called for improved and transparent rules and standards for water carry-over access, allocation and IVT determinations (Seidl et al. 2020b), along with consistent information on important water information (such as storage levels etc.). Some changes suggested include investigating removing annual limits on carry-over, in place of limits on the volume of unused allocation that can be held at any time, reflective of storage capacity constraints (Hughes et al. 2013).

There also may be a need for further research around computerised ‘smart markets’; blockchains; American-style centralised ‘water banks’; or a review of river operations (e.g. export more water into the Murray through the Snowy Mountains Hydro-electric Scheme to lower the IVT account balance). In absence of clear standards for water forwards and options, product comparability is problematic, and information is only available to certain parties. A review of tagging and transmission losses through trading should identify and quantify corresponding third party impacts. Conversely, very careful assessment needs to be given to any change in unregulated entitlements to allow trading, such as allowing trading in floodplain water harvesting rights (especially without strong institutions governing extraction). Legal loopholes enabling stakeholders to bypass trade restrictions and extraction embargoes need to be closed. Entitlement ownership by stakeholder type data should be analysed at a catchment level to identify and address concerns of market power and monopolistic behaviour (ACCC 2019; DELWP 2019a) – and also improve the access and ability to search for water titles. In addition, accounting practices of water valuation that have no clear standardisation are exasperated by poor quality water entitlement ownership data, misreporting the location and security of stakeholders' water entitlement ownership.

Another form of information asymmetry occurs through membership of consultation bodies, such as water steering committees, and specific knowledge of water brokers. Such information asymmetry can allow for insider trading, and there is statistically significant quantitative evidence that this may have been present in Australian water markets, especially prior to rules being enforced in 2014 (de Bonviller et al. 2019). Productivity Commission

(2018) outlined that NSW had committed to have a disclosure policy around this in 2017. Standards for water brokers need to be fully transparent and publicly declared to avoid rent seeking. Some see a need for intermediary regulation to provide minimum quality standards and address conflicts of interest (such as intermediaries owning and principally trading water, and unethical handling of customer accounts, being open and transparent with all information) (Seidl et al. 2020b).

Concerns have been raised regarding the level of foreign ownership of water entitlements. The latest estimates available suggest that 9% of MDB water entitlements as at mid-2018 were held by companies with some level of foreign ownership (ATO 2019). Information on ownership is difficult to establish without paying for a register search and knowing the water access licence number. This has led some to call for increased public information transparency in regards to water ownership, especially by those who make decisions about water in government.

Another form of information asymmetry in water markets that can impact on irrigators and EWHs is the method of water evaluation. There is a need for guidelines on a dedicated water valuation methodology – transparent valuation of water resources should follow a standardised approach with regards to data cleaning, data sources considered, and valuation methods employed. It has been found that problems of valuation are greatest in thin markets, where data scarcity and quality arguably require the use of longer time-periods and multiple data sources. As noted in Quiggin (2019), a "thick" market with many active groups of participants is needed for prices to be truly informative. Two potential consequences of valuation difficulties include: 1) governments acquiring water (water may easily be overvalued when government uses strategic purchases rather than open tender to buy water); and 2) farms using water for mortgages with banks. Seidl et al. (2020a) reported banks using conservative valuation practices (and discounting prices further before applying extension rates) – prior to applying conservative extension rates (50-70% lower than the valuation, which is significantly less compared to land). The issue is related to the definition of water as intangible, and hence water assets are treated with greater risk. Smaller businesses may be at a particular disadvantage in accessing capital since water is often one of the most important parts of their asset base, and they often do not have access to other forms of capital compared to larger corporates. Seidl et al. (2020a) propose fair value accounting for water assets is possibly more transparent, more reflective of economic realities, and arguably easier than historical cost accounting – along with the need for full water accounting of return flows from a hydrological perspective.

In summary, there is evidence of market failure in water markets within Australia. Imperfect competition does seem to exist in some forms, especially with regards to the northern Basin, IVT issues and unregulated water broker behaviour. Negative externalities are also clearly present, mainly because of the lack of clear property rights and institutional rules. Such externalities have also resulted from government policy. Information asymmetry is also clearly present in water markets, again in relation to IVT issues, data and information on prices, water registers and weather, insider trading issues of working groups and water brokers, to name but a few issues.

5.2.2 Pecuniary externalities and inequalities

As highlighted in Chapter 1, water market failures are at times closely intertwined with inequality issues in water access – on both demand and supply sides. Pecuniary externalities are where various stakeholders are impacted from increases or decreases in market prices. In complete markets, pecuniary externalities do not matter, but they do matter when markets are incomplete, and the welfare effects of a price movement on consumers and producers do not generally offset each other. Hence, where stakeholders are subject to: a) resource constraints; b) capacity thresholds; or c) contract issues – particularly when some agents are subject to resource constraints – the updated decision due to price changes may no longer be optimal. This typically occurs when there is a capacity requirement/threshold to access certain agricultural, finance and resource markets, or when smallholders are usually marginalised by modern market organisation forms, such as contract farming due to high transaction costs. As discussed above, because of the issues associated with imperfect competition and information in the water markets, this does raise capacity issues – especially for smaller family farms.

Buyers versus sellers

The literature review detailed the characterististics of traders and non-traders, in both allocation and entitlement markets (private and government). This provides us information on who benefits from changes in water market prices. Higher water market prices benefit water sellers, but disadvantage water buyers. When worried about price impacts as a pecurniary externality on irrigators, one needs to understand the characteristics associated with trade behaviour – namely what is associated with irrigators' trade behaviour. The cluster analysis undertaken in Chapter Six is valuable here. It highlights that buyers of water allocations (Cluster One) (as at 2015-16 in the sMDB) tended to be younger, owned less water entitlements (but not less land), had more debt and named higher water stress (and water allocations received). Cluster One buyers were also much more likely to express a traditional approach to farming (e.g. to agree with an attiudinal statement that farming is the only occupation they want to do). Buyers of water entitlements (and diversifiers) – Cluster Two – did not show the same statistical profile. For example, debt, age, water ownership and water stress were not statisitically significant, while other factors such as being in broadacre more important. Cluster Three, the sellers of water entitlements and water allocations, on the other hand were statistically more likely to be older, under financial distress, did not name water stress (but showed climate temperature stress) and had smaller farm area. In addition, Cluster Three sellers were less likely to agree with the view that farming was the only occupation they would want to do. Such a profile suggests that younger farmers (owning far less water entitlements), in higher debt, who feel strongly about the farming lifestyle, are the ones in the market buying water allocations – compared to the sellers who are older, live on smaller farms and have off-farm income, but are experiencing financial stress. Other studies have emphasised the role of debt in water entitlement selling (Wheeler et al. 2012b; Wheeler et al. 2013a) and illustrate how the selling of water allows a pathway out of irrigation (and debt) for many irrigators – while it has also been shown that many used debt to restructure and reinvest in their farms (Wheeler and Cheesman 2013). The other impact that may arise is the path dependency from a certain behaviour (such as selling permanent water entitlements) resulting in increased business vulnerability in the future – and weak statistical evidence has been found on this (e.g. Wheeler et al. 2014c).

Gifted infrastructure asset issues and impacts on small irrigation dependent rural economies

Water recovery has a number of distributional issues. Firstly, there is the potential that increased sale of permanent water out of districts (along with not keeping or paying for delivery rights) can increase the spread of fixed costs across less users in irrigation districts; and cause stranded assets. This is a distributional issue, not necessarily a market failure. Gifted infrastructure assets have uncertain costs for irrigators' delivery and other future charges – Chapter 5 provided considerable discussion on this. Secondly, very small local areas more dependent on irrigation also can suffer correspondingly (MJA 2019), although what is clear is that there are many factors that drive rural economic outcomes (Wheeler et al. 2020b). Again, this was not the remit of the ACCC's study into water markets and is not commented upon further here, other than to say there is a strong argument that water recovery should have been planned differently and with greater thought given to properly restructuring irrigation regions and how to support rural economies (Grafton and Wheeler 2018). Thirdly, water recovery itself, through both the buyback of water entitlements and the subsidisation of irrigation infrastructure, results in changed incentives for irrigator behaviour, as discussed in the externalities section above (and in Chapter Three). Given it is known that irrigators who received an irrigation infrastructure grant were more likely to increase their water utilisation of existing entitlements and enter the market to buy water entitlements and allocations (Wheeler et al. 2020), this has potential implications on seasonal allocations to existing entitlements over time and therefore water market demand and prices. Aither (2017) estimated an impact on water allocation prices from increased demand from irrigation infrastructure upgrades, albeit Zuo et al. (2019) did not find any significant quantitative evidence of overall water recovery on water allocation and high security permanent market prices in the Goulburn, using a time-series panel analysis of twenty years. Again, further modelling on low and general security permanent water market prices and allocation shares is warranted.

Initial distribution of property rights in water

Issues associated with the distribution of initial property rights result in inequitable markets. In Australia one of the key water distribution inequalities is the need for a fairer allocation of water rights for First Nations people (Grafton and Wheeler 2018; Jackson et al. 2019). The *National Water Initiative* was the first time water policy acknowledged the need to take into account, include and recognise indigenous interests in water management, however there remain strong calls for urgent reform. Even though $40 million was allocated in mid-2018 to support First Nations Basin communities by investing in cultural and economic water entitlements – to date there is no evidence that any cultural water has been purchased. There also remain significant issues with priorities regarding urban and domestic use of water, especially in the northern Basin, but this is not directly related to water markets per se, more so general issues regarding water take and sharing (namely state water resource plans).

5.3 Summary and Key Points

- There are three distinct forms of economic efficiency associated with water markets: *Allocative efficiency*: improving water resource short-term decision-making, reflecting seasonal conditions, is facilitated by water allocation trade. *Dynamic efficiency*: improving or facilitating water resource structural or long-term decision making, reflecting new investment opportunities, regulatory shifts in access arrangements or personal strategic choices, can be achieved through water entitlement trade; and *Productive efficiency*: increasing the flexibility of water prices offer incentives for the efficient use of water resources, as either an investment or input for productive outcomes. Australian water markets have shown evidence of all these efficiency benefits.
- In particular, the individual benefits of water markets include: allows water to be traded to its highest value use (including urban and environmental); involves only willing buyers and sellers, and hence provides some security tenure over transactions; supports long-term farm development; provides risk-management strategy for farmers; provides flexibility and additional income stream for annual growers in times of high water scarcity and a source of much needed water for permanent growers; reduces probability of bankruptcy during drought; allows purchase for environmental (or cultural) benefits and the same rights as irrigation holders; can free up capital for farmers to use elsewhere; increases water entitlement value and asset values of irrigators; movement of water can have positive environmental impact; and allows non-landholders to enter the market, who often develop new innovative risk products, and their increased demand in the market increases water values for existing users.
- However, there is strong evidence of market failure in water markets in Australia. **Imperfect competition** does seem to exist in some forms, especially with regards to the northern Basin, IVT issues, tagged entitlement and delivery of water, unregulated water issues, interstate trade between NSW and QLD and ACT; and unregulated water broker behaviour. **Negative externalities** are also clearly present, mainly because of the lack of clear property rights,

enforcement and monitoring and institutional rules. Such externalities have also resulted from government policy – most particularly irrigation infrastructure subsidies to recover water. There is evidence of both positive and negative environmental externalities from water markets. **Information asymmetry** is also clearly present in water markets, again in relation to IVT issues, data and information on prices, water ownership information, water registers and weather, insider trading issues of working groups and water brokers, to name but a few issues.

- Many of the perceived costs of Australian water markets represent pecuniary externalities (e.g. increases or decreases in market prices from various actions), which can have different distributional issues. Distributional issues include: a) initial distribution of property rights can make markets inequitable – which is especially the case for First Nations communities; b) legacy and gifted asset issues – the increased sale of permanent water out of districts (along with not keeping delivery rights or not paying for delivery rights) can increase the spread of fixed costs across less users in irrigation districts and cause stranded assets, impacting smaller irrigation dependent rural economics more; and c) profile of buyers and sellers – buyers of water allocations are more likely to be younger, own less water entitlements and in higher debt, compared to those buying water entitlements, selling water or not trading.
- There are a variety of lessons identified, including:
    - Water markets only exist within institutions and structures that allow and govern the transfer of water – including the implementation of state water resource plans. If these institutions and structures are corrupted or missing, then this can result in negative impacts for society. Greater attention needs to be focussed on ongoing attempts to reform both state water institutions in terms of monitoring and compliance; and water licence conditions through water resource plans, especially in the northern Basin. Further improvements are needed in providing both future and historical water extraction and consumption information from satellite and thermal imaging, along with increased information and development of water registers, water accounting, water ownership issues, water hydrology and connectivity, water pricing and trade products – again, particularly in the northern Basin.
    - Although non-stakeholder involvement is likely limited, monopolistic concentration of entitlement ownership and market power can lead to price gauging by landholder and non-landholder actors alike, particularly in illiquid markets or when combined with insider information. There is a need for more quantitative evidence (such as linking both ownership and trading register data) to be collected and analysed.
    - Other water market reforms in the areas of data, rules and regulations, new institutions development and infrastructure are required.

6 Detailed new quantitative analysis of water ownership, trading strategies and water market attitudes in the MDB from GFAR survey data

GFAR were asked by ACCC to conduct additional analysis on irrigator water ownership and trading strategies to answer a range of questions. The following section outlines the data used from a variety of surveys, the sample sizes, the types of trade questions and the years available. Note: only GFAR survey data was used to answer these questions in this section, and it is important to note that they may not fully represent the situation as at 2020. The question asked by the ACCC is placed in a box at the front of each section.

6.1 Data and Methodology

6.1.1 Data

Table 6.1 details the year, location, sample and water trade types in our irrigator surveys from 1999 to 2015, and details of publications where the data has been used. The surveys are randomly sampled from a given irrigator population and have very high response rates and can be regarded as representative (for example, average age, industry and farm size are similar to ABS and ABARES irrigation farm survey results). Representativeness is very important when assessing attitudes to various issues, as other surveys that follow methods such as open to all online surveys etc., potentially suffer from a biased response due to non-randomness. However, there are other issues to be aware with attitudinal questions, as they represent stated behaviour rather than revealed behaviour, and correspondingly suffer from issues such as hypothetical and strategic bias. Appendix B provides the full-set of descriptive statistics of the variables used.

Table 6.1 A summary of available quantitative surveys of the Centre for Global Food and Resources, The University of Adelaide

Survey year	**Location**	**Sample size**	**Trade in previous season**	**Trade in the previous five years**	**Selected publications for more detail on survey methods (journal abbreviation)**
1998-99	GMID	300	Allocation	*Not available*	Wheeler et al. 2009 (AE) Wheeler et al. 2012a (JRS)
2003-06 (3 years)	GMID	1068 (all traders)	Allocation; Entitlement	Entitlement	Wheeler et al. 2010b (AWM) Wheeler et al. 2012a (JRS)
2008	VIC & SA	624	*Not available*	Allocation; Entitlement	Wheeler et al. 2012b (ERE) Wheeler et al. 2012a (JRS)
2010-11	sMDB (NSW, VIC and SA)	946	Allocation; Entitlement	Entitlement	Wheeler et al. 2012b (ERE) Wheeler et al. 2012a (JRS) Wheeler et al. 2013b (GEC) Wheeler et al. 2015 (EE) Haensch et al. 2019 (JOH)
2011	sMDB (NSW, VIC and SA)	535	Allocation; Entitlement	*Not available in survey*	Zuo et al. 2016 (AJAE) Zuo et al. 2015b (ER) Wheeler et al. 2017a (LUP) Haensch et al. 2019 (JOH) Loch et al. 2016 (AE)
2015-16	sMDB (NSW, VIC and SA)	1000	Allocation; Entitlement	Allocation; Entitlement	Wheeler et al. 2018b (JRS) Daghagh Yazd 2019 (Sus) Seidl et al. 2020b (JOH)

In addition, a total of 64 semi-structured qualitative interviews were conducted by Constantin Seidl in late 2018 as part of his PhD study with key stakeholders across the MDB in 2018 (with 63 interviews analysed due to the incompleteness of one interview). The qualitative data and method are described further in Seidl et al. (2020a) and Seidl et al. (2020b), and have been outlined previously in Chapter Two.[5] Because of the lack of public information available on non-landholders involvement in water markets, interviews represent one of the few ways to obtain information in this area. To summarise, the breakdown of interviews included: 20 investors and agri-corporates (corporates were defined as very large landholders owning and/or trading large amounts of water who have a corporate business structure (eg publicly listed, producing annual financial reports) but still generating their main income from farming who often had a dedicated water trading/portfolio manager); 15 EWH and NGO employees (public or private entities, owning or delivering water entitlements or allocations for environmental purposes); 10 water evaluators (consultants etc. specialised in water valuation); 7 financial investors (non-landholders trading water for financial gain); 6 bankers (employees from financial institutions who were the key individuals responsible for significant lending portfolios in water entitlements); and 5 water brokers (who earn commission-based revenue from water market transactions).

6.1.2 Descriptive statistics and non-parametric comparison test

For the descriptive statistics, we employed independent two sample t-tests to compare the mean of continuous variables and proportion test for binary variables between two groups, i.e. trader and non-trader. We also used Pearson Chi-squared test for associations between categorical variables (such as education and industry) and water trading.

The independent t-test, assuming the variances of the two groups are equal,[6] is a type of hypothesis test that is used to test whether the means of continuous variables are different between two independent groups. The null hypothesis assumes that the difference between the two groups is zero. Suppose group A and group B are the two groups to compare, the t test statistic value can be calculated as follows:

$$t = \frac{m_A - m_B}{\sqrt{\frac{S^2}{n_A} + \frac{S^2}{n_B}}}$$

[5] Participants were identified using the following criteria, whether they: represent an organisation with a “large” water portfolio/trading volume; represent an organisation that is an agri-corporate, a financial water investor or an environmental water holder; have managerial responsibilities over this water portfolio, including strategic decision-making capabilities; have an in-depth understanding of MDB water markets – or: represent an organisation with a “large” involvement in water mortgaging, or financial water valuation; have managerial responsibilities over water lending or water valuation processes; and have an in-depth understanding of MDB water markets, and water lending or water valuation. As there is no publicly available database containing names of agri-corporates and financial investors in the MDB, a chain-referral sampling approach was employed to identify and recruit additional research participants. The initial potential participants and organisations were identified (83 in total) from a wide range of publicly available sources, including newspaper articles, reports by government departments and NGOs, conference attendance, company annual and financial reports, personal and professional networks, company websites and web searches. Overall, 64 of the 83 identified contacts agreed to be interviewed, and semi-structured personal interviews were conducted. Although it is strictly not a survey response rate, this represents a response rate of 77% (with one of two written responses excluded due to incompleteness). One eligible written response was received and 25% of the interviews were conducted by phone. One written response was discarded as it was incomplete and did not answer all the questions (hence n=63).

[6] Equal variances are tested prior to the t-test and in a few cases equal variances were rejected and therefore subsequent t-tests were under an unequal variance assumption.

where m_A and m_B represent the means of groups A and B respectively, n_A and n_B represent the sizes of groups A and B respectively, and S^2 is an estimator of the common variance of the two samples which can be calculated as:

$$S^2 = \frac{\sum(x - m_A)^2 + \sum(x - m_B)^2}{n_A + n_B - 2}$$

Binary data are useful for calculating proportions or percentages. Therefore, for binary data, a proportion hypothesis test is employed to compare whether the proportion of group A is the same as the proportion of group B. Let $\widehat{P_1}$ be the observed proportion in group A and $\hat{P}_2$ be the observed proportion in group B. A test of the difference between the two proportions used an asymptotically normally distributed test statistic expressed as:

$$z = \frac{\widehat{P_1} - \widehat{P_2}}{\sigma}$$

where σ is the standard error of $\widehat{P_1} - \widehat{P_2}$.

The chi-square test provides a method for testing the association between the row and column variables in a two-way table. The null hypothesis assumes that there is no association between the variables (in other words, one variable does not vary according to the other variable), while the alternative hypothesis claims that some association does exist.

Aggregate mean and proportion numbers for the whole sample were weighted proportionally to irrigating business numbers in NSW, VIC and SA in the sMDB to have a more representative picture of the sMDB, for surveys in 2010, 2011 and 2015.[7]

6.1.3 Factor analysis

Principal component factor analysis (e.g. see Hamilton (2009)) is a statistical method used to identify a small set of unobserved variables (also called factors) which can account for the covariance among a larger set of observed variables. Since water strategies are rarely adopted separately and irrigators often use them in combination with other strategies to manage their farms, for this report different factors will be identified based on a set of water trading and farm management strategies irrigators undertook in the past five years. Since all strategy variables are binary in nature, a tetrachoric correlation matrix (Edwards & Edwards 1984) that is appropriate to measure correlations among binary variables was generated and used in the principal component factor analysis. In general, tetrachoric correlation coefficients are larger (in absolute value) and more dispersed than the Pearson correlations that are more appropriate for continuous variables.

After principal component factor analysis, each of the factors can then be given an identity based on the nature of the strategies with high factor loadings contributing to that factor. Promax rotation was used and factor loadings below 0.40 were considered as insignificant both statistically (Stevens 2002) and practically Hair et al. (1998) and thus dropped. Bartlett's test and the Kaiser-Meyer-Olkin measure of sampling adequacy (Kaiser 1974) was used to test the suitability of the variables for principal component factor analysis. Thomson's regression method (Thomson 1951) is used subsequently to predict the factor scores for each irrigator.[8] According to the *n* factor scores for each

[7] Irrigating business numbers in NSW, VIC and SA in sMDB are from Water Use on Australian Farms, (ABS, multiple years)

[8] Since the irrigator groups are used in subsequent regression analysis to identify the characteristics associated with each group membership, we used irrigators' next five year's strategies to predict their factor scores and thus their group memberships. Therefore, regression analysis using current characteristics to group memberships based on future strategies will not incur the reverse causality problem.

irrigator, each irrigator is then classified into the group having the largest factor score and the strategies consisting of that factor are considered as the irrigator's dominant ones.

6.1.4 Regression analysis

The multinomial logit model is employed since there are multiple choices and our particular interest lies in the understanding the individual effects of explanatory variables on each group of the irrigator water market participant typology. As such, choice of being in one typology group is the optimization where farmers are assumed to maximize their utility function subject to the constraints. For the ith farmer faced with J typology groups, suppose the utility of choosing to be in group j (j=1,2…5) as follows:

$$U_{ij} = x_i'\theta + \varepsilon_{ij}$$

If U_{ij} is the maximum among the J utilities, then farmer i will choose the typology group j. Following Greene (2005), let Y_i be a random variable which indicates the choice that farmer i made. Therefore, the probabilities are determined by the following equation:

$$P_{ij} = \text{Prob}(Y_i = k|x_i) = \frac{\exp(x_i'\theta_k)}{\sum_{j=1}^{J}\exp(x_i'\theta_j)}, j = 1,2, \dots, J$$

where k is one of the j subgroups and $P(y_i = j)$ is the probability that the ith farmer choose k subgroup. x_i describes business, farm and location characteristics which determine farmer's choice. In order to identify the model, constraints must be imposed. A common approach is to assume that β1 = 0 (Greene 2005; Long 1997). This normalization makes it possible to identify the coefficients relative to the base outcome. The model can be therefore written as:

$$P_{ij} = \text{Prob}(Y_i = k|x_i) = \frac{\exp(x_i'\theta_k)}{1 + \sum_{j=2}^{J}\exp(x_i'\theta_j)}, for\ k > 1$$

$$\text{Prob}(Y_i = 1|x_i) = \frac{1}{1 + \sum_{j=2}^{J}\exp(x_i'\theta_j)}$$

The multinomial logit model is estimated using maximum likelihood. The log-likelihood can be derived by defining, for each individual, $d_{ij} = 1$ if alternative j is chosen by individual i, and 0 if not. The log-likelihood is therefore as follows:

$$lnL = \sum_{i=1}^{n}\sum_{j=0}^{J} d_{ij}\,\text{Prob}(Y_i = 1|x_i)$$

Coefficients are interpreted using the relative risk ratios, which is the relative probability of $Y_i = k\ for\ \boldsymbol{k} > 1$ to the base category:

$$\frac{P(y = k)}{P(y = 1)} = \exp\left(x_i'\theta_j\right), for\ k > 1$$

The coefficient is difficult to interpret as it is relative to the base group. Therefore, marginal effects are recommended and can be taken as follows:

$$\delta_{ij} = \frac{\partial P_{ij}}{\partial x_i} = P_{ij}[\theta_j - \bar{\theta}]$$

6.2 Results

6.2.1 Characteristics of participating and non-participating irrigators in water trade

ACCC QUESTION: What types of irrigators are participating (and not participating) in water trading? Describe irrigator water market participants and non-participants based on their characteristics including:

- Business characteristics: e.g. farm type, business size (irrigated area), business size (EVAO), revenues, profitability, level of access to finance, use of on farm infrastructure investments/grants
- Location characteristics: e.g. state, northern vs southern MDB, water system, water trading zone)
- Individual characteristics: e.g. education level, gender, age
- How has this changed over time?

6.2.1.1 Water Allocation trade

The following tables in this section provide the results of the two sample equal mean tests determining whether the difference between the means of the two independent groups (trader and non-trader in the previous season of the survey year) were statistically significant. Characteristics highlighted in grey are statistically significant (p-value < 0.1) which means that the difference between the population means of the two groups was statistically significant and the null hypothesis of equal means can be rejected.

Results for the early water allocation trading year (1998-99) in the GMID (Table 6.2) show a number of statistically significant business characteristics. Specifically, the differences between the means of net farm income, water entitlements held and total irrigated land of the two groups were statistically significant. Water allocation traders had a significantly higher net farm income and owned higher entitlement volumes and hectares of irrigated land as compared to non-traders. Traders also were more likely to have whole farm plans and farm successors as compared to non-traders and also perceived their farms to be more long-term financially viable than non-traders did. Non-traders used more irrigation scheduling aids; whereas traders used more extension services and were more involved in community and professional groups. Furthermore, test results for the Pearson Chi-squared tests for associations between the categorical variables of education, industry and water trading show a statistically significant difference between traders and non-traders. Namely, traders' level of education was higher between the years 10 and 12, whereas non-traders' level of education was higher in both the lower (< year 10) and the higher (> year 12) levels of education. In terms of industry, traders were statistically significantly more likely to be in dairy production and non-traders were statistically significantly more likely to be engaged in livestock production on their farm.

Table 6.3 provides the results for water allocation trading data ten years later in the sMDB. Compared to the 1998-99 result that net farm income was found significantly different between traders and non-traders, it was not found to be the case, but similarly traders own statistically significantly more hectares of irrigated farm-land and volumes of water entitlements. This dataset also shows that traders had larger dryland, as well as larger farm-land overall and used more laser grading and reuse systems on their irrigated land area. Traders' farm businesses further employed more full-time employees and were more often supported by an irrigation infrastructure grant. In contrast to the 1998-99 data (albeit note different populations), traders were significantly less likely to be in dairy production. In 2009-10 dataset, traders were mainly broadacre farmers; while non-traders were mainly horticulture and dairy farmers. In line with earlier water trading data, traders were more likely to have whole farm plans but having farm successors was not more associated with traders in 2009-10. This dataset also shows that traders were younger, statistically significant at the 0.01 level. Test results for the categorical variables of education and location show that traders and non-traders' education levels differed mainly at the lower than Year 10 and TAFE levels, with a higher percentage of non-traders than traders at the lower than Year 10 level while a higher percentage of traders than non-traders at the TAFE level; a higher percentage of traders than non-traders were from NSW (in particular Murrumbidgee-Coleambally and NSW Murray-Deniliquin regions) while the opposite holds for SA (in particular SA Murray-Renmark and SA Murray-Murray Bridge regions).

Table 6.4 shows the test results for the following water trading year of 2010-11 for the sMDB. Net farm income was again found to be not statistically significant, along with hectares of (irrigated) land and volumes of entitlements held. Instead, traders had significantly more of their farm income from off-farm work than non-traders did. In contrast to both earlier water trading years, in 2010-11 water allocation traders were mainly horticultural farmers (and non-traders were relatively evenly distributed across horticulture, broadacre and dairy industries). Furthermore, in this year farmers' experience and whether they were married were statistically significant characteristics. Specifically traders had less farming years in total and a higher percentage were married. Results for 2010-11 also suggested trading status was statistically significantly associated with state location, and in particular, traders were more likely to be in SA than non-traders; while non-traders in this year were more likely to be in NSW or VIC.

Finally, Table 6.5 provides the results for the more recent water trading year of 2014-15 for the sMDB. Similar to 1998-99, traders earned statistically significantly more income and were more likely to have a whole farm plan than non-traders, but hectares of (irrigated) land and volumes of entitlements held were again not found to be statistically significantly different for the two groups. This year's results also showed a statistically significantly higher water use for traders. Similar to 2010-11, traders were mainly horticultural farmers but were also broadacre and dairy farmers, whereas non-traders produced mainly livestock. In line with 2009-10 data, traders were statistically significantly younger and corresponding to 2010-11 results, traders had less farm experience and were more likely to be married. Results further showed that traders had more children but less likely to have named a successor and a higher percentage were planning for climate change on their farms. The education variable changed again slightly, with traders more likely to have TAFE or university education than non-traders.

As water allocation markets in sMDB become increasingly popular among irrigators, differences between traders and non-traders are less apparent compared to early years. For the year 2014-15, a number of characteristics still differentiated water allocation traders and non-traders, both in terms of the size of the practical difference and also their statistical significance. First, water allocation traders' net farm income on average was 15% higher than that of non-traders. Second, traders' water use was on average 47% higher than non-traders. Third, traders on average carried over 72% more water into 2014-15 than non-traders. These differences may suggest that traders usually managed a larger water volume than non-traders, which offered them the flexibility to trade water allocations as well as to gain a higher economic return from trading. Fourth, on average traders were three years younger, had four years less farming experience, and had 0.14 higher (i.e. 41% versus 27%) probability of TAFE or University education than non-traders. Fifth, in terms of profiling water allocation traders in terms of farming attitudes, traders appeared less traditional than non-traders (this is because traders agreed less than non-traders with the statements 'Farming is the only occupation I want to do' and 'I could never imagine living anywhere other than this area').

Table 6.2 1998-99 GMID survey (based on 1998-99 trading history) mean characteristics of water allocation traders[1] vs non-traders

Farm and farmer characteristics	*Non-water allocation trader (n=100)*	*Water Allocation Trader (n=200)*	*p-value*
Business characteristics			
% of irrigation area with laser grading	59.17	62.80	0.41 [a]
% of irrigation technology with surface drain	73.84	75.98	0.65 [a]
% of irrigation area with off farm drainage	57.33	62.89	0.31 [a]
% of irrigation area with reuse system	44.80	47.46	0.61 [a]
Net farm income (AUD, in 10,000)	2.63	3.66	0.00 [a]
% of income from off farm work	23.28	19.12	0.29 [a]
Total water entitlement (high security, ML)	244.17	498.05	0.00 [a]
Total area of irrigated land (hectares)	103.47	210.41	0.00 [a]
Use aid in scheduling irrigation (%)	48.00	46.73	0.84 [b]
Have a whole farm plan (%)	50.00	69.70	0.00 [b]
Use scheduling irrigation aids (%)	48.00	46.73	0.04 [b]
Have a farm successor identified (%)	26.00	43.50	0.00 [b]
Long-term financially viable (%)[2]	60.00	70.85	0.06 [b]
Productivity of your farm over the last five years (Likert scale from 1 to 5, 1=strongly decreasing, 5=strongly increasing)[3]	3.48	3.48	0.98 [a]
Extension services used (%)	31.00	44.50	0.02 [b]
Community group membership (%)	32.00	45.50	0.03 [b]
Professional organisation membership (%)	35.00	59.50	0.00 [b]
Industry: livestock (%)	60.87	37.36	0.00 [c]
Industry: dairy (%)	22.83	41.76	
Industry: broadacre (%)	9.78	16.48	
Industry: horticultural (%)	6.52	4.40	
Individual characteristics			
Age	50.54	50.55	1.00 [a]
Years of farming	30.83	32.28	0.43 [a]
Male (%)	88.00	84.00	0.36 [b]
Married (%)	81.00	87.50	0.13 [b]
Level of education: lower than Y10 (%)	34.34	21.50	0.01 [c]
Level of education: Y10 to Y12 (%)	47.47	66.00	
Level of education: above Y12 (%)	18.18	12.50	

[1] Water allocation (temporary) trade includes both buy and sell water allocation behaviour.
[2] The answer 'Yes' to 'Do you think your farm business is long-term financially viable?'
[3] Attitudinal statement was measured by Likert scales: 1=strongly decreasing; 2=decreasing; 3=neither decreasing nor increasing; 4=increasing; and 5=strongly increasing.
[a] Two sample equal mean test (t-stat) for continuous and Likert scale variables was used.
[b] Two sample equal proportion test (z-score) for binary variables was used.
[c] Pearson Chi-squared test was used for categorical variables.

Table 6.3 2010-11 NSW, VIC and SA southern MDB survey (based on 2009-10 trading history) mean characteristics of water allocation traders[1] vs non-traders

Farm and farmer characteristics	*Non-allocation trader (n=444)*	*Water allocation trade (n=502)*	*Two sample t-test (p-value)*
Business characteristics			
Net farm income ($)	30343.14	30373.63	0.99[a]
Total area of irrigated land (hectares)	111.76	172.57	0.00[a]
Total are of dryland (hectares)	275.10	373.68	0.08[a]
Total area of the farm (hectares)	386.89	546.28	0.01[a]
% of irrigation area with laser grading	31	41	0.00[a]
% of irrigation area with reuse system	20	30	0.00[a]
% of irrigation area with centre pivot irrigation	3	4	0.51[a]
% of irrigation area with spray or drip irrigation technology	28	24	0.16[a]
Number of full-time employees	2.01	2.36	0.05[a]
Total volume of high security water entitlement (ML)	260.69	324.13	0.07[a]
Total volume of low security entitlement water in VIC	134.53	212.74	0.08[a]
Total volume of general security entitlement water in NSW	1075.61	1252.52	0.30[a]
Total vol. of surface-water entitlements (high, general, low)	624.23	914.72	0.00[a]
Received an exit package (%)	2	2	0.62[b]
Received an irrigation infrastructure grant (%)	40	48	0.01[b]
Debt to equity ratio (debt divided by land value)	0.45	0.53	0.12[a]
Industry: Horticulture (%)	40.88	30.98	0.00[c]
Industry: Broadacre (%)	27.98	41.03	
Industry: Dairy (%)	31.14	27.99	
Individual characteristics			
Age	55.96	54.14	0.01[a]
Years of farming	35.11	33.86	0.15[a]
Number of children	3.08	2.99	0.28[a]
Married (%)	86	89	0.14[b]
Have a successor (%)	36	35	0.85[b]
Whole farm plan (%)	68	74	0.04[b]
Attitude to risk from farmer (Likert scale from 1= totally unwilling to take risk, 2=unwilling to take risk; 3=risk neutral; 4=willing to take risk; and 5=completely willing to take risk)	3.17	3.22	0.50[a]
Level of education: lower than Y10 (%)	19.59	13.15	0.02[c]
Level of education: Y10 to Y12 (%)	52.03	52.59	
Level of education: TAFE (%)	9.91	14.34	
Level of education: University (%)	18.47	19.92	
NSW (%)	25.68	39.64	0.00[c]
VIC (%)	38.74	37.25	
SA (%)	35.59	23.11	
Murrumbidgee-Griffith	8.13	9.40	0.00[c]
Murrumbidgee-Coleambally	6.77	13.00	
NSW Murray-Deniliquin	10.38	15.80	
VIC Murray-above Barmah Choke	4.29	4.00	
Goulburn Central	13.09	11.40	
VIC Murray-below Barmah Choke	21.67	23.20	
SA Murray-Renmark	10.38	6.20	
SA Murray-Waikerie	15.35	13.60	
SA Murray-Murray Bridge	9.93	3.40	
Attitude: Family should be an integral part of the farming enterprise[2]	3.86	3.76	0.14[a]

Attitude: My family is fully committed to farming as an occupation and way of life	3.56	3.50	0.48[a]
Attitude: Farmers should encourage family members to be involved in the family farm	3.43	3.31	0.09[a]
Attitude: I would like to buy or develop enough land for my family to remain or become farmers	3.26	3.30	0.53[a]
Attitude: Financial gain is the only reason for my involvement in farming	2.77	2.56	0.01[a]
Attitude: A maximum annual return from my property is my most important aim	3.37	3.42	0.49[a]
Attitude: I view my farm first and foremost as a business enterprise	3.59	3.66	0.27[a]
Attitude: My land is just something I use to generate an income	3.08	2.80	0.00[a]
Attitude: Improving my farm is important because it will increase its future sale value	3.91	3.83	0.22[a]
Attitude: I could never imagine living anywhere other than this area	3.18	3.08	0.19[a]
Attitude: I want to continue farming for as long as I am able	4.02	4.00	0.65[a]
Attitude: Farming is the only occupation I can imagine doing	3.51	3.30	0.01[a]
Attitude: My quality of life would decline if I moved from this farm	3.21	3.15	0.39[a]
Attitude: Land stewardship by farmers is more important than other farming issues	3.76	3.61	0.01[a]
Attitude: The wider community can reasonably expect landholders to adopt recommended practices that lead to improved environ. outcomes	3.76	3.60	0.01[a]
Attitude: My right to do what I want with my property has to be balanced against wider environmental concerns	3.67	3.65	0.78[a]
Attitude: I would like to leave my land in better condition than I found it	4.40	4.43	0.52[a]
Attitude: Knowing about new technology that becomes available is important to me	4.13	4.16	0.42[a]
Attitude: I am open to new ideas and alternatives about farming	4.19	4.25	0.12[a]
Attitude: Humans should have more respect and admiration for water in rivers	4.09	4.04	0.42[a]
Attitude: essential to make allocations to the environment	3.27	3.17	0.21[a]
Attitude: We would be willing to have our seasonal allocations reduced to ensure sufficient water for the environment	2.03	1.83	0.00[a]
Attitude: Most irrigators think increasing environmental water flows is a good thing	2.84	2.61	0.00[a]
Attitude: Governments should avoid changing trading rules or conditions during the season	3.95	4.13	0.00[a]
Attitude: Covering fixed water access expense is important when I trade	3.41	3.58	0.01[a]
Attitude: I am well informed about seasonal allocation changes	3.83	3.87	0.47[a]
Attitude: I believe water trading has been a good thing for farming	3.01	3.02	0.90[a]
Attitude: Trading water allows me to cope with seasonal uncertainty	3.50	3.84	0.00[a]
Attitude: I closely track water market prices to obtain maximised trade outcomes	3.31	3.62	0.00[a]
Attitude: I am well informed about the trading rules in my district	3.84	3.91	0.19[a]
Attitude: I usually follow the same strategic approach to allocation trading each year	3.17	3.00	0.02[a]
Attitude: I am generally a risk taker when it comes to allocation trades	2.50	2.56	0.33[a]

[1] Water allocation (temporary) trade includes both buy and sell water allocation behaviour.

[2] Attitudinal statements are measured by Likert scales:1=strongly disagree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree.

[a] Two sample equal mean test (t-stat) for continuous and Likert scale variables was used.

[b] Two sample equal proportion test (z-score) for binary variables was used.

[c] Pearson Chi-squared test was used for categorical variables.

Table 6.4 2011 NSW, VIC, SA southern MDB survey (based on 2010-11 trading history) mean characteristics of water allocation traders[1] vs non-traders

Farm and farmer characteristics	*Non-trader (n=402)*	*Allocation trader (n=133)*	*Two sample t-test (p-value)*
Business characteristics			
Net farm income (dollars)	34213.20	39069.77	0.19[a]
Total area of irrigated land in hectares	169.91	165.20	0.89[a]
Total are of dryland in hectares	513.03	252.59	0.13[a]
Total volume of high security water entitlement (ML)	308.27	320.75	0.88[a]
Total volume of low security entitlement water in VIC (ML)	277.87	194.65	0.61[a]
Total volume of general security entitlement water in NSW (ML)	1108.94	1479.88	0.17[a]
Total volume of surface-water (high, general, low & other, ML)	827.47	756.89	0.61[a]
% of income from off farm work	32.54	40.37	0.04[a]
Debt to equity ratio	0.10	0.13	0.15[a]
Those answering that a cap prevented entitlement trade (%)	11	17	0.10[b]
Industry: Horticulture (%)	33.68	44.35	0.05[c]
Industry: Broadacre (%)	34.99	33.87	
Industry: Dairy (%)	31.33	21.77	
Individual characteristics			
Age	55.95	54.27	0.13[a]
Years of farming	35.58	31.80	0.01[a]
Male (%)	0.89	0.89	0.77[b]
Number of children	2.99	3.02	0.81[a]
Married (%)	88	95	0.01[b]
Have a successor (%)	35	31	0.47[b]
Level of education: lower than Y10 (%)	15.92	10.53	0.15[c]
Level of education: Y10 to Y12 (%)	53.48	51.88	
Level of education: TAFE (%)	12.94	12.03	
Level of education: University (%)	17.66	25.56	
NSW (%)	35.82	24.06	0.00[c]
VIC (%)	40.05	33.08	
SA (%)	25.13	42.86	

[1] Water allocation (temporary) trade includes both buy and sell water allocation behaviour.
[a] Two sample equal mean test (t-stat) for continuous and Likert scale variables was used.
[b] Two sample equal proportion test (z-score) for binary variables was used.
[c] Pearson Chi-squared test was used for categorical variables.

Table 6.5 2015-16 NSW, VIC, SA sMDB survey (based on 2014-15 trading history) mean characteristics of water allocation traders[1] vs non-traders

Farm and farmer characteristics	*Non-water allocation trader (n=404)*	*Allocation trader (n=595)*	*Two sample t-test (p-value)*
Business characteristics			
Net farm income ($)	78206.81	90250.45	0.03[a]
Total area of irrigated land (hectares)	223.23	256.76	0.33[a]
Total are of dryland (hectares)	710.32	614.94	0.56[a]
Total area of the farm (hectares)	933.55	871.70	0.72[a]
Total volume of high security water entitlement (ML)	244.01	267.44	0.54[a]
Total volume of low security entitlement water in VIC (ML)	149.15	210.07	0.08[a]
Total volume of general security entitlement water in NSW (ML)	1050.88	1377.72	0.19[a]
Amount of water carried over into 2014/15 season (ML)	128.28	220.26	0.05[a]
Total water used for irrigation in 2014/15 season (ML)	706.56	1038.41	0.01[a]
Hours normally spent in planning water use before start of season	24.90	25.13	0.97[a]
Number of full-time employees	2.54	2.62	0.70[a]
Have a whole farm plan (%)	70	78	0.00[b]
Received an irrigation infrastructure grant (%)	34	39	0.14[b]
Cap prevented entitlement trade (%)	3	5	0.39[b]
Industry: Horticulture	28.54	33.95	0.00[c]
Industry: Broadacre	25.06	28.24	
Industry: Dairy	17.62	19.50	
Industry: Livestock	28.78	18.32	
Individual characteristics			
Age	60.45	57.45	0.00[a]
Male (%)	86	87	0.48[b]
Years of farming	39.61	35.30	0.00[a]
Number of children	2.69	2.85	0.07[a]
Married (%)	85	89	0.09[b]
Have a successor (%)	43	37	0.08[b]
% of household income derived off-farm	23.72	25.57	0.36[a]
Planning for climate change on farm (0=No 1=Yes) (%)	30	37	0.02[b]
Any family members belong to a community group(s) (0=No 1=Yes) (%)	45	42	0.44[b]
Any family members belong to a professional group(s) 0=No 1=Yes (%)	20	24	0.12[b]
Any family members belong to an environmental group(s) (0=No 1=Yes) (%)	17	17	0.98[b]
Any family members belong to a social group (0=No 1=Yes) (%)	57	58	0.78[b]
Have income protection insurance (0=No 1=Yes) (%)	27	29	0.62[b]
Have crop insurance (0=No 1=Yes) (%)	33	33	0.95[b]
Level of education: lower than Y10 (%)	21.09	13.61	0.00[c]
Level of education: Y10 to Y12 (%)	50.87	44.71	
Level of education: TAFE (%)	15.88	20.50	
Level of education: University (%)	12.16	21.18	
NSW (%)	40.10	43.03	0.57[c]
VIC (%)	39.11	35.97	
SA (%)	20.79	21.01	

Attitude: Farming is the only occupation I can imagine doing[2]	3.84	3.65	0.03[a]
Attitude: Financial gain is the only reason for my involvement in farming	2.56	2.44	0.11[a]
Attitude: I am generally a risk taker when it comes to operating my farm business	3.10	3.04	0.48[a]
Attitude: I believe water trading has been a good thing for farming	2.22	2.70	0.00[a]
Attitude: I could never imagine living anywhere other than this area	3.49	3.24	0.00[a]
Attitude: Knowing about new technology that becomes available is important to me	4.12	4.22	0.10[a]
Attitude: We would be willing to have our seasonal allocations reduced to ensure sufficient water for the environment	1.59	1.58	0.95[a]
Attitude: most irrigators think increasing environmental water flows is a good thing	1.93	2.03	0.19[a]
Attitude: Generally I feel optimistic about my future in this region	3.30	3.26	0.59[a]
Attitude: It is essential to make allocations to the environment otherwise irrigation will not be long-term sustainable	2.52	2.63	0.23[a]
Attitude: I want to continue farming for as long as I am able	4.25	4.18	0.21[a]
Attitude: I like to make my own decisions and not be too influenced by others	4.41	4.30	0.04[a]
Attitude: The Commonwealth Environmental Water Holder belongs in the agriculture not the environment department	4.17	4.05	0.08[a]
Attitude: the water portfolio belongs in the agriculture not environment department	4.39	4.29	0.11[a]
Attitude: Corporate non-farm entities should be allowed to invest in water	1.52	1.69	0.01[a]
Attitude: Retired irrigators no longer farming should be allowed to retain and trade water	2.58	2.92	0.00[a]
Attitude: Water buybacks for the Basin Plan should be suspended	3.91	3.93	0.80[a]
Attitude: More money should be spent on on-farm irrigation infrastructure by the Commonwealth	3.88	3.75	0.08[a]
Attitude: More money should be spent on water buybacks by the Commonwealth	2.05	1.96	0.28[a]
Attitude: The MDBA is serious about helping our community to solve our own environmental flow problems	2.44	2.44	0.92[a]
Attitude: I believe the Basin Plan should be suspended	3.60	3.43	0.06[a]
Attitude: Irrigation infrastructure money has been wasteful and inefficient	3.54	3.37	0.04[a]
Attitude: I would rather irrigation infrastructure money was spent instead on rural health and education services	2.72	2.66	0.39[a]

[1] Water allocation (temporary) trade includes both buy and sell water allocation behaviour.
[2] Attitudinal statements are measured by Likert scales:1=strongly disagree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree.
[a] Two sample equal mean test (t-stat) for continuous and Likert scale variables was used.
[b] Two sample equal proportion test (z-score) for binary variables was used.
[c] Pearson Chi-squared test was used for categorical variables.

6.2.1.2 Entitlement trade

Results for the 2009-10 entitlement trading year (Table 6.6) show that water entitlement traders had a statistically significantly lower farm income, a higher percentage of whole farm plans and they irrigated a higher percentage of their land with centre pivot irrigation. A higher percentage of entitlement traders also had received an exit package. Furthermore, compared to non-traders, traders were more likely to be broadacre farmers and less likely to be horticultural farmers. Results also showed that entitlement traders reported being statistically significantly less risk averse.

Table 6.6 2010-11 NSW, VIC, SA sMDB survey (based on 2009-10 trading history) mean characteristics of water entitlement traders[1] vs non-traders

Farm and farmer characteristics	*Non-entitlement trader (n=886)*	*Entitlement trader (n=60)*	*Two sample t-test (p-value)*
Business characteristics			
Net farm income in dollars	30964.15	21296.30	0.02[a]
Total area of irrigated land in hectares	145.96	115.57	0.44[a]
Total are of dryland in hectares	318.39	460.63	0.21[a]
Total area of the farm in hectares	464.38	576.22	0.39[a]
% of irrigation area with laser grading	36	39	0.55[a]
% of irrigation area with reuse system	25	33	0.12[a]
% of irrigation area with centre pivot irrigation	3	14	0.00[a]
% of irrigation area with spray or drip irrigation technology	26	23	0.57[a]
Number of full-time employees	2.16	2.74	0.10[a]
Total volume of high security water entitlement (ML)	299.01	225.60	0.32[a]
Total volume of low security entitlement water in VIC	172.27	221.18	0.61[a]
Total volume of general security entitlement water in NSW	1175.27	1349.70	0.59[a]
Total volume of surface water entitlements (high, general and low)	774.63	833.72	0.70[a]
Received an exit package (%)	2	8	0.00[b]
Received an irrigation infrastructure grant (%)	44	52	0.25[b]
Debt to equity ratio	0.49	0.50	0.95[a]
Industry: Horticulture (%)	36.27	24.49	0.09[c]
Industry: Broadacre (%)	34.10	48.98	
Industry: Dairy (%)	29.64	26.53	
Individual characteristics			
Age	55.04	54.23	0.58[a]
Years of farming	34.45	34.30	0.93[a]
Number of children	3.02	3.22	0.21[a]
Married (%)	88	93	0.19[b]
Have a successor (%)	35	41	0.40[b]
Whole farm plan (%)	70	83	0.03[b]
Attitude to risk from farmer (Likert scale from 1=totally unwilling to take risk; 2=unwilling to take risk; 3=risk neutral; 4=willing to take risk; and 5=completely willing to take risk)	3.17	3.60	0.00[a]
Level of education: lower than Y10 (%)	15.80	21.67	0.26[c]
Level of education: Y10 to Y12 (%)	53.16	40.00	
Level of education: TAFE (%)	12.08	15.00	
Level of education: University (%)	18.96	23.33	
NSW (%)	32.73	38.33	0.64[c]
VIC (%)	38.04	36.67	
SA (%)	29.23	25.00	
Murrumbidgee-Griffith	8.94	6.78	0.77[c]
Murrumbidgee-Coleambally	10.18	8.47	
NSW Murray-Deniliquin	12.67	22.03	
VIC Murray-above Barmah Choke	4.19	3.39	
Goulburn Central	12.33	10.17	
VIC Murray-below Barmah Choke	22.40	23.73	
SA Murray-Renmark	8.26	6.78	
SA Murray-Waikerie	14.59	11.86	
SA Murray-Murray Bridge	6.45	6.78	
Attitude: Family should be an integral part of the farming enterprise[2]	3.81	3.78	0.83[a]

Attitude: My family is fully committed to farming as an occupation and way of life	3.53	3.50	0.84[a]
Attitude: Farmers should encourage family members to be involved in the family farm	3.37	3.29	0.57[a]
Attitude: I would like to buy or develop enough land for my family to remain or become farmers	3.28	3.27	0.91[a]
Attitude: Financial gain is the only reason for my involvement in farming	2.66	2.57	0.53[a]
Attitude: A maximum annual return from my property is my most important aim	3.40	3.25	0.32[a]
Attitude: I view my farm first and foremost as a business enterprise	3.62	3.63	0.95[a]
Attitude: My land is just something I use to generate an income	2.94	2.88	0.73[a]
Attitude: Improving my farm is important because it will increase its future sale value	3.87	3.77	0.37[a]
Attitude: I could never imagine living anywhere other than this area	3.13	3.02	0.47[a]
Attitude: I want to continue farming for as long as I am able	4.01	4.00	0.93[a]
Attitude: Farming is the only occupation I can imagine doing	3.40	3.37	0.84[a]
Attitude: My quality of life would decline if I moved from this farm	3.18	3.19	0.95[a]
Attitude: Land stewardship by farmers is more important than other farming issues	3.69	3.51	0.12[a]
Attitude: The wider community can reasonably expect landholders to adopt recommended practices that lead to improved environmental outcomes	3.69	3.52	0.16[a]
Attitude: My right to do what I want with my property has to be balanced against wider environmental concerns	3.66	3.68	0.86[a]
Attitude: I would like to leave my land in better condition than I found it	4.41	4.45	0.61[a]
Attitude: Knowing about new technology that becomes available is important to me	4.14	4.22	0.29[a]
Attitude: I am open to new ideas and alternatives about farming	4.22	4.27	0.56[a]
Attitude: Humans should have more respect and admiration for water in rivers	4.06	4.08	0.84[a]
Attitude: essential to make allocations to the environment	3.22	3.12	0.49[a]
Attitude: We would be willing to have our seasonal allocations reduced to ensure sufficient water for the environment	1.91	2.07	0.23[a]
Attitude: Most irrigators think increasing environmental water flows is a good thing	2.72	2.73	0.91[a]
Attitude: Governments should avoid changing trading rules or conditions during the season	4.04	4.14	0.44[a]
Attitude: Covering the fixed water access expense is important when I trade	3.50	3.56	0.67[a]
Attitude: I am well informed about seasonal allocation changes	3.84	4.02	0.04[a]
Attitude: I believe water trading has been a good thing for farming	3.02	3.00	0.91[a]
Attitude: Trading water allows me to cope with seasonal uncertainty	3.67	3.82	0.27[a]
Attitude: I closely track water market prices to obtain maximised trade outcomes	3.46	3.67	0.14[a]
Attitude: I am well informed about the trading rules in my district	3.86	4.10	0.00[a]
Attitude: I usually follow the same strategic approach to allocation trading each year	3.09	3.00	0.56[a]
Attitude: I am generally a risk taker when it comes to allocation trades	2.51	2.85	0.01[a]

[1] Water entitlement (permanent) trade includes both buy and sell water entitlement behaviour.
[2] Attitudinal statements are measured by Likert scales 1=strongly disagree; 2=disagree; 3=neither agree nor disagree; 4=agree; and 5=strongly agree.
[a] Two sample equal mean test (t-stat) for continuous and Likert scale variables was used.
[b] Two sample equal proportion test (z-score) for binary variables was used.
[c] Pearson Chi-squared test was used for categorical variables.

Results of the 2014-15 entitlement trading year (Table 6.7) showed that compared to non-entitlement traders, water entitlement traders had statistically significantly larger total irrigated land area, total volumes of high security entitlements, low security entitlement in VIC and general security entitlements in NSW. Entitlement traders also carried over statistically significantly more water into 2014-15 season, extracted more water in 2014-15, and had a higher number of full-time employees. A statistically significantly higher percentage of entitlement traders had received an irrigation infrastructure grant, had planned for climate change on farm, had bought income protection insurance, had bought crop insurance, and belonged to professional groups. Finally, a statistically significantly higher percentage of entitlement traders were married compared to non-entitlement traders, and had a dispute over a water trade compared to non-entitlement traders.

In terms of the size of the practical differences besides their statistical significance, the following characteristics are considered to be the most important to differentiate traders and non-traders of water entitlements in 2014-15. First, entitlement traders' irrigated land was on average 78% larger than non-traders' and their water extraction was on average 139% more than non-traders. Second, the probability of receiving an irrigation infrastructure grant was 0.16 higher for traders than for non-traders. Third, trading probability varied among industries substantially, with a 0.17 higher probability of being in the horticultural industry for traders than for non-traders. Fourth, the probability of planning for climate change on farms or belonging to a professional group was 0.1 higher for traders than for non-traders. Fifth, the probability of a trader being from SA is 0.20 higher than that of a non-trader from SA.

Table 6.7 2015-16 NSW, VIC, SA southern MDB survey (based on 2014-15 trading history) mean characteristics of water entitlement traders[1] vs non-traders

Farm and farmer characteristics	Entitlement trade in 2014-15 (1=yes; 0=no)		
	Non-entitlement trader (n=864)	*Entitlement trader (n=135)*	*Two sample t-test (p-value)*
Business characteristics			
Net farm income ($)	83,871.46	94,824.22	0.22[a]
Total area of irrigated land (ha)	220.05	391.37	0.02[a]
Total area of dryland (ha)	630.22	802.60	0.56[a]
Total area of the farm (ha)	850.27	1193.97	0.29[a]
Total volume of high security water entitlement (ML)	245.39	338.47	0.17[a]
Total volume of low security entitlement water in VIC (ML)	174.09	278.53	0.23[a]
Total volume of general security entitlement water in NSW (ML)	1043.77	2887.21	0.09[a]
Amount of water carried over into 2014/15 season (ML)	135.03	490.52	0.07[a]
Total water use for irrigation in 2014/15 season (ML)	761.36	1818.44	0.01[a]
Hours normally spent in planning water use before start of season	23.80	32.92	0.37[a]
Number of full-time employees	2.48	3.26	0.01[a]
Have a whole farm plan (%)	74	78	0.37[b]
Received an irrigation infrastructure grant (%)	35	51	0.00[b]
Have had a dispute over a water trade (0=No; 1=Yes) (%)	3	7	0.04[b]
A cap prevented entitlement trade (%)	4	4	0.83[b]
Industry: Horticulture	29.43	46.67	0.00[c]
Industry: Broadacre	26.88	27.41	
Industry: Dairy	19.93	11.11	
Industry: Livestock	23.75	14.81	
Individual characteristics			
Age	58.84	57.53	0.22[a]
Male (%)	87	83	0.23[b]
Years of farming	37.32	35.26	0.11[a]
Number of children	2.79	2.75	0.76[a]
Married (%)	86	94	0.00[b]
% of household income derived off-farm	24.89	24.35	0.85[a]
Planning for climate change on farm 0=No 1=Yes (%)	33	43	0.02[a]
Likelihood of succession 0=No/uncertain; 1=Yes (%)	40	36	0.31[a]
Any family members belong to a community group(s) (0=No 1=Yes) (%)	43	45	0.64[a]
Any family members belong to a professional group(s) (0=No 1=Yes) (%)	21	31	0.01[a]
Any family members belong to an environmental group(s) (0=No 1=Yes) (%)	17	19	0.64[a]
Any family members belong to any social groups (0=No 1=Yes) (%)	57	63	0.16[a]
Have income protection insurance (0=No 1=Yes) (%)	27	35	0.07[a]
Have crop insurance (0=No 1=Yes) (%)	32	41	0.04[a]
Level of education: lower than Y10 (%)	17.82	8.96	0.00[c]

Level of education: Y10 to Y12 (%)	46.88	49.25	
Level of education: TAFE (%)	19.10	15.67	
Level of education: University (%)	16.20	26.12	
NSW (%)	42.94	34.81	0.00[c]
VIC (%)	38.89	26.67	
SA (%)	18.17	38.52	
Attitude: Farming is the only occupation I can imagine doing[2]	3.73	3.70	0.85[a]
Attitude: Financial gain is the only reason for my involvement in farming	2.48	2.54	0.60[a]
Attitude: I am generally a risk taker when it comes to operating my farm business	3.06	3.08	0.84[a]
Attitude: I believe water trading has been a good thing for farming	2.42	3.04	0.00[a]
Attitude: I could never imagine living anywhere other than this area	3.36	3.21	0.23[a]
Attitude: Knowing about new technology that becomes available is important to me	4.16	4.33	0.05[a]
Attitude: We would be willing to have our seasonal allocations reduced to ensure sufficient water for the environment	1.57	1.68	0.20[a]
Attitude: most irrigators think increasing environmental water flows is a good thing	1.93	2.34	0.00[a]
Attitude: Generally I feel optimistic about my future in this region	3.27	3.36	0.40[a]
Attitude: It is essential to make allocations to the environment otherwise irrigation will not be long-term sustainable	2.54	2.86	0.01[a]
Attitude: I want to continue farming for as long as I am able	4.21	4.22	0.86[a]
Attitude: I like to make my own decisions and not be too influenced by others	4.34	4.33	0.80[a]
Attitude: The Commonwealth Environmental Water Holder belongs in the agriculture not the environment department	4.14	3.84	0.00[a]
Attitude: the water portfolio belongs in the agriculture not environment department	4.36	4.14	0.01[a]
Attitude: Corporate non-farm entities should be allowed to invest in water	1.59	1.80	0.03[a]
Attitude: Retired irrigators no longer farming should be allowed to retain and trade water	2.75	2.96	0.11[a]
Attitude: Water buybacks for the Basin Plan should be suspended	3.96	3.70	0.03[a]
Attitude: More money should be spent on on-farm irrigation infrastructure by the Commonwealth	3.79	3.86	0.53[a]
Attitude: More money should be spent on water buybacks by the Commonwealth	1.97	2.20	0.03[a]
Attitude: The Murray-Darling Basin Authority is serious about helping our community to solve our own environmental flow problems	2.38	2.79	0.00[a]
Attitude: I believe the Basin Plan should be suspended	3.55	3.15	0.00[a]
Attitude: Irrigation infrastructure money has been wasteful and inefficient	3.51	3.02	0.00[a]
Attitude: I would rather irrigation infrastructure money was spent instead on rural health and education services	2.70	2.53	0.08[a]

[1] Water entitlement (permanent) trade includes both buy and sell water entitlement behaviour.

[2] Attitudinal statements are measured by Likert scales:1=strongly disagree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree.

[a] Two sample equal mean test (t-stat) for continuous and Likert scale variables was used.

[b] Two sample equal proportion test (z-score) for binary variables was used.

[c] Pearson Chi-squared test was used for categorical variables.

6.2.1.3 Carry-over

Results of the 2010-11 trading year (Table 6.8) show that compared to irrigators who did not use carry-over, those who did had statistically significantly higher net farm income, larger total area of irrigated land and dryland, and held significantly larger amounts of general security entitlement water in NSW and total surface-water entitlements altogether. Also, irrigators who carried over their water had statistically significant lower debt equity ratio, and had statistically significantly more years of farming and more children. Irrigators who carried over water were less likely to be in the horticultural industry (i.e. they were more likely to be in the broadacre or dairy industry) than those not carrying over water. Finally, results reveal that irrigators carrying over water were less likely to be in SA (more likely to be in NSW or VIC) than those not carrying water over (which is unsurprising given carryover rules – see Chapter 1 for further discussion).

Table 6.8 2011 NSW, VIC and SA southern MDB survey (based on 2010-11 trading history) mean characteristics of those who carryover vs no carry-over

Farm and farmer characteristics	*No carryover (n=194)*	*Did carryover (n=341)*	*Two sample t-test (p-value)*
Business characteristics			
Net farm income ($)	25,459.46	40,857.99	0.00[a]
Total area of irrigated land (ha)	69.16	224.20	0.00[a]
Total area of dryland (ha)	211.04	579.13	0.00[a]
Total volume of high security water entitlement (ML)	342.90	293.43	0.59[a]
Total volume of low security entitlement water in VIC	127.45	282.73	0.07[a]
Total volume of general security entitlement water in NSW	289.63	1490.16	0.00[a]
Total volume of surface water (high, general, low and other, ML)	442.14	1019.17	0.00[a]
% of income from off farm work	35.84	33.72	0.54[a]
Debt to equity ratio	0.16	0.09	0.00[a]
A cap prevented entitlement trade (%)	7	16	0.00[b]
Industry: Horticulture (%)	68.85	17.90	0.00[c]
Industry: Broadacre (%)	14.21	46.30	
Industry: Dairy (%)	16.94	35.80	
Individual characteristics			
Age	56.58	54.93	0.10[a]
Years of farming	33.13	35.48	0.06[a]
Male (%)	0.88	0.89	0.52[b]
Number of children	2.82	3.10	0.01[a]
Married (%)	91	89	0.64[b]
Have a successor (%)	30	36	0.19[b]
Level of education: lower than Y10 (%)	16.49	13.49	0.61[c]
Level of education: Y10 to Y12 (%)	52.06	53.67	
Level of education: TAFE (%)	10.82	13.78	
Level of education: University (%)	20.62	19.06	
NSW (%)	23.71	38.12	0.00[c]
VIC (%)	15.46	51.32	
SA (%)	60.82	10.56	

Notes: [a] Two sample equal mean test (t-stat) for continuous variables was used.
[b] Two sample equal proportion test (z-score) for binary variables was used.
[c] Pearson Chi-squared test was used for categorical variables.

Table 6.9 shows results based on 2014-15 data. Compared with 2010-11, there were not as many distinctions between irrigators who carried over their water and who did not. Carry-over irrigators versus non-carryover irrigators had statistically significant differences in net farm income, total area of irrigated land, amount of carried over water, total water used for irrigation, and number of employees. The ratios of whole farm plan and climate change plan were also statistically significantly different.

In terms of the size of the practical differences besides just their statistical significance, the following characteristics differentiate irrigators who carried over water and who did not carry-over water into the 2014-15 season. First, irrigators who used carry-over had a net farm income 33% higher and an irrigated land area 58% larger than those who did not use carry-over. Second, irrigators in NSW who used carryover had a general security water entitlement volume 87% higher and used 92% more water than those who did not use carry-over. Third, 14% of irrigators using carry-over were horticultural farms while 33% of irrigators not using carryover were from horticulture; and equivalently irrigators who carried over water were less likely to be from SA (a decrease in probability of 0.20). Fourth, 38% of irrigators using carry-over were planning for climate change compared to 28% of irrigators not using carryover planning for climate change.

Table 6.9 2015-16 NSW, VIC, SA southern MDB survey (based on 2014-15 trading history) mean characteristics of those who carry-over vs no carry-over

Farm and farmer characteristics	***No carryover (n=212)***	***Did carryover (n=536)***	***Two sample t-test (p-value)***
Business characteristics			
Net farm income ($)	72,409.33	96,519.61	0.00[a]
Total area of irrigated land (ha)	204.21	323.34	0.00[a]
Total are of dryland (ha)	591.32	782.36	0.33[a]
Total area of the farm (ha)	795.53	1105.70	0.13[a]
Total volume of high security water entitlement (ML)	224.98	264.61	0.23[a]
Total volume of low security entitlement water in VIC (ML)	178.77	185.86	0.88[a]
Total volume of general security entitlement water in NSW (ML)	899.05	1680.02	0.00[a]
Total water use for irrigation in 2014/15 season (ML)	627.02	1204.26	0.00[a]
Hours normally spent in planning water use before start of season	27.73	21.89	0.55[a]
Number of full-time employees	2.19	2.67	0.02[a]
Have a whole farm plan (%)	73	79	0.09[b]
Received an irrigation infrastructure grant (%)	37	39	0.58[b]
A cap prevented entitlement trade (%)	5	4	0.39[b]
Industry: Horticulture	33.02	14.37	0.00[c]
Industry: Broadacre	26.42	34.14	
Industry: Dairy	22.64	23.32	
Industry: Livestock	17.92	28.17	
Individual characteristics			
Age	59.00	58.83	0.85[a]
Male (%)	84	87	0.29[b]
Years of farming	37.68	38.41	0.50[a]
Number of children	2.75	2.81	0.63[a]
Married (%)	87	87	0.96[b]
Have a successor (%)	38	41	0.48[b]

% of household income derived off-farm	23.41	22.63	0.75[a]
Planning for climate change on farm 0=No 1=Yes (%)	28	38	0.01[b]
Any family members belong to a community group(s) (0=No 1=Yes) (%)	45	48	0.44[b]
Any family members belong to a professional group(s) (0=No 1=Yes) (%)	21	25	0.32[b]
Any family members belong to an environmental group(s) (0=No 1=Yes) (%)	18	19	0.93[b]
Any family members belong to any social groups (0=No 1=Yes) (%)	60	63	0.48[b]
Have income protection insurance (0=No 1=Yes) (%)	27	29	0.50[b]
Have crop insurance (0=No 1=Yes) (%)	33	40	0.11[b]
Level of education: lower than Y10 (%)	17.45	14.37	0.36[1]
Level of education: Y10 to Y12 (%)	51.42	47.95	
Level of education: TAFE (%)	16.51	19.40	
Level of education: University (%)	14.62	18.28	
NSW (%)	34.91	46.83	0.00[1]
VIC (%)	41.04	49.25	
SA (%)	24.06	3.92	
[1]Attitude: Farming is the only occupation I can imagine doing	3.74	3.77	0.75[a]
Attitude: Financial gain is the only reason for my involvement in farming	2.54	2.47	0.48[a]
Attitude: I am generally a risk taker when it comes to operating my farm business	3	3.1	0.34[a]
Attitude: I believe water trading has been a good thing for farming	2.34	2.36	0.87[a]
Attitude: I could never imagine living anywhere other than this area	3.47	3.26	0.06[a]
Attitude: Knowing about new technology that becomes available is important to me	4.14	4.18	0.61[a]
Attitude: We would be willing to have our seasonal allocations reduced to ensure sufficient water for the environment	1.59	1.49	0.15[a]
Attitude: most irrigators think increasing environmental water flows is a good thing	2.03	1.74	0.00[a]
Attitude: Generally I feel optimistic about my future in this region	3.26	3.26	0.95[a]
Attitude: It is essential to make allocations to the environment otherwise irrigation will not be long-term sustainable	2.55	2.37	0.08[a]
Attitude: I want to continue farming for as long as I am able	4.19	4.24	0.57[a]
Attitude: I like to make my own decisions and not be too influenced by others	4.43	4.3	0.05[a]
Attitude: The Commonwealth Environmental Water Holder belongs in the agriculture not the environment department	4.22	4.18	0.62[a]
Attitude: the water portfolio belongs in the agriculture not environment department	4.4	4.42	0.81[a]
Attitude: Corporate non-farm entities should be allowed to invest in water	1.53	1.57	0.60[a]
Attitude: Retired irrigators no longer farming should be allowed to retain and trade water	2.84	2.67	0.13[a]
Attitude: Water buybacks for the Basin Plan should be suspended	3.8	4.16	0.00[a]
Attitude: More money should be spent on on-farm irrigation infrastructure by the Commonwealth	3.91	3.79	0.21[a]
Attitude: More money should be spent on water buybacks by the Commonwealth	2.07	1.78	0.00[a]
Attitude: The Murray-Darling Basin Authority is serious about helping our community to solve our own environmental flow problems	2.52	2.21	0.00[a]

Attitude: I believe the Basin Plan should be suspended	3.48	3.71	0.03[a]
Attitude: Irrigation infrastructure money has been wasteful and inefficient	3.53	3.45	0.41[a]
Attitude: I would rather irrigation infrastructure money was spent instead on rural health and education services	2.81	2.62	0.04[a]

Notes: [1] Attitudinal statements are measured by Likert scales: 1=strongly disagree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree.
[a] Two sample equal mean test (t-stat) for continuous and Likert scale variables was used.
[b] Two sample equal proportion test (z-score) for binary variables was used.
[c] Pearson Chi-squared test was used for categorical variables.

6.2.2 Irrigators' engagement with water markets

ACCC QUESTION: How irrigators are engaging with water markets (i.e. what type of market behaviours they undertake including buying and selling entitlements and allocations, leasing, and use of newer water market products such as carryover parking or allocation forwards etc.)? How has this changed over time? Using cluster analysis or other suitable statistical technique, develop a **typology of water market participant types ('irrigator participant typology')** based on available survey data.

Figure 6.1 provides three years of data, across different water trade behaviours (buy and sell of water allocations and entitlements, non-trade and carryover). It shows that only a small proportion of irrigators (less than 10%) traded water entitlements within one specific season ten years ago. However, this percentage increased slightly from 2009 to 2015. Compared to entitlement trade, more irrigators traded water allocations, ranging from around 10% to 30% in different years (2009-2015). Specifically, the percentage of irrigators who sold water entitlements was higher than those whom purchased water entitlements, but there was no statistically significant difference between the purchase and sale of water allocation trade. Within the 2009-10 season, more than 70% of farmers carried over water into the next season. However, the percentage dropped down considerably from 2009-10 to 2014-15.

Figure 6.1 Trade and carryover percentage across three seasons, sMDB

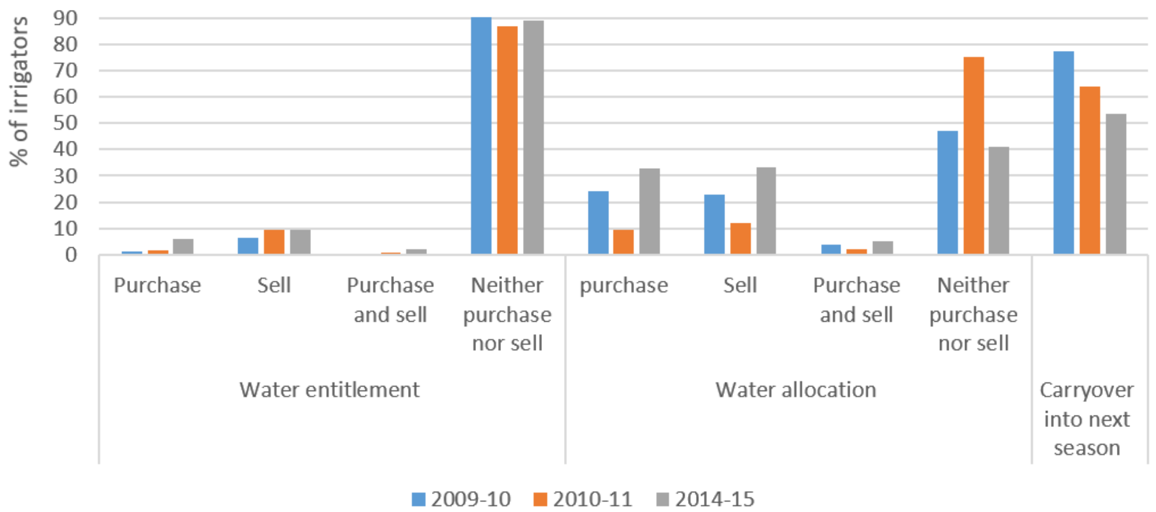
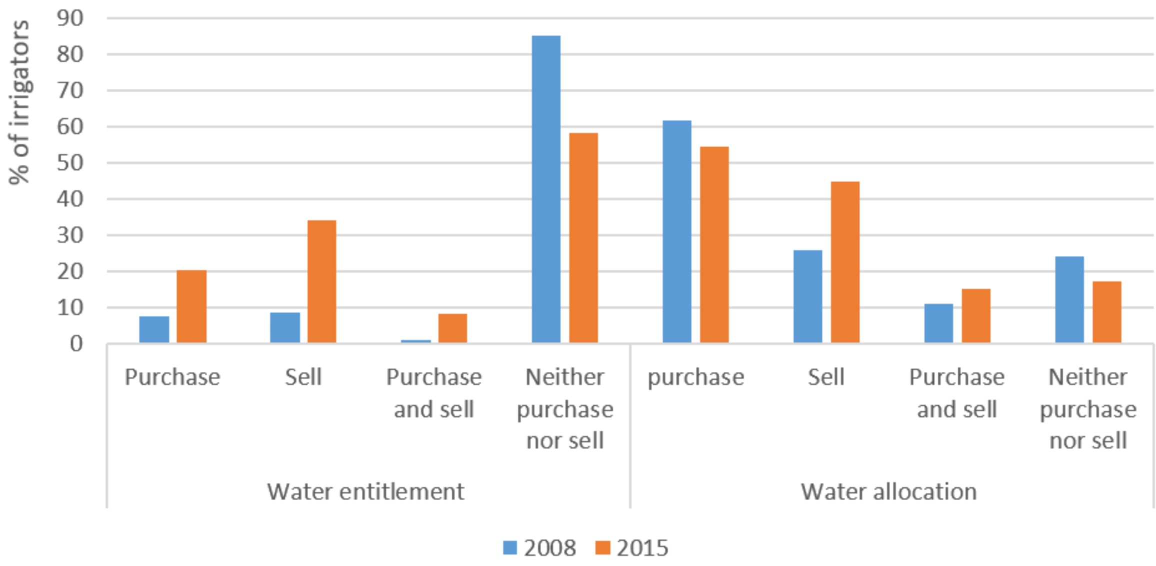


Figure 6.2 Trade in the previous five years to the current season, 2008 (SA, VIC) and sMDB 2015-16



Note: The previous five years is the five years before each survey date year.
The exact question was 'We are interested in the changes you have made to your farm operation during the last five years. Have you done any of the following: purchased water entitlements (permanent water rights); sold water entitlements; purchased water allocations (temporary/seasonal water); sold water allocations? For each of them, there were Yes and No choices given.

Figure 6.2 provides another way of looking at trade behaviour, namely the trade behaviour of irrigators in the previous five years before the survey date. Similar to Figure 6.1, in the previous five years before the survey in 2008 and 2015-16, the percentage of irrigators' trading water allocations was much higher than the percentage of irrigators' trading water entitlements. Within water entitlement trade, the percentage of water entitlement sellers was higher than the percentage of water entitlement purchasers. It can be seen the percentage of both buyers and sellers of water entitlement trade rose noticeably from 2008 to 2015-16. Conversely, the percentage of water allocation buyers was higher than the percentage of water allocation sellers. The percentage of buyers decreased over time but water allocation sellers increased from 2008 to 2015-16 (see Figure 6.2). This is reflective of the fact that more irrigators had to enter the market to buy temporary water in the Millennium Drought period than the five years before 2015.

Identifying clusters of trade and other farm management behaviours

Since water trade actions are rarely undertaken independently, and are often taken in conjunction with other farm management behaviours, it is appropriate to analyse as many farm management strategies as possible in order to identify the clusters of strategies, from which irrigators can be grouped together according to their dominant strategies. Principal component factor analysis fitted with irrigators' water and farm management strategies in the last five years retained five factors with a minimal eigenvalue of one.

The full set of farm management actions included 20 behaviours:

- purchased water entitlements; sold water entitlements; purchased water allocations; sold water allocations; increased irrigated area; decreased irrigated area; changed irrigated production such as mix of crops and varieties grown; purchased any farm land near current properties; purchased any farm land in different regions for risk purposes; sold any farm land; diversified production; changed farm ownership structures; increased farm insurance;

increased any collective bargaining or collaboration with other farmers; improved the efficiency of irrigation infrastructure; increased area of dryland production; decreased area of dryland production; thought about selling the whole farm; carried over water into 2014-15 season; and carried over water into 2015-16 season.

In the end, 14 strategies remained in the final principal component factor analysis model as the dropped strategies either did not have a loading greater than 0.4 onto any of the factor identified; or loaded onto more than one factor and could not clearly show which factor the strategy is associated with. Five factors were identified.

In total the five factors identified explain 87% of the variance of the water and farm management strategies (factor 1—24%, factor 2—21%, factor 3—11%, factor 4—13% and factor 5—18%), which is considered very high. After factor loading rotation, Table 6.10 presents the factor loadings greater than 0.40. The trade behaviour in each factor is highlighted in bold. The diagnosis indicated the appropriateness of the retained variables for factor analysis. Specifically the determinant of the correlation matrix is 0.09 (this determinant will equal 1.0 only if all correlations equal 0, which indicates inappropriateness of the variables for factor analysis); Bartlett's test for sphericity (the null hypothesis is that the inter-correlation matrix comes from a population in which the variables are non-collinear, and that the non-zero correlations in the sample matrix are due to sampling error.) was rejected and the Kaiser–Meyer–Olkin measure of sampling adequacy was 0.64 [unacceptable if below 0.5 (Kaiser 1974)].

Table 6.10 Factor analysis of irrigators' water trade and farm management behaviours in the previous five years (2015-16 survey)

Strategies (1=yes; 0=otherwise for all)	***Factor 1***	***Factor 2***	***Factor 3***	***Factor 4***	***Factor 5***
In the last 5 years, purchased water allocations	0.8				
In the last 5 years, increased your irrigated area	0.5				
In the last 5 years, changed your irrigated production (e.g. the mix of crops, varieties grown etc.)	0.4				
In the last 5 years, improved the efficiency of your irrigation infrastructure	0.8				
In the last 5 years, purchased water entitlements		0.5			
In the last 5 years, purchased any farm land near your current properties		0.7			
In the last 5 years, purchased any farm land in different zones/regions for risk purposes		0.9			
In the last 5 years, sold water entitlements			0.8		
In the last 5 years, sold water allocations			0.8		
In the last 5 years, sold any farm land			0.5		
In the last 5 years, decreased your irrigated area				0.9	
In the last 5 years, have you increased your area of dryland production				0.6	
Carryover into 2014-15					1.0
Carryover into 2015-16					1.0

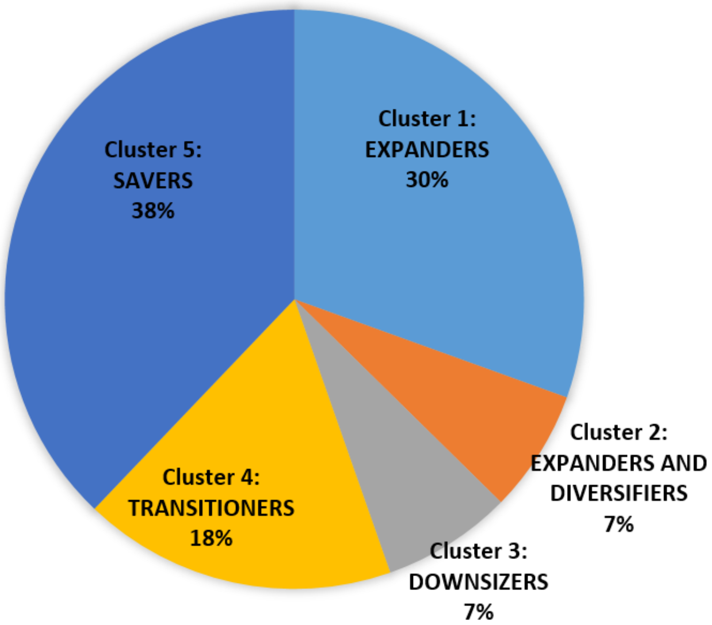
Note: Carryover was classified as 1=yes carried over water; 0=otherwise.

6.2.3 Water strategy typology and irrigator participant typology

ACCC QUESTION: Water strategy use by water market participant type: Using the **ACCC draft water strategy typology** (refer above) and the **irrigator participant typology** developed at (ii), describe the relative frequency of use different water strategies, and assess to what degree water market participant types vary across water strategy type.

Based on the five factors identified by the principal component factor analysis (explained in previous section), irrigators are grouped together according to their dominant strategies. Five factor scores were predicted (using the Thomson's regression method—a common prediction tool that can be employed from the principal component factor analysis) based on irrigators' strategies *in the next five years*. Irrigators were then assigned to the cluster with the highest factor score out of the five factors. The five clusters for the irrigator participant typology are displayed in the following figure, and named as EXPANDERS, EXPANDERS AND DIVERSIFIERS; DOWNSIZERS; TRANSITIONERS AND SAVERS, respectively according to their dominant strategies. Predicting irrigators' cluster membership using their next five year strategies avoids the problem of reverse causality in the subsequent regression analysis since it is not appropriate to use current characteristics to explain irrigators' cluster membership based on last five years' strategies. Carry-over is an exemption since we do not have information on future carry-over plans. However, irrigators are most likely to continue to carry-over if they have done so in the past.

Figure 6.3 sMDB Irrigator participant typology (based on 2015-16 survey, n=977)



Cluster 1's (the EXPANDERS) (n=298) dominant strategies (with the trade action highlighted in bold) include:

- **purchase water allocations**
- increase irrigated area
- change irrigated production
- improve the efficiency of irrigation infrastructure

Cluster 2's (the EXPANDERS AND DIVERSIFIERS) (n=67) dominant strategies include:

- **purchase water entitlements**
- purchase farm land near your current properties
- purchase farm land in different zones/regions for risk purposes

Cluster 3's (the DOWNSIZERS) (n=71) dominant strategies include:

- **sold water entitlements**
- **sold water allocations**
- sold farm land

Cluster 4's (the TRANSITIONERS) (n=171) dominant strategies include:

- decrease irrigated area
- increase area of dryland production

Cluster 5's (SAVERS) (n=370) dominant strategies include:

- Carry-over into 2014-15
- Carry-over into 2015-16

Three out of the five clusters have water trading (in bold) as dominant behaviour. Cluster 1 (30%) mainly purchased water allocations, in combination with increasing irrigated area and accommodating strategies such as changes in irrigation production and improvements in irrigation efficiency, and therefore is named as *Expanders*. Cluster 2 (7%) mainly purchase water entitlements, which is accompanied by farm-land purchases, named as *Expanders and Diversifiers*. Cluster 3 (7%) clearly identifies a group that are downsizing or exiting by selling both water allocations and entitlements, named as *Downsizers*. The other two clusters do not have water trading in their dominant actions. Cluster 4 (18%) are mainly in the process of switching from irrigation to dryland production, named as *Transitioners* while Cluster 5 (38%) are those mainly use carryover, named as *Savers*.

Table 6.11 displays the next five year's water and farm management strategies and key farm, business and location characteristics of irrigators in each of the five clusters. Overall, water and farm management strategies are consistent with the cluster membership, which is identified by the dominant strategies of each cluster.

Table 6.11 Irrigators' key characteristics (mean) by cluster (2015-16 survey, n=977)

	Cluster 1: Water allocation buyer – Expander	***Cluster 2: Water entitlement buyer – Expander and Diversifier***	***Cluster 3: Water seller - Downsizer***	***Cluster 4: Irrigators switching from irrigation to dryland - Transitioner***	***Cluster 5: Irrigator carrying over water - Saver***
In the next five years, % of irrigators planning to (the dominant strategies in bold for each cluster):					
Purchase water allocations (%)	**86**	64	17	63	51
Increase irrigated area (%)	**52**	64	9	4	20
Change irrigated production (%)	**58**	61	33	59	45
Improve irrig. infrastructure efficiency (%)	**87**	67	42	52	69
Purchase water entitlements (%)	52	**67**	9	8	22
Purchase farmland near current properties (%)	44	**90**	3	21	20
Purchase farmland in different zones/regions for risk purposes (%)	4	**79**	5	20	7
Sell water entitlements (%)	12	4	**48**	21	3
Sell water allocations (%)	11	45	**88**	20	40
Sell farmland (%)	11	6	**54**	34	19
Decrease irrigated area (%)	13	1	2	**96**	10
Increase area of dryland production (%)	18	40	5	**44**	22
Carryover water into 2014-15 (%)	49	49	33	56	**100**
Carryover water into 2015-16 (%)	30	34	17	35	**100**
Other irrigator individual and farm characteristics					
Net farm income ($)	97545.45	117418.03	83582.09	62946.43	84232.95
Total are of dryland (ha)	569.14	1451.18	656.59	508.09	680.75
Total area of irrigated land (ha)	271.40	563.82	263.14	118.33	229.36
Total area of the farm (ha)	840.54	2015.00	919.74	626.42	910.10
Total vol. of low/general security entitlements (ML)	641.38	1307.39	636.56	296.33	635.67
Total vol of high security entitlement (ML)	331.40	281.57	204.30	202.55	238.63
Total irrigation water use in 2014/15 (ML)	1156.66	1608.54	800.55	324.40	877.83
Amount of time normally spent planning water use before start of season (Hour)	28.19	56.04	45.18	20.24	16.16
Number of full-time employees	3.23	3.75	2.14	1.85	2.34
Have a whole of farm plan (%)	80	75	76	64	76
Horticulture (%)	38	34	25	56	14
Broadacre (%)	24	42	27	16	32
Dairy (%)	25	9	21	8	21
Livestock (%)	13	15	27	20	32
Age	55.94	55.06	57.76	60.74	60.56
Years of farming	33.88	34.79	38.42	36.95	40.00
Number of children	2.90	2.73	2.99	2.56	2.83
Percentage of off-farm income (%)	19.48	19.67	32.01	33.13	23.66
Planning for climate change (%)	34	46	39	29	34
Have a succession plan (%)	50	60	31	22	38
Have crop insurance 0=No 1=Yes	34	44	28	23	38
[1]Attitude: Farming is the only occupation I can imagine doing	3.81	4.01	3.48	3.54	3.75

Attitude: Financial gain is the only reason for my involvement in farming	2.55	2.54	2.46	2.47	2.45
Attitude: I am generally a risk taker when it comes to operating my farm business	3.08	3.55	3.20	2.91	3.02
Attitude: I believe water trading has been a good thing for farming	2.47	2.58	2.15	2.89	2.39
Attitude: I could never imagine living anywhere other than this area	3.32	3.40	3.45	3.33	3.31
Attitude: Knowing about new technology that becomes available is important to me	4.33	4.60	4.21	4.01	4.07
Attitude: We would be willing to have our seasonal allocations reduced to ensure sufficient water for the environment	1.53	1.69	1.46	1.75	1.53
Attitude: Most irrigators think increasing environmental water flows is a good thing	2.07	2.27	1.69	2.26	1.76
Attitude: Generally I feel optimistic about my future in this region	3.37	3.85	2.72	3.08	3.29
Attitude: It is essential to make allocations to the environment otherwise irrigation will not be long-term sustainable	2.66	2.91	2.32	2.80	2.36
Attitude: I want to continue farming for as long as I am able	4.29	4.40	4.06	3.93	4.27
Attitude: I like to make my own decisions and not be too influenced by others	4.28	4.52	4.32	4.49	4.30
Attitude: The Commonwealth Environmental Water Holder belongs in the agriculture not the environment department	4.07	4.19	4.25	4.00	4.15
Attitude: The water portfolio belongs in the agriculture, not environment department	4.29	4.34	4.49	4.23	4.41
Attitude: Corporate non-farm entities should be allowed to invest in water	1.64	1.72	1.46	1.71	1.55
Attitude: Retired irrigators no longer farming should be allowed to retain and trade water	2.78	2.76	2.72	3.02	2.70
Attitude: Water buybacks for the Basin Plan should be suspended	3.92	3.96	3.93	3.63	4.11
Attitude: More money should be spent on on-farm irrigation infrastructure by the Commonwealth	3.97	3.85	3.59	3.60	3.81
Attitude: More money should be spent on water buybacks by the Commonwealth	1.98	2.13	1.86	2.27	1.85
Attitude: The Murray-Darling Basin Authority is serious about helping our community to solve our own environmental flow problems	2.53	2.36	1.94	2.80	2.26
Attitude: I believe the Basin Plan should be suspended	3.49	3.45	3.83	3.10	3.66
Attitude: Irrigation infrastructure money has been wasteful and inefficient	3.40	3.45	3.79	3.49	3.40
Attitude: I would rather irrigation infrastructure money was spent instead on rural health and education services	2.61	2.66	3.11	2.80	2.58

Note: [1] Attitudinal statements are measured by Likert scales: 1=strongly disagree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree.

There are mainly three differences between the **Water trade typology** proposed by the ACCC and the irrigator participant typology derived above. First, the water trade typology is for a wide range of stakeholders including irrigators, environmental water holders, and a number of non-user groups while our irrigator participant typology focuses on only irrigators who still account for the major share of participants in water markets. Second, regarding irrigators, the water strategy typology has a hierarchy format that first divide irrigators into no water portfolio, limited water portfolio and diverse water portfolio, then the latter two groups are further divided by trading frequencies and lease activities. It is not clear what reference period (i.e. one year, five years, or historically) applies to qualify frequent trading in the ACCC water trade typology. Our irrigator participant typology is derived from analysing water trading and carryover in combination with farm management strategies simultaneously in the previous five year period, which identifies the dominate strategy groups undertaken by irrigators. Third, the water trade typology is a conceptual construct in that at present some groups within the typology account for small proportions of the population, such as innovative irrigators and diverse portfolio irrigators plus leases. Therefore, it is difficult to collect quantitative empirical data to verify the concept although qualitative interview information collected by the research team does suggest their presence in the water markets (see Figure 2.11).

6.2.4 Drivers of water market strategies

ACCC QUESTION: Explanatory factors / drivers of water market strategy use: using statistical methods, classify survey respondents according to water market strategy type, and examine the explanatory factors or drivers that explain (i.e. are statistically significant) for water strategy type.

Drivers of irrigators' buying/selling water allocations and entitlements

In the 2003-06 GMID surveys, respondents were asked about the reasons for buying/selling water allocations/entitlements. The results are displayed in Table 6.12.

Water allocations provide the seasonal water rights while water entitlements offer a perpetual right. Therefore they can be considered as substitutes to a certain degree and the questions were designed in a way that asked respondents the reasons for selling/purchasing one water product rather than the other. An average score of 3 for the reasons indicates neither important nor unimportant, and therefore any reason with an average score above 3 suggests it is considered important. Important reasons for buying water allocations rather than entitlements were: 1) respondents could not afford permanent water although they needed water every year; 2) it was cheap and quick to buy water allocations through the exchange—(the previous Watermove); respondents were uncertain about water entitlement certainty and worried it being eroded by government policy; and 3) water was not needed on an annual basis and only depended on the profitability of growing certain crops. On the other hand, important reasons for buying water entitlements rather than allocations were (note from a much smaller sample size): 1) respondents regarded it as good investment; 2) respondents would like a degree of water security for their irrigated farming which only water entitlements can provide; and 3) more water entitlements were needed since seasonal allocations were declining.

Important reasons for selling water allocations rather than entitlements were: 1) respondents would like to keep land and water entitlements together for more options in the future and asset value preservation; and 2) respondents only sold water when it was more profitable than using it for growing crops. On the other hand, only one reason for selling water entitlements rather than allocations was considered as important (note from a much smaller sample size), namely that respondents needed to use the proceeds to reduce debt.

Overall, water security, water scarcity, profitability, water right certainty, long-term value preservation, debt retirement were the main drivers of water buying and selling during 2003-06. It is also worth mentioning that 'speculation' was not rated as an important driver of water trade.

Table 6.12 Reasons for buying/selling water allocations/entitlements (based on 2003-06 survey in GMID) (n=1068 altogether)

Reasons for buying water allocations (temporary water)[1]	***Mean of Likert scale (1=very unimportant; 2=unimportant; 3=neither unimportant nor important; 4=important; 5=very important)***
We need the water permanently, but keep buying temporary water because we cannot afford to buy permanent entitlement (n=435)	3.47
With Watermove it is so easy, quick and cheap to buy temporary water relative to permanent water (n=428)	3.39
With water entitlements still being eroded by government policy why would you buy it (n=425)	3.34
We don't need the water every year we only buy water when it is profitable to grow more of a certain crop (n=417)	3.31
We don't need the water every year, I only buy water when seasonal allocations are very low and we would be suffering from long term losses if we do not irrigate (n=431)	3.00
We are in the process of developing our farm to its full potential, while doing this we use the temporary market (n=423)	2.78
We need the water permanently but keep buying temporary water because it is tax deductible (n=433)	2.21
Speculate in the buying and selling of water (n=429)	1.73
Reasons for selling water allocations (temporary water)[2]	
I want to keep my land and entitlements together to keep my future options open (n=353)	4.43
I want to keep my land and entitlements together to protect the value of my assets (n=355)	4.37
I only sell the water when it is profitable to sell the water rather than using it (n=343)	3.27
We are in the process of developing our farm to its full potential, while doing this we have excess water which we sell on the temporary market (n=331)	2.61
We have stopped irrigation but want to stay on our property, we therefore sell our water every season to gain an income (n=336)	2.45
Reasons for buying water entitlements (permanent water)[3]	
We think permanent entitlements is a good investment (n=80)	4.33
We don't want our investments in irrigated farming to be dependent on temporary water allocations (n=80)	3.94
Seasonal allocations have been declining and therefore we need more permanent entitlements (n=79)	3.75
We have traditionally used the temporary market but it has increasingly become uncertain and expensive to buy water on the temporary market. So we now buy more permanent entitlement (n=73)	2.88
We buy water entitlements to speculate in the water market (n=76)	1.74
Reasons for selling water entitlements (permanent water)[4]	
We needed the money to reduce our debt so we had to sell water permanently (n=40)	3.53
We sold our water entitlement because we are better off with the money, we then buy temporary water when it is profitable to grow more of our crop (n=36)	2.89
We did not need the water (n=38)	2.82
We needed the money so we sold water permanently and will in the future buy temporary water when it is profitable to grow more of our crop (n=36)	2.78
We needed the money to improve our farm so we sold water permanently (n=33)	2.48

We sold our water to reduce our council rates and water charges, we will then buy temporary water when it is profitable to grow more of our crop (n=36)	2.44
We wanted to stop irrigation all together (n=34)	2.09
We wanted to retire (n=37)	2.05
We wanted to reduce our irrigated area (n-34)	1.91
To speculate in the buying and selling of water (n=33)	1.48

Notes: [1] The exact question was: 'Please tick the box which best describe how important each of these reasons were when you decided to buy temporary water rather than permanent entitlement.'
[2] 'Please tick the box which best indicate how important each of these reasons were when you decided to sell temporary water rather than permanent entitlement.'
[3] 'Please tick the box which best indicate how important each of these reasons were when you decided to buy permanent entitlements rather than temporary water.'
[4] 'Please tick the box which best indicate how important each of these reasons were when you decided to sell permanent entitlements rather than temporary water.'

Drivers of irrigator participant water trading and farm management typology

Multinomial regression was used to identify the characteristics that are significantly associated with irrigators' cluster membership from the 2015-16 sMDB survey of 1000 irrigators. The regression methodology was described in section 6.1.4. Pre-testing of more independent variables was undertaken and a few variables (such as education level, re-use irrigation system, laser grading, state location, etc.) were dropped due to insignificance in the regressions. Independent variables in the final regression did not have serious collinearity and robust standard errors were used to mitigate heteroscedasticity. Overall the regression model achieved a reasonable prediction power, with the adjusted R^2 being 0.21.

Table 6.13 presents the marginal effects. For a continuous variable, the marginal effect is interpreted as the change in probability when the independent variable changes by one unit, or by one percent for natural logged variables. For example, the probability of an irrigator being in Cluster 1 - **expanders** increases by 1.26 percentage points when full time employment increases by one employee. For a dummy variable, the marginal effect is interpreted as the change in probability when the dummy variable changes from 0 to 1. For example, being in the broadacre industry increases the probability of Cluster 2 – **expanders and diversifiers** membership by 8.08 percentage points, relative to the horticulture industry. Note that since the probability of being in each of the clusters sum up to one, the marginal effects sum up to zero, implying that any increase in the probability of being in one cluster must be accompanied by a decrease in the probability of being in the remaining one or more clusters.

To summarise Table 6.13 and to consider both statistical and practical significance, Cluster 1 (**expanders**) membership was statistically significantly associated with:

- water ownership size (-), age (-), number of FTE employees (+), having a whole farm plan (+), debt equity ratio (+), past five year average water allocation percentage of both high and general/low security entitlements (-), having a farm successor (+), water stress (+), and finance stress (-).

Cluster 2 (**Expanders and diversifiers**) membership was statistically significantly associated with:

- past five year average water allocation percentage of high security entitlements (-), broadacre industry (+), sprinkler irrigation technology (+), attitude toward technology importance (+).

Cluster 3 (**Downsizers**) membership was statistically significantly associated with:

- irrigated area (+), previous five year average water allocation percentage of high security entitlements (-), having a successor (-), off-farm work % (+), and long-term annual temperature (+).

Cluster 4 (**Transitioners**) membership was statistically significantly associated with:

- irrigated area (-), age (+), having a farm successor (-), finance stress (+), water stress (-), attitude toward technology importance (-), spray or drip irrigation technology (+), and being in drought (-).

Cluster 5 (**Savers**) membership was statistically significantly associated with:

- debt to equity ratio (-), age (+), previous five year average water allocation percentage of high, general and low security entitlements (+), area in spray and drip (-), and long-term annual temperature (-).

Overall, the multinomial regression results highlight the importance of water scarcity in driving irrigator water and farm management strategies. Variables such as end of season allocations, drought, temperature, water entitlement ownership all drove irrigator water trading and farm management behaviour. Size of the farm measured by irrigated area and number of FTE employees are important in determining irrigators' cluster membership. Farmer related characteristics such as succession and attitudes are also statistically significantly associated with the strategies undertaken.

Table 6.13 Multinomial regression results for irrigator water trading and farm management typology (marginal effects) in 2015-16 survey

	Cluster 1: Water allocation buyer - Expander	*Cluster 2: Water entitlement buyer – Expander and Diversifier*	*Cluster 3: Water seller - Downsizer*	*Cluster 4: Irrigators switching from irrigation to dryland - Transitioner*	*Cluster 5: Irrigator carrying over water - Saver*
Total area of irrigated land (ha) (ln)	0.0205	0.0142	0.0142*	-0.0316***	-0.0173
Total water ownership, LTAAY (ln,	-0.0243***	-0.0040	-0.0001	0.0155	0.0129
Number of full-time employees	0.0126**	0.0036**	-0.0085	-0.0112*	0.0035
Have a whole farm plan 0=No 1=Yes	0.0730*	-0.0194	-0.0048	-0.0050	-0.0437
Debt to equity ratio	0.0942***	0.0040	-0.0064	0.0124	-0.1042**
Net farm income (ln, AUD)	-0.0026	-0.0027	-0.0009	0.0032	0.0030
Average end season allocation percentage in the previous five years for high security entitlements	-0.024***	-0.016***	-0.015**	-0.005	0.059***
Average end season allocation % in the past five years for general and low security entitlements	-0.002***	0.001	0.0001	0.001	0.001*
% of irrigation area with sprinkler	-0.0003	0.0010***	-0.0006	0.0004	-0.0006
% of irrigation area with spray or drip	0.0003	0.0007*	-0.0005	0.0008**	-0.0013*
Industry: Horticulture (reference)					
Industry: Broadacre	-0.0481	0.0808**	-0.0217	-0.0587	0.0477
Industry: Dairy	-0.0052	0.0335	0.0042	-0.0657	0.0332
Industry: Livestock	-0.0791	0.0371	-0.0034	-0.0341	0.0795
Age	-0.0051***	-0.0012	-0.0010	0.0035***	0.0038***
Number of children	0.0159	-0.0047	0.0058	-0.0155	-0.0015
% of income from off farm work	-0.0007	0.0000	0.0007**	0.0006	-0.0006
Have a successor (1=yes; 0=otherwise)	0.1049***	0.0264	-0.0338*	-0.0719***	-0.0257
[1]Agreement level on water stress to affect day to day farming life	0.0446**	-0.0064	0.0056	-0.0240*	-0.0198
[1]Agreement level on finance stress to affect day to day farming life	-0.0585***	-0.0089	0.0233*	0.0464**	-0.0023
[1]Attitude: farming is only occupation I want to do	0.0191	0.0155*	-0.0172*	-0.0120	-0.0054
[1]Attitude: new technology is very impt	0.0306*	0.0280**	-0.0068	-0.0271**	-0.0246
[1]Attitude: risk-taker for farming	-0.0197*	0.0146**	0.0079	0.0000	-0.0028
[1]Attitude: farming all about financial	0.0024	0.0007	0.0045	0.0034	-0.0110
[2]Drought (1=yes; 0=no)	-0.0100	0.0382	0.0439	-0.0721*	0.0000
[3]Long-term annual temperature (30 years)	0.0133	0.0094	0.0221**	-0.0065	-0.0383**
[3]Long-term annual rainfall (30 years)	0.0000	0.0000	0.0003	0.0000	-0.0003
Observations	881				
Wald chi^2-stat	376.98***				
Adjusted count R^2	0.21				

Note: *, **, *** indicate statistical significance at the 0.1, 0.05, and 0.01 level respectively.

[1] Attitudinal statements are measured by a Likert scale: 1=strongly disagree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree.

[2] Drought is the 10th percentile rainfall deficiency for the statistical local area (SLA) of the farm, based on 12 month rainfall deficiency grids prior to Oct 2015, through a special request from the Bureau of Meteorology (BOM).

[3] Temperature and rainfall data are over 30 year period (1986–2015), through a special request from BOM.

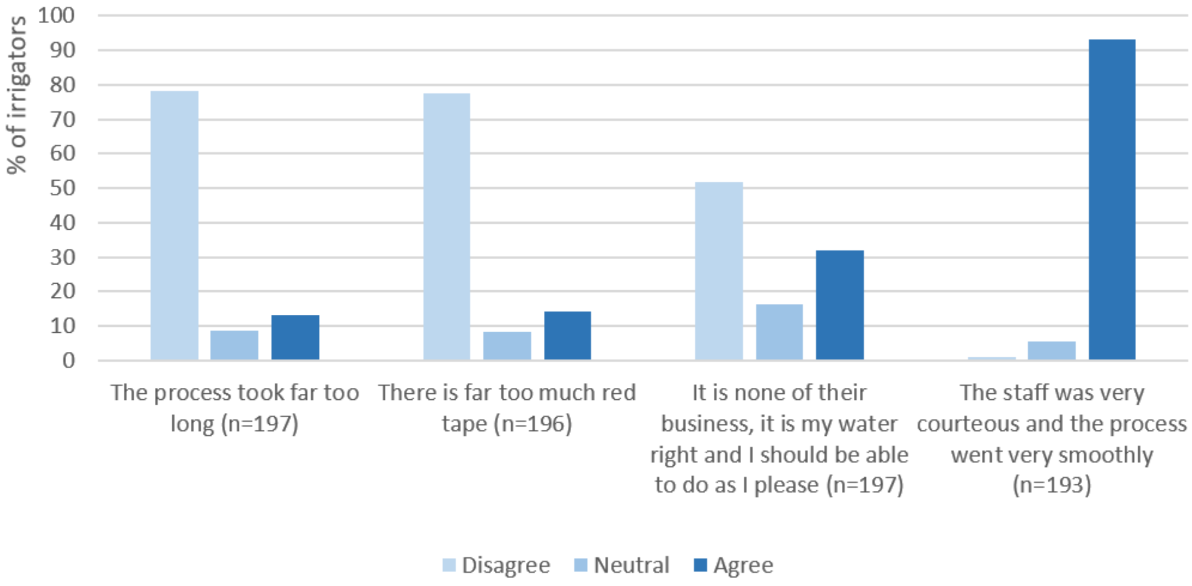
6.2.5 Water market intermediaries

ACCC QUESTION: How do irrigator participants make use of water market intermediaries such as brokers, and trading platforms? If possible, provide an analysis of the specific water brokers and exchanges used by irrigators to conduct trade.

Early findings about water market intermediaries

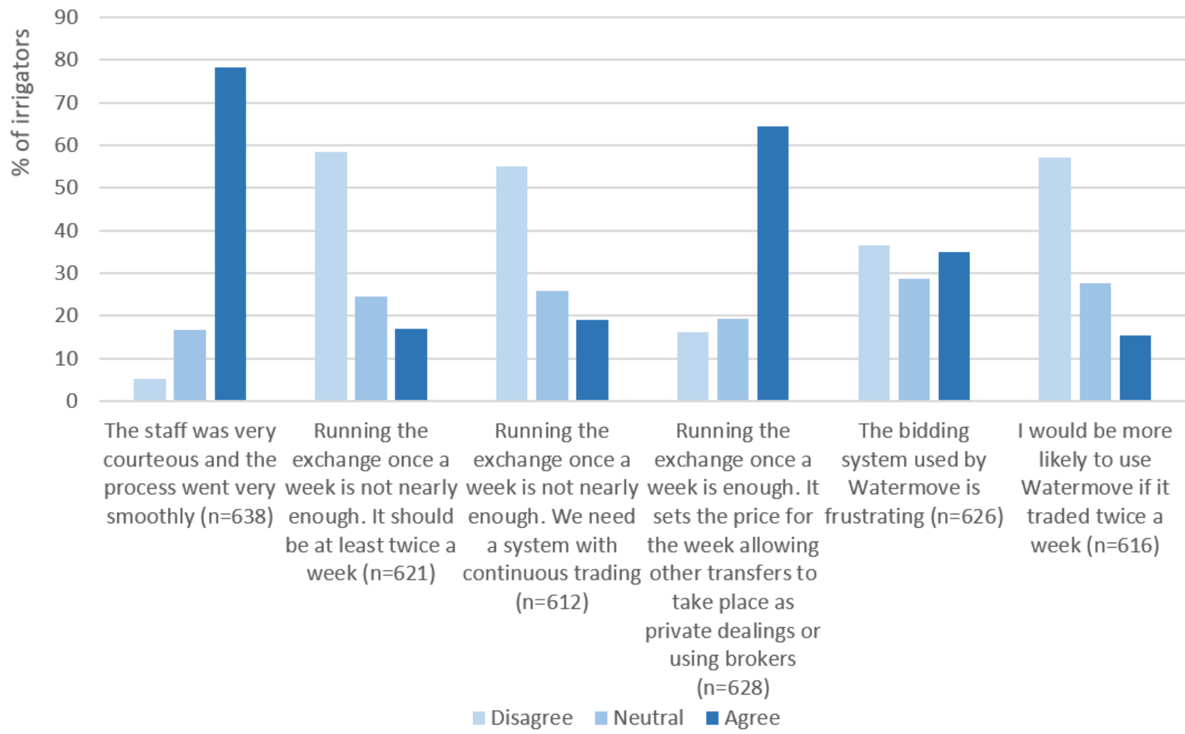
Watermove, operated by Goulburn–Murray Water in northern Victoria until 2012 was used by many irrigators in the 1998 and 2003-06 surveys. Figure 6.4 and Figure 6.5 show farmers' intermediary experience in 1998-99 and 2003-06 respectively. Most of them provided very positive feedback in both surveys. Higher than 90% in 1999 and around 80% of farmers in 2003-06 agreed that the staff was very courteous, and the process went very smoothly. Only a small portion of people (lower than 20%) agreed that an exchange once a week was not enough, or that an increase of exchange frequency was necessary.

Figure 6.4 Intermediary experience in 1998-99 in GMID



Note: The exact question was 'We would like to know how you feel about the transfer process and the way you were dealt with by Goulburn-Murray Water. Please indicate to which extent you agree or disagree with the following statements using a 1 to 5 scale with 1=strongly disagree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree. For clearer illustration, Likert scale answers from 1 to 5 were converted to Disagree (1 and 2), Neutral (3) and Agree (4 and 5).

Figure 6.5 Intermediary experience in 2003-06 (2003-06 GMID Survey)



Note: The exact question was 'Please tick the box which best reflect how much you agree with the following statements about WaterMove.'
For clearer illustration, Likert scale answers from 1 to 5 were converted to Disagree (1 and 2), Neutral (3) and Agree (4 and 5).

Later findings about water market intermediaries

In 2014-15, 404 (40%) of surveyed irrigators in the sMDB did not trade temporary water while 595 (60%) did (Table 6.12). Among the 595 temporary water traders, 68 (11%) indicated that they used more than one broker or exchange for trading. Table 6.14 displays the first mentioned brokers or exchanges they used in 2014-15.

Table 6.14 Brokers or exchanges used in 2014-15 (sMDB 2015 survey n=1000)

	Obs.	%
Irrigation district internal exchange (e.g. CIT exchange, Murray Irrigation exchange, etc.)	193	32
Waterfind	88	15
RuralCo.	47	8
Waterpool	41	7
Private trade without any brokers	38	6
Wilks Water	18	3
Elders	15	3
Other brokers (e.g. Rob Crow, Ray White, Rod Wells, Breed and Hutchinson, Integra, etc.)	122	21
Not named	33	6
Total responses	*595*	*100*

6.2.6 Innovative water market products

ACCC QUESTION: To what extent are irrigator participants making use of innovative water market products such as multi-year leases, carryover parking and forward contracts? To what extent do irrigators purchase services from investors? How has this changed over time?

Forward and option water market products are an important risk management tool for irrigators and other stakeholders in the MDB. However, Seidl et al. (2020b) find that irrigators' use of leases, forwards, options and parking contracts is limited. This section uses further insights from: 1) the 63 interviews analysed (see the beginning of Chapter Six for more detail on the method and the interviews undertaken), however it must be noted that this is based on a very small sample size only and care must be cautioned in any use of these results in this section; and 2) data from a private water market broker.[9] Water market innovative product data was provided from 2016-17 to the 12th June 2019, and this data provided information on both buyer and seller categories, and a definition of the stakeholder group (namely defined as farmer/corporate agriculture/investor/IIO). It is important to note that data is limited and hence care must be cautioned in relying on only these results for any overall water market trends. Preferably ACCC should collect data directly from all brokers to provide an overall view on trends in innovative trade products.

Leases

While leases are the most commonly used of these products, from our qualitative interviews, a substantial number of irrigators and agri-corporates are not using any leases, around 40% of the agri-corporates surveyed in Seidl et al. (2020b). Based on analysis of lease use by water portfolio size, there seems to be a difference in lease usage corresponding to water ownership size: smaller operators are much less likely to use leases than larger operators. There is also evidence that relatively smaller corporate stakeholders (as compared to much larger corporate stakeholders) seem to be more likely to: 1) lease from friends and relatives; 2) lease from their own self-managed super accounts; and 3) lease from other irrigators, often with land.

> *"We still own our own water and own our own land. It all gets leased into a parent company which we are all directors of." (Family Irrigator 500-1,000 ML)*
>
> *"Me personally, I've leased my vineyard out now so that someone else is managing and buy our water from us". (Private Irrigator <500 ML)*
>
> *"This year we leased from mum and dad water at $150/ML….We have other investments in water individually, that we then lease back to the business." (Private Irrigator 500-1,000 ML)*

Larger and more corporatised stakeholders seem to prefer longer-term leases sourced from big commercial operators, either as part of leasing land, or as a stand-alone water lease from often non-landholder investors:

> *"The development that I am a partner in, we did a 5-year lease deal and we wanted to do a renewal, this is with (Financial Investor Company name), for 1GL and we wanted a right of renewal and the price we agreed on was $190/ML." (Corporate Irrigator, 1,000-10,000 ML)*

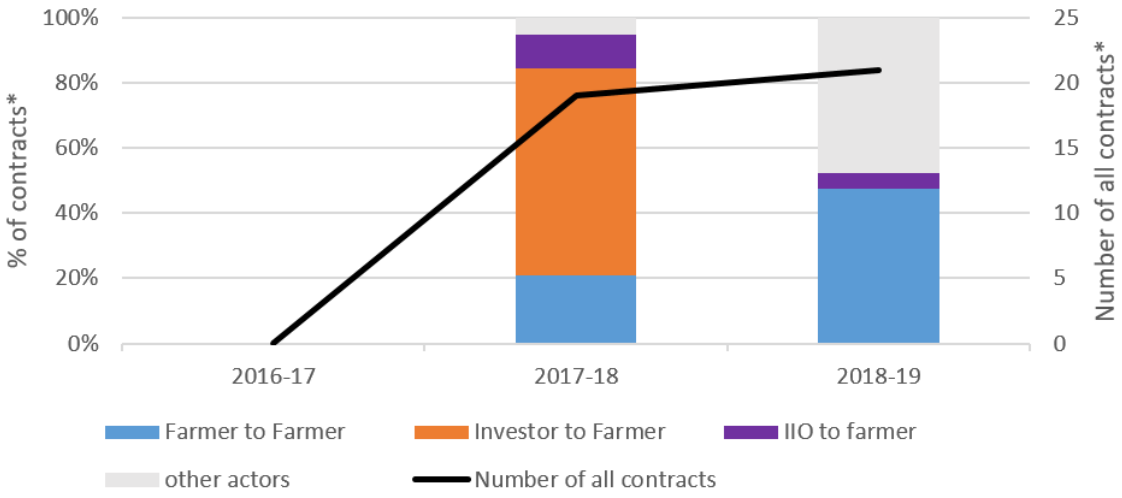
Parking

Parking is an important risk management product, but is adopted by differing rates by irrigators across different states, with 90% and 55% of all parking contracts in the data set sold and bought by

[9] Note that the broker providing deidentified data to us operates mainly in NSW and VIC. While SA-based brokers may well report more parking trades by SA irrigators, trends in our data match anecdotal and qualitative evidence suggesting that SA irrigators are less active in parking markets than irrigators from other states. The broker had a market share of 11% of all non-zero-price MDB allocation trade volume in 2018/19.

Victorian allocation water accounts respectively.[10] Figure 6.6 displays parking trade by counterparty type, based on private water broker data. The most important trading zones for parking are 1A Goulburn (45% of parking contracts sold), Zone 6 (12.5% of parking contracts sold) and 7 (32.5% of parking contracts sold) and Zone 13 (10% of parking contracts sold); with around 76% of parking trades captured in available private water broker data in 2018-19 occurred within the same zone (e.g. the buyer trading zone equals seller trading zone). This points to irrigators in NSW and VIC potentially being more experienced with parking. SA irrigators' limited participation in parking trading may have to do with irrigators being unfamiliar with carry-over arrangements in other states and interstate trading, or based on a limited need to access parking, given the high security of SA water entitlements and often lack of access to carryover (see Chapter One). The market for parking also seems highly variable between years, with no clear trend in regards to counter parties involved emerging from the data available.

Figure 6.6 Parking trade by seller and buyer, based on private water broker data



Note: * Based on all parking contracts traded by the private broker in the relevant year. Other actors includes all other trades including trades from corporate agriculture[11] and other combinations of trade (e.g. farmer to investor, farmer to IIO, IIO to investor). Parking contracts were offered in 2016-17 by the broker but none were transacted in that year given the infancy of the market.

Forwards

Similar to parking, forward usage by irrigators seems to differ between years and regions. In 2017/18, 42% and 8% of forward contracts in the data set were sold by Victorian and NSW allocation water accounts respectively, whereas in 2018/19 31% of forwards were sold by Victorian allocation water accounts and 69% by NSW accounts (the remaining contracts had no nominated seller trade zone). Note that in the whole data set, no forward contract was neither sold nor bought by an allocation water account nominated as South Australian. Figure 6.7 displays forward trade by counter party type, based on private water broker data.

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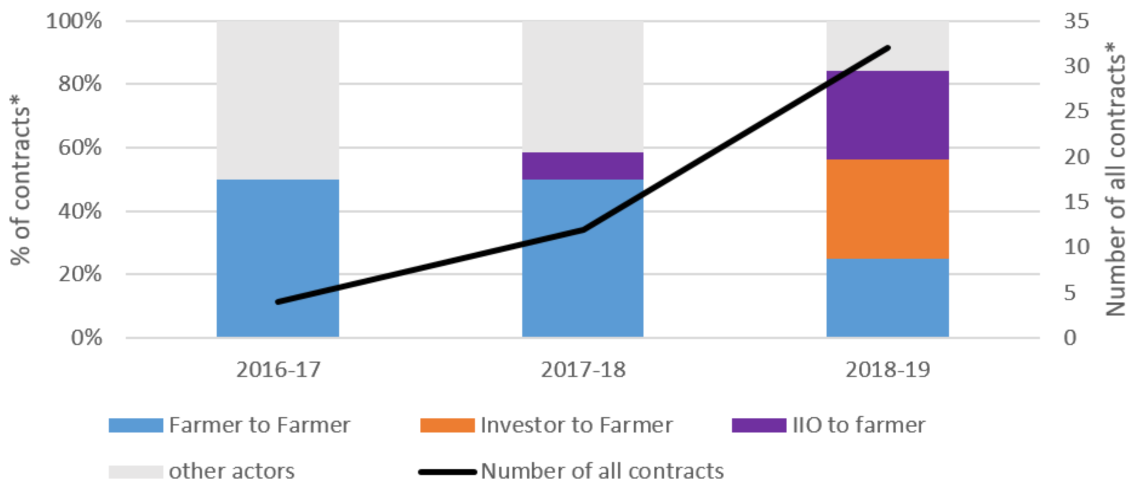
[10] Identified by the seller or buyer source as trade zone 6, 7, or 1A.

[11] Definitions of actors by the broker are the same as used in the qualitative interviews, namely: corporate agriculture are large companies with a corporate business structure, generating their main income (in a normal year) from agricultural production. Investors are non-landholding entities, generating their main income from water trading and capital appreciation of water entitlements. Farmers refers to irrigation businesses generating their main income from agricultural production, with no corporate structure, often family owned.

Figure 6.7 Forward trade by seller and buyer, based on private water broker data



Note * Based on all forward contracts traded by the private broker in the relevant year. Other actors includes all other trades including trades from corporate agriculture; and other combinations of trade (e.g. farmer to investor, farmer to IIO, IIO to investor). Analysis is based on the one transaction, not on the multiple years across which a transaction can occur.

In the private broker data available to be analysed, 100% of forward trades bought by irrigators were 1-year forwards (defined as delivery within one calendar year of contract date – hence can include multiple deliveries), indicating their very limited take-up of multi-year forwards. In 2018-19, 37% of forwards purchased by irrigators were sold by investors. In terms of trading zones and irrigators from different states participating in the forward market, a similar picture to parking emerges. Around 87% of forward trades in 2018-19 were within the same trading zone (e.g. 56% within zone 13, 25% within zone 1A, and rest within other zones), with Zone 7 (e.g. 15% of forwards sold 2016-17 to 2018-19) and Zone 13 (e.g. 44% of forwards sold 2016-17 to 2018-19) as the most important regions overall. This is likely a function of forward sellers minimising forward delivery risk (Seidl et al. 2020b). Forwards seem to be traded more by Victorian and NSW irrigators, whereas SA irrigators have limited participation in the market data analysed. This may be due to either SA using other water brokers for this, or a comparative a lack of trust or sophisticated water market understanding in SA or a lesser need for SA irrigators to use some of the newer innovative products, given their high security water entitlements. Many IIOs own/manage the water entitlements from which members receive allocations. Thus, if the IIO has unused carry-over capacity, it can sell this as parking to irrigators inside or outside the IIO. Similarly, if an IIO has a high volume of allocation carried over, it may choose to sell this volume as a forward to irrigators or investors. Given the generally risk-averse nature of IIOs, these forwards seem to be limited to one year.

While our data shows increasing forward trade volumes (note that our data set only encompasses contractual data until 12th June 2019, naturally limiting 2019-20 observations), some intermediaries argue that forward trade activity has been reduced in 2019-20 based on investors' unwillingness to offer forwards given the political uncertainty about future restrictions of water ownership to landholders, and awaiting the outcome of the ACCC water market review (Testa 2019).

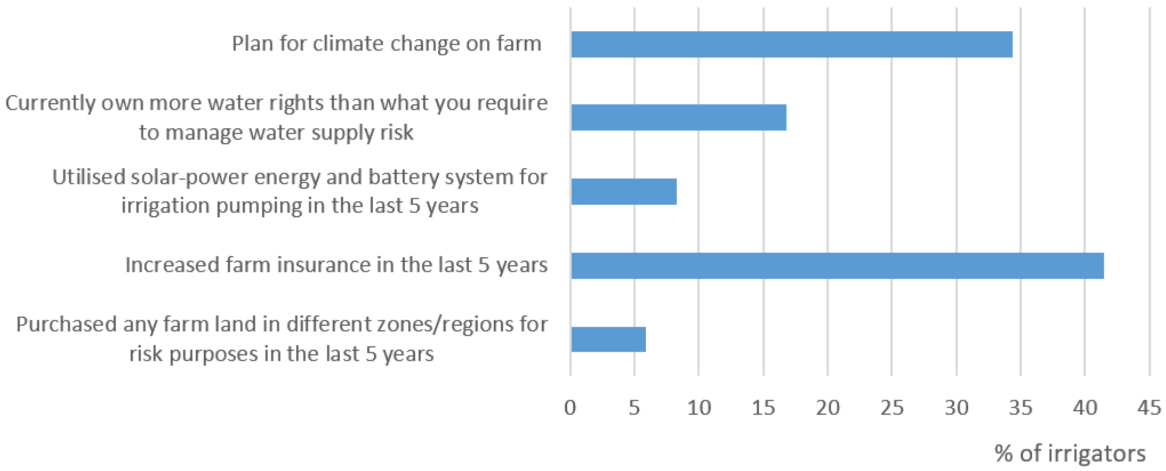
ACCC QUESTION: What risk mitigation strategies do irrigators take, and what risks do these strategies address? How do irrigators use water markets as part of risk mitigation strategies?

As covered in Chapter 1, there are multiple ways irrigators manage risk on their farm. Along with water trade behaviour, our surveys offered additional information on some of these strategies.

Figure 6.8 illustrates it was common for irrigators to state they had increased farm insurance (41 %) and make plans for climate change (34%) to mitigate their risks. Other less popular strategies included: owning more water rights (17 %); utilising solar-power energy (8%) and purchasing farmland in different zones/regions for risk purposes (6%).

With regards to measures in response to climate change, using water more efficiently (14.5%) and trying different crops/livestock (10.8%) were the most named strategies by irrigators. Other measures included increasing water supply security, reducing dryland, changing timing of practices, tree planting and soil management (see Table 6.15).

Figure 6.8 Risk mitigation strategies irrigators named in 2015-16 in the sMDB (% naming) (n=1000)



Note: The full questions were: “Are you planning for climate change on your farm?” ”Do you currently own more water rights that you require to manage any water supply risk?” “Have you utilised solar-power energy and battery system for your irrigation pumping?” “Have you increased your farm insurance in last 5 years?” “Have you purchased any farm land in different zones/regions for risk purposes”.

Table 6.15 Measures undertaken by irrigators in response to climate change in 2015-16 survey in the sMDB

Measures undertaken by irrigators	Obs.	% (n=1000)
Planning for climate change on farm (0=No 1=Yes)	340	34.00
Climate change measure 1: farming practice in general	36	3.60
Climate change measure 2 : feed management	23	2.30
Climate change measure 3: use water more efficiently	145	14.50
Climate change measure 4: try different crops/livestock	108	10.80
Climate change measure 5: increase water supply security, i.e. buy more water	38	3.80
Climate change measure 6: tree planting/canopy/shed	35	3.50
Climate change measure 7: soil management	22	2.20
Climate change measure 8: reduce dryland	28	2.80
Climate change measure 9: change timing of certain practices	31	3.10

Notes: [1] The survey question of this Table is "Are you planning for climate change on your farm? If yes, please specify". Farmers are then divided into 9 groups based on their responses.
[2]Farmers who did not plan for climate change are not included in this table.

6.2.7 Correlations between risk mitigation and water strategies

ACCC QUESTION: What correlations exist between risk mitigation strategies and water strategies?

Table 6.16 displays the percentage of risk mitigation strategies given water trade engagement. No matter what an irrigator's water trade behaviour was, increasing farm insurance in the last five years and planning for climate change on farm were two of the most popular risk mitigation strategies (both were higher than 40%).

Table 6.16 Risk mitigation strategies undertaken % when a particular water trade was undertaken in the 2015-16 survey in the sMDB

Risk mitigation strategies that irrigators took in 2014-15 (1=Yes, 0=No)	***Entitlement trade in 2014-15=1***	***Allocation trade in 2014-15=1***	***Entitlement trade in last 5 years=1***	***Allocation trade in last 5 years=1***
Purchased any farm land in different zones/regions for risk purposes in last five years	25.93	17.65	21.05	18.18
Increased farm insurance the last 5 years	49.63	41.18	46.05	43.59
Utilised solar-power energy and battery system for irrigation pumping in last 5 years	11.11	9.08	11.84	9.59
Currently own more water rights that you require to manage any water supply risk	25.93	20.17	17.32	16.94
Planning for climate change on farm	42.96	36.81	40.13	36.86
Climate change measure 1: farming practice in general	5.93	3.36	4.39	3.49
Climate change measure 2: feed management	1.48	2.52	1.54	2.37
Climate change measure 3: use water more efficiently	19.26	15.80	18.86	16.44
Climate change measure 4: try different crops/livestock, especially drought tolerant ones	13.33	12.44	12.50	12.83
Climate change measure 5: increase water supply security, i.e. buy more water	4.44	3.87	4.39	3.61
Climate change measure 6: tree planting/canopy/shed	6.67	3.19	4.82	3.99
Climate change measure 7: soil management, cover, moisture	1.48	2.69	3.07	2.37
Climate change measure 8: reduce dryland	2.22	2.86	3.29	3.11
Climate change measure 9: change timing of certain practices, such as cropping, irrigation, etc	2.22	4.03	3.73	3.49

Table 6.17 displays the percentage of water trade given the adoption of a given risk mitigation strategy. It shows that most (75-95%) irrigators who have used risk mitigation strategies also used allocation trade in the previous 5 years. More than half of them have used allocation trade in 2014-15 and entitlement trade in the previous 5 years. However, not many irrigators (9-26%) who have used risk mitigation strategies traded water entitlements in 2014-15.

Table 6.17 Water trade undertaken (%) when a given risk strategy is undertaken in the 2015-16 survey in the sMDB

Risk mitigation strategies that irrigators took in 2014-2015 (1=Yes, 0=No)	***Entitlement trade in 2014-2015***	***Allocation trade in 2014-2015***	***Entitlement trade in last 5 years***	***Allocation trade in last 5 years***
Purchased any farm land in different zones/regions for risk purposes in the last five years=1	20.23	60.69	55.49	84.39
Increased farm insurance in the last 5 years=1	16.38	59.90	51.34	85.57
Utilised solar-power energy and battery system for irrigation pumping in the last 5 years=1	15.96	57.45	57.45	81.91
Currently own more water rights that you require to manage any water supply risk=1	19.23	65.93	43.41	74.73
Planning for climate change on farm=1	17.06	64.41	53.82	87.06
Climate change measure 1: farming practice in general=1	22.22	55.56	55.56	77.78
Climate change measure 2: feed management=1	8.70	65.22	30.43	82.61
Climate change measure 3: use water more efficiently=1	17.93	64.83	59.31	91.03
Climate change measure 4: try different crops/livestock, especially drought tolerant ones=1	16.67	68.52	52.78	95.37
Climate change measure 5: increase water supply security, i.e. buy more water=1	15.79	60.53	52.63	76.32
Climate change measure 6: tree planting/canopy/shed=1	25.71	54.29	62.86	91.43
Climate change measure 7: soil management, cover, moisture =1	9.09	72.73	63.64	86.36
Climate change measure 8: reduce dryland=1	10.71	60.71	53.57	89.29
Climate change measure 9: change timing of certain practices, such as cropping, irrigation, etc=1	9.68	77.42	54.84	90.32

Table 6.18 displays correlations between risk mitigation strategies and water trading. Water trading has the highest correlation coefficients with using water more efficiently, trying different crops/livestock, especially drought tolerant ones and planning for climate change, as compared to other risk mitigation strategies (but note, correlation coefficients are still relatively low).

Specifically, planning for climate change was statistically significantly correlated with both allocation and entitlement trade, both in the previous year and in the previous five years. The positive coefficient suggests irrigators who plan for climate change on farm are also likely to trade water, although the strength of the correlation is relatively weak overall. Increasing insurance in the previous five years was statistically significantly correlated with water trade except for allocation trade in previous year. Purchasing farm-land in different zones/regions is statistically significantly correlated with entitlement trade in the previous year and in the last five years. Some specific climate change measures undertaken on the farm are also statistically significantly correlated with water trade. For example, measures to use water more efficiently was positively correlated with both water entitlements and allocation trade in the last five years. Trying different crops/livestock was positively correlated with allocation trade, both in the previous year and in the last five years. Measures to plant trees, build canopies and sheds was positively correlated with entitlement trade, both in the previous year and in the last five years.

Table 6.18 Correlation coefficients between risk mitigation strategies and water trade behaviour in the 2015-16 sMDB survey

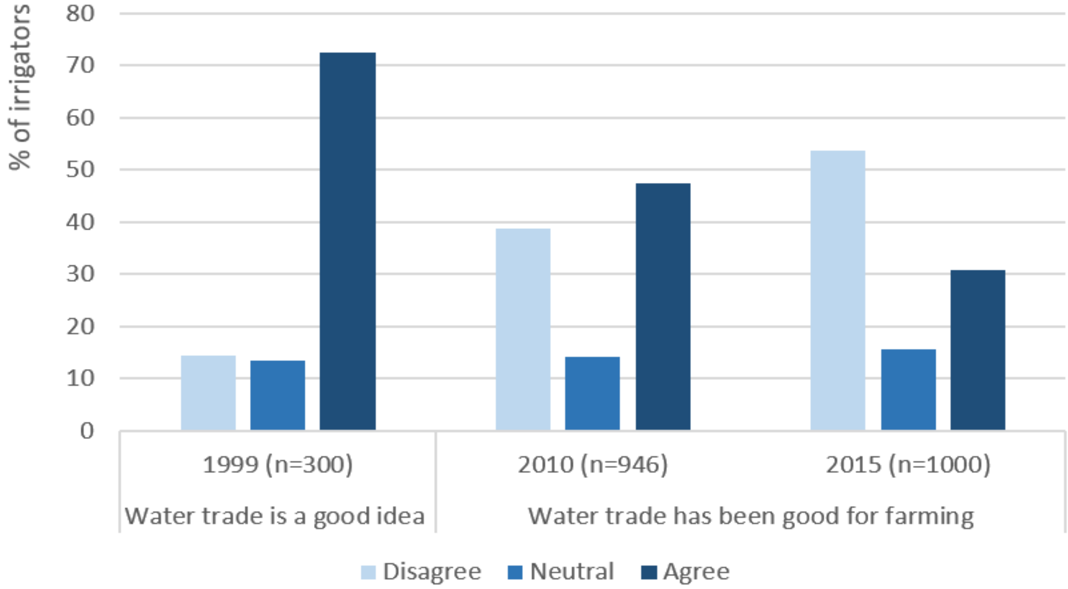
Risk mitigation strategies that irrigators took in 2014-15 (Yes=1, No=0)	***Entitlement trade in 2014-15 0=No 1=Yes***	***Allocation trade in 2014-15 0=No 1=Yes***	***Entitlement trade in last five years 0=No 1=Yes***	***Allocation trade in last five years 0=No 1=Yes***
Purchased any farm land in different zones/regions for risk purposes in the last five years	0.19***	0.02	0.17***	0.10
Increased farm insurance in the last 5 years	0.14**	0.01	0.15***	0.20***
Utilised solar-power energy and battery system for irrigation pumping in the last 5 years	0.06	-0.03	0.17**	0.03
Currently own more water rights that you require to manage any water supply risk	0.17**	0.11*	-0.04	-0.13**
Planning for climate change on farm (0=No 1=Yes)	0.15**	0.12**	0.19***	0.23***
Climate change measure 1: farming practice in general	0.16	-0.05	0.11	-0.04
Climate change measure 2: feed management	-0.11	0.06	-0.17	0.04
Climate change measure 3: use water more efficiently	0.12	0.09	0.22***	0.28***
Climate change measure 4: try different crops/livestock, especially drought tolerant ones	0.08	0.14**	0.10	0.41***
Climate change measure 5: increase water supply security, i.e. buy more water	0.05	0.01	0.08	-0.06
Climate change measure 6: tree planting/canopy/shed	0.21**	-0.06	0.20**	0.22
Climate change measure 7: soil management, cover, moisture	-0.10	0.15	0.19	0.10
Climate change measure 8: reduce dryland	-0.06	0.01	0.09	0.16
Climate change measure 9: change timing of certain practices, such as cropping, irrigation, etc	-0.09	0.22**	0.10	0.19

Note: Tetrachoric correlation coefficients which are appropriate for binary variables are presented. *, ** and *** represents statistical significance at 10%, 5% and 1% levels, respectively.

6.2.8 Attitudes towards water trading and markets

ACCC QUESTION: What attitudes do irrigators hold towards water trading and water markets (include positive, neutral and negative attitudes)? What are irrigators' stated experiences of the impacts of trading for them or their farm (include positive, neutral and negative experiences)? How have these attitudes or experiences changed over time?

Figure 6.9 Irrigators' overall attitudes towards water trading in 1998-99 (GMID), 2010-11 (sMDB) and 2015-16 (sMDB)

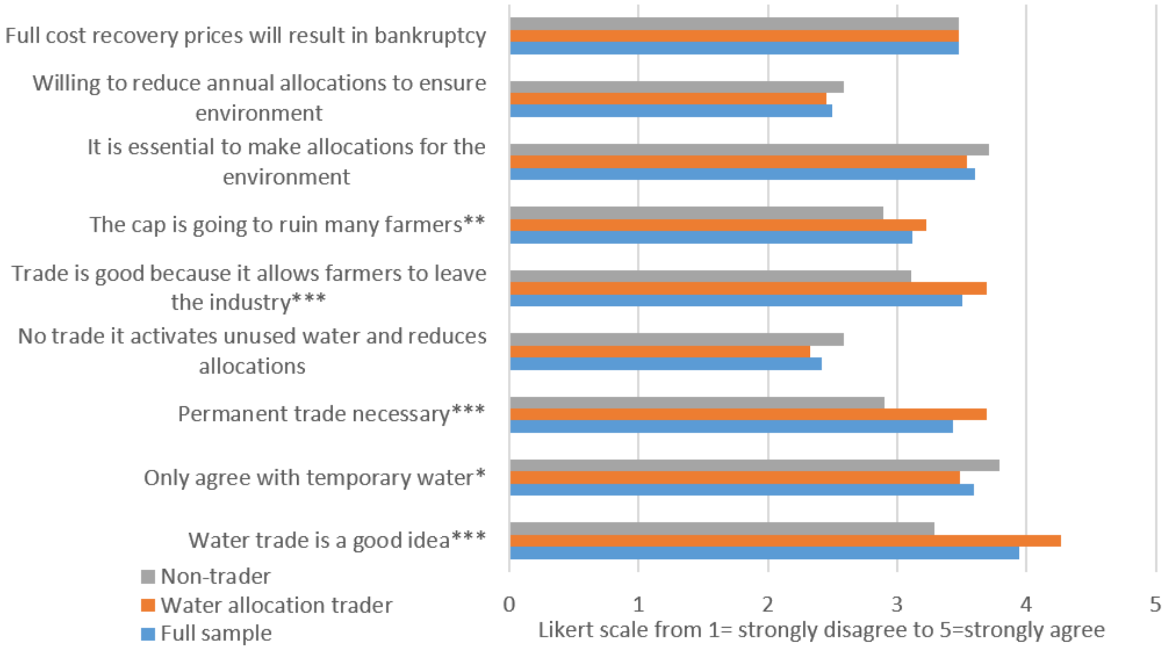


Note: The question for 1999 is 'Please indicate to which extent you agree with the statements using the scale from 1 to 5 (1=strongly disagree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree),' and the statement is 'Water trade is a very good idea'. The question for 2010 and 2015 is 'Using the scale from 1 to 5 (1=strongly disagree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree), could you respond to the following?' and the statement is "I believe water trading has been a good thing for farming". For clearer illustration, Likert scale answers were converted to Disagree (1 and 2), Neutral (3) and Agree (4 and 5).

Figure 6.9 shows that most irrigators (higher than 80%) in the GMID agreed that water trade was a good idea in 1999-99. As time went on, just less than half of irrigators in the sMDB agreed/strongly agreed that water trade has been good for farming in 2010-11 and the rate declined further in the sMDB in 2015-16 (from 46% to 28%), with between 14 to 16% remaining neutral. There was a strong increase in the strongly disagree attitude, and a slight increase in the strongly agree attitude from 2010-11 to 2015-16. Figure 6.10 elaborates on the attitudes held by GMID irrigators in 1998-99, and shows that generally irrigators had positive attitudes towards water trading and water markets, and the difference was small between water allocation traders and non-traders.

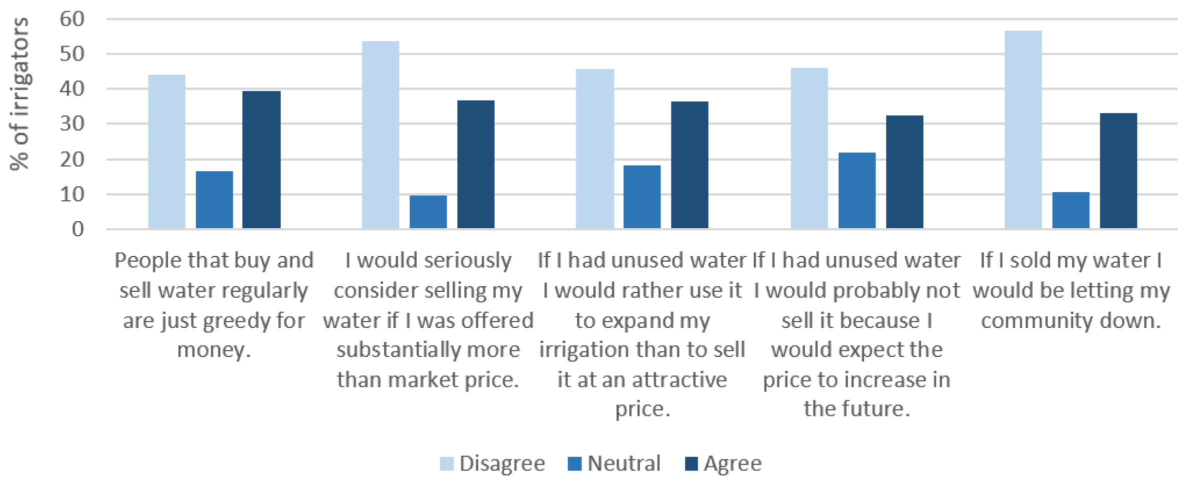
Figure 6.11 illustrates that 56% of irrigators in Victoria and SA in 2008 disagreed that if they sold water they would be letting their community down. Many irrigators (45%) chose to sell the water even though expected price in the future was going to increase, and many irrigators (45%) were willing to sell unused water rather than keep it than irrigators who were not willing to sell.

Figure 6.10 Irrigators' attitudes towards water trading and water markets, 1998-99 (GMID, n=300)



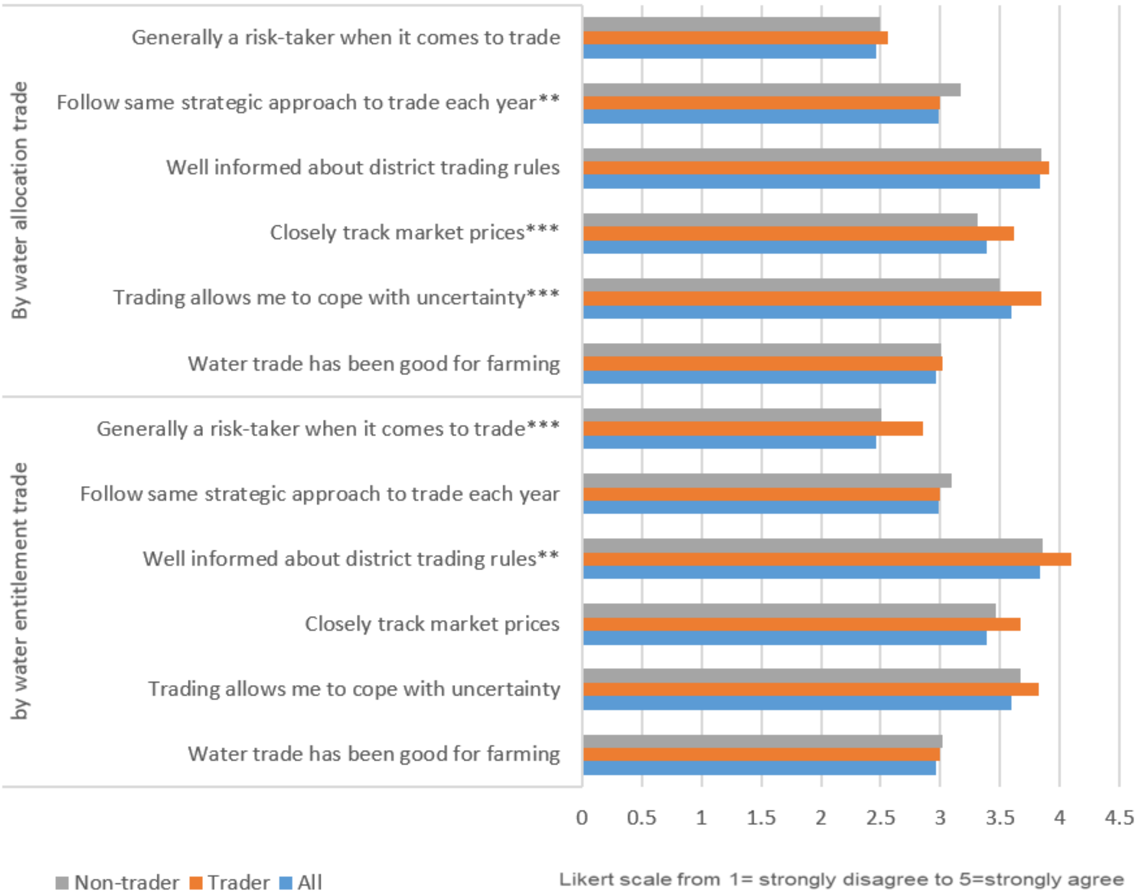
Note: *, ** and *** represents significant differences between trader and non-traders at the 0.10, 0.05 and 0.01 significance level, respectively.
Likert scale is 1=strongly disagree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree.

Figure 6.11 Irrigators' attitudes towards water trading and water markets, in Victoria and South Australia, 2008 (n=619)



Note: The question is 'I would now like you to tell me how much you agree or disagree with the following statements. For each statement please state whether you: strongly disagree (1); disagree (2); neither agree nor disagree (3); agree (4); or strongly agree (5).' For clearer illustration, Likert scale answers were converted to Disagree (1 and 2), Neutral (3) and Agree (4 and 5).

Figure 6.12 Irrigators' attitudes towards water trading and water markets, in sMDB, 2010-11 (n=946)



Note: ** and *** represents significant differences between trader and non-traders at the 0.05 and 0.01 significance level, respectively.
The exact question is 'Using the scale 1=strongly disagree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree, could you respond to the following?' The statements related to this figure are 'I am generally a risk taker when it comes to allocation trades', 'I usually follow the same strategic approach to allocation trading each year', 'I am well informed about the trading rules in my district', 'I closely track water market prices to obtain maximised trade outcomes', 'Trading water allows me to cope with seasonal uncertainty', 'I believe water trading has been a good thing for farming'.

Figure 6.12 indicates that most traders and non-traders (in both allocations and entitlements) held similar attitudes towards water trading (neutral overall in the answer to 'water trade has been good for farming') in the sMDB in 2010. They agreed that they were well informed about district trading rules, checked market prices very closely and believed that trading allowed them to cope with uncertainty and water trade had been good for farming.

In 2015-16, a very small percentage irrigators in the sMDB agreed that corporate non-farm entities should be allowed to invest in water (NSW=9%, VIC=7% and SA=11%), while more irrigators (NSW=33%, VIC=32% and SA=49%) agreed that retired irrigators no longer farming should be allowed to retain and trade water. Most irrigators (>80%) across all states believed that corporate non-farm entities should not be allowed to invest in water, while just less than half of them believed that retired irrigators should be allowed to retain and trade water (Figure 6.13 and Figure 6.15).

Figure 6.13 Irrigators' attitudes towards water trading and water markets, sMDB, 2015-16 (n=1000)

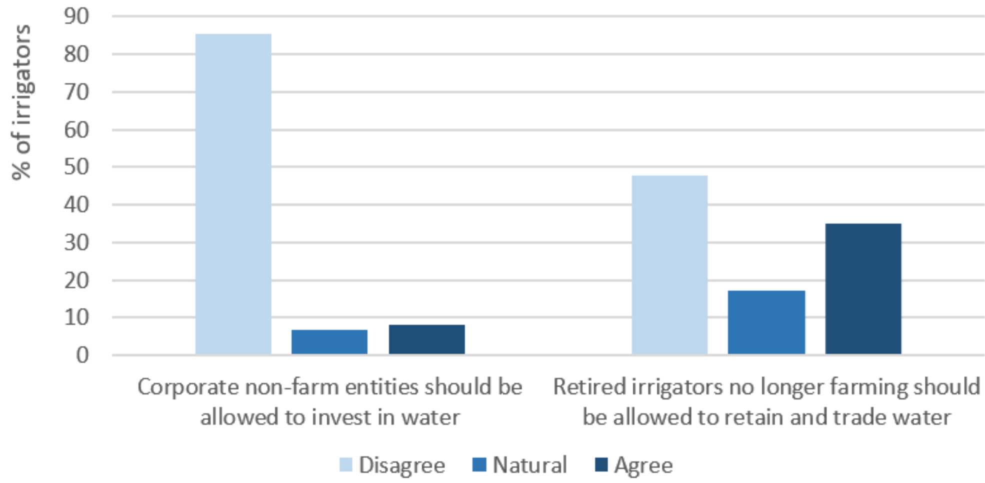
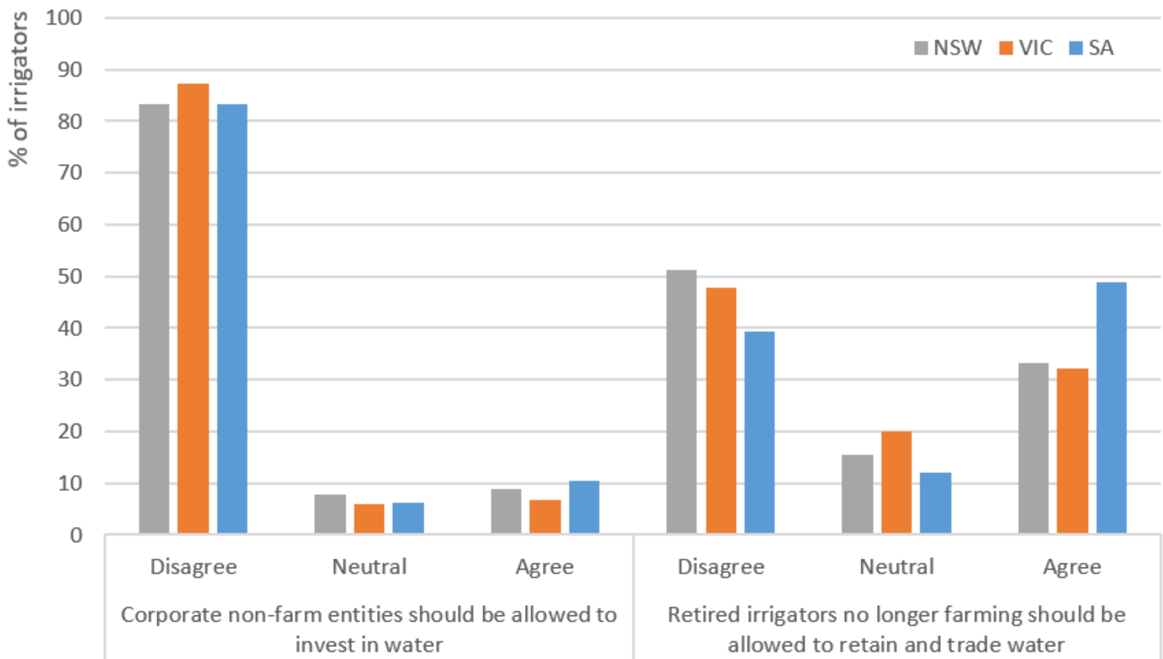


Figure 6.14 Irrigators' attitudes towards water trading and water markets by state in sMDB, 2015-16 (n=1000)



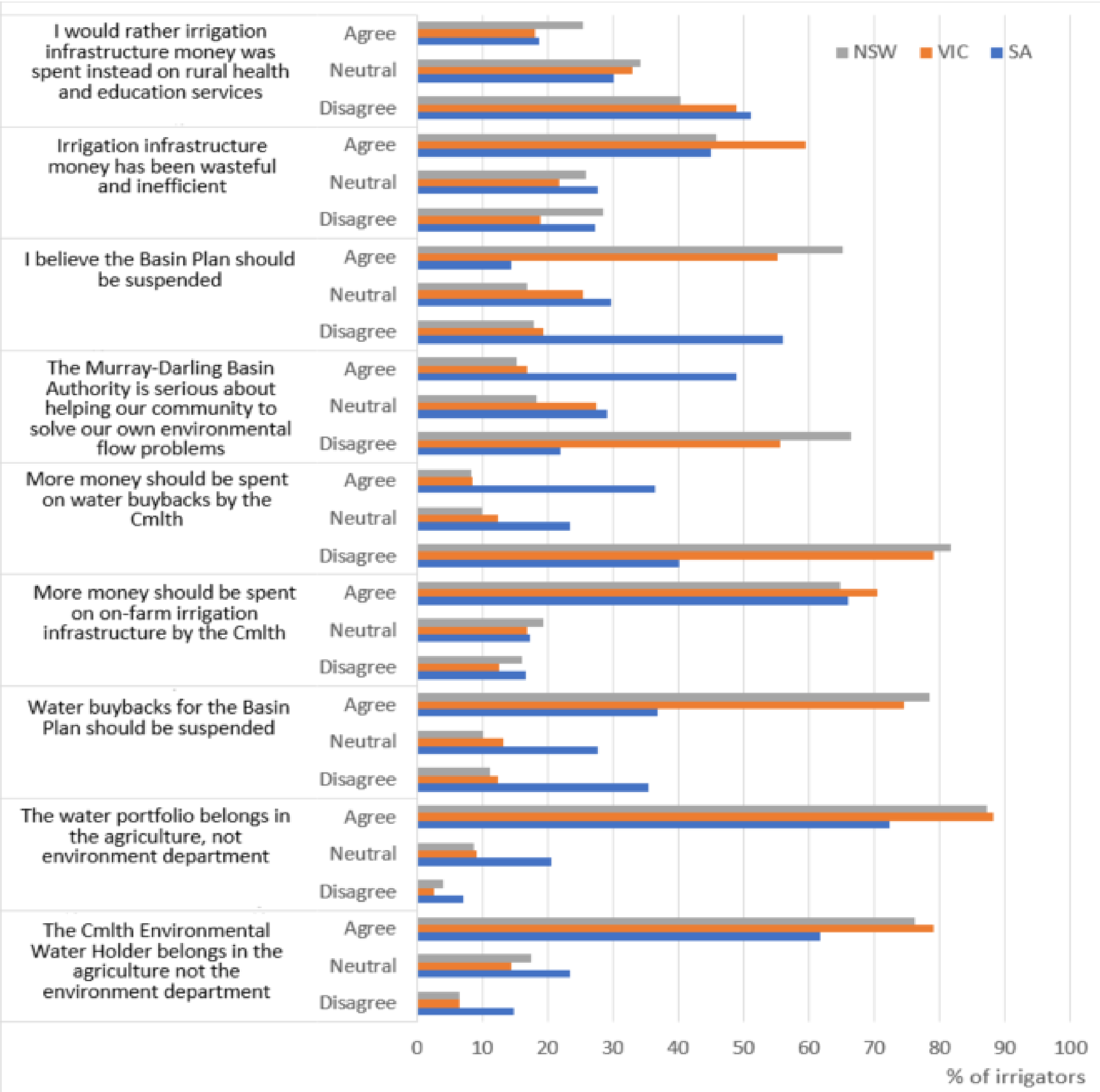
Note: The exact question is 'Using the scale 1=strongly disagree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree, could you respond to the following?' The statements are exactly the same as appeared in the figure. For clearer illustration, Likert scale answers were converted to Disagree (1 and 2), Neutral (3) and Agree (4 and 5).

6.2.9 Attitudes towards water policy and reform

ACCC QUESTION: What attitudes do irrigators hold towards water policy and water reform more generally? How does this correlate with irrigator views towards water markets and trading? How does this correlate with irrigator participation in water markets?

Figure 6.15 displays the attitudes that sMDB irrigators held towards water policy and water reform in 2015-16. Overall, irrigators were more likely to agree than disagree with attitudinal statements such as irrigation infrastructure money had been wasteful and inefficient; that the Basin Plan should be suspended (with SA irrigators clearly the outlier); that more money should be spend on irrigation efficiency by the Commonwealth, water buybacks should be suspended; water portfolio belongs in the agriculture not the environment department; and that the Commonwealth Environmental Water Holder belongs in the agriculture not the environment department. They were more likely to disagree than agree with attitudinal statements such as that irrigation infrastructure money should be spent on rural health and education services; that the MDBA is serious about helping our community to solve our own environmental flow problems (with SA the outlier again); and that more money should be spent on buyback by the Commonwealth.

Figure 6.15 Attitudes of irrigators towards water policy and water reform by state in sMDB, 2015-16



Note: The exact question was 'Using the scale 1=strongly disagree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree, could you respond to the following?' The statements are exactly the same as in the figure above. For clearer illustration, Likert scale answers were converted to Disagree (1 and 2), Neutral (3) and Agree (4 and 5).

Table 6.19 Correlation coefficients between water policy and water reform attitudes and water strategies in the sMDB, 2015-16

Attitudes of irrigators towards water policy and water reform in 2015 (1-strongly disagree 5-strongly agree)	***Water trade has been good for farming***	***Entitlement trade in 2014-15***	***Allocation trade in 2014-15***	***Entitlement trade in last five years***	***Allocation trade in last five years***
The Commonwealth Environmental Water Holder belongs in the agriculture not the environment department	-0.24***	-0.18***	-0.08*	-0.10**	0.06
The water portfolio belongs in the agriculture, not environment department	-0.27***	-0.15***	-0.07	-0.07	0.12**
Corporate non-farm entities should be allowed to invest in water	0.45***	0.14**	0.13***	0.09*	-0.09*
Retired irrigators no longer farming should be allowed to retain and trade water	0.40***	0.08	0.15***	0.02	-0.01
Water buybacks for the Basin Plan should be suspended	-0.33***	-0.13***	0.01	-0.07	0.17***
More money should be spent on on-farm irrigation infrastructure by the Commonwealth	-0.02	0.03	-0.08*	-0.06	0.01
More money should be spent on water buybacks by the Commonwealth	0.33***	0.12**	-0.03	0.02	-0.25***
The Murray-Darling Basin Authority is serious about helping our community to solve our own environmental flow problems	0.37***	0.18***	-0.00	-0.03	-0.09*
I believe the Basin Plan should be suspended	-0.34***	-0.16***	-0.08*	-0.06	0.13***
Irrigation infrastructure money has been wasteful and inefficient	-0.18***	-0.21***	-0.08**	-0.11**	-0.02
I would rather irrigation infrastructure money was spent instead on rural health and education services	-0.04	-0.09*	-0.04	-0.10**	-0.06

Note: Polychoric correlation coefficients that are appropriate between binary and ordinal variables are presented. *, ** and *** represents statistical significance at 10%, 5% and 1% levels, respectively.

Table 6.19 reveals the Polychoric correlation between water policy and reform attitudes and irrigators' views towards water markets and trading, and the correlation between water policy and reform attitudes and the water strategies. The water policy and reform attitudes were more correlated with irrigators' views towards water markets and trading (ranging from 0.02 to 0.45) than that with water strategies (ranging from 0.00 to 0.25). Specifically, irrigators who agreed more with water trading also agreed more with the statements:

- 'Corporate non-farm entities should be allowed to invest in water' (r=0.45),
- 'Retired irrigators no longer farming should be allowed to retain and trade water' (r=0.40),
- 'The Murray-Darling Basin Authority is serious about helping our community to solve our own environmental flow problems' (r=0.37).

But, irrigators who agreed more with water trading agreed less with:

- 'I believe the Basin Plan should be suspended' (r = -0.34), and
- 'Water buybacks for the Basin Plan should be suspended' (r = -0.33).

Correlations between water policy and reform attitudes and water trading behaviours were relatively weak. The strongest two were:

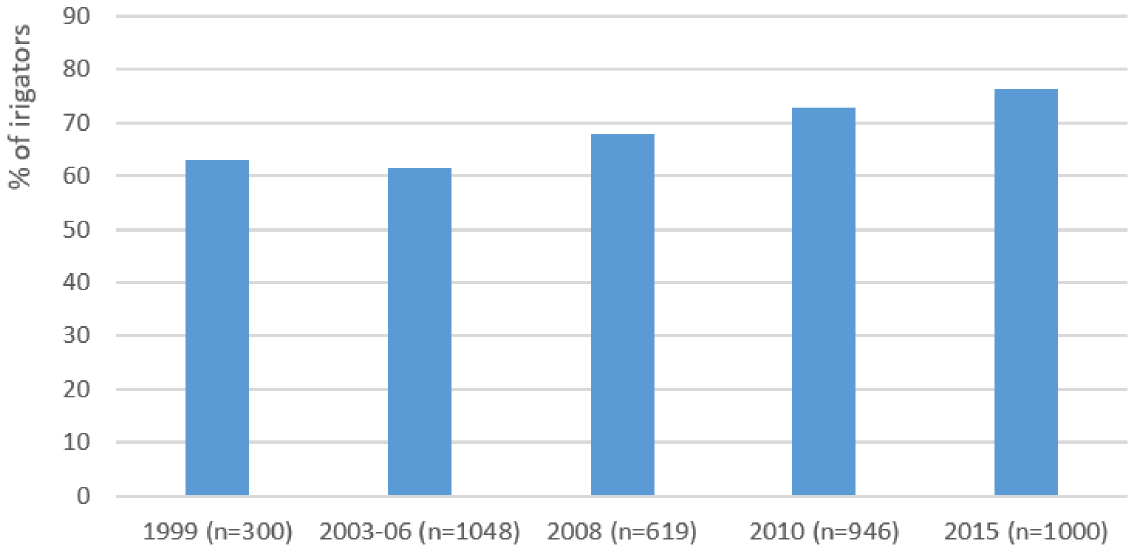
- irrigators who agreed more with ‘More money should be spent on water buybacks by the Commonwealth’ were less likely to trade water allocations in the last five years (r = -0.25); and
- irrigators who agreed more with ‘Irrigation infrastructure money has been wasteful and inefficient’ were less likely to trade water entitlements in 2014-15 (r = -0.21).

6.2.10 Farm management abilities

ACCC QUESTION: What are irrigators’ views of the own farm management

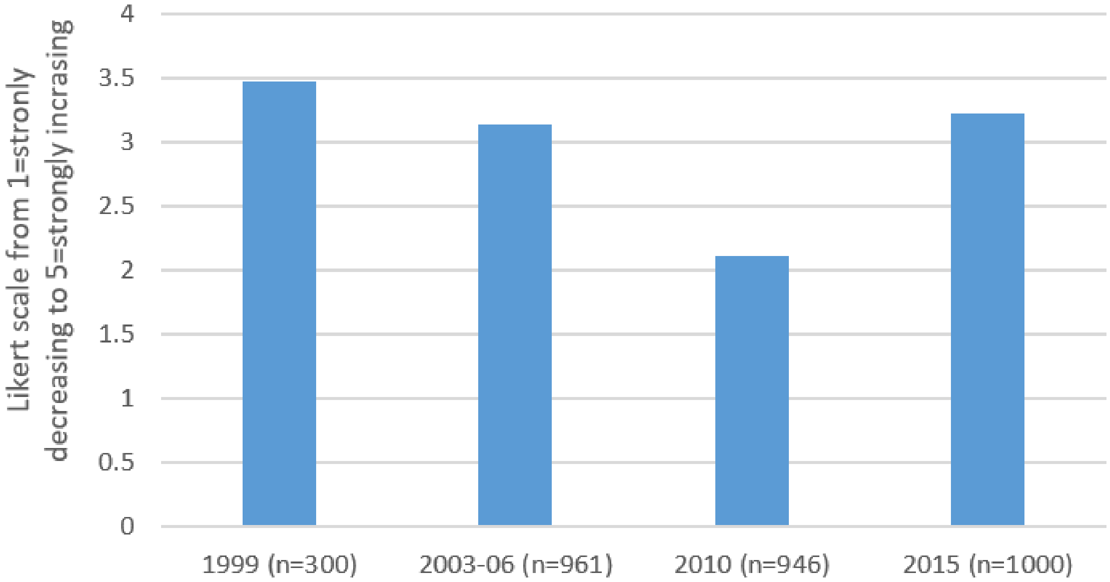
Whole farm plans are widely used by irrigators (higher than 60% in 1999) and have been increasingly adopted over time (increasing to 76% in 2015) (see Figure 6.16). Farm productivity increased slightly (average score above 3) in most years except in 2010 when the Millennium Drought just ended (Figure 6.17). About half of irrigators felt optimistic about their future and most of them (81%) believed that new technology that becomes available are important to them (see Figure 6.18).

Figure 6.16 Percentage of irrigators who have a whole farm plan over time in the GMID and sMDB



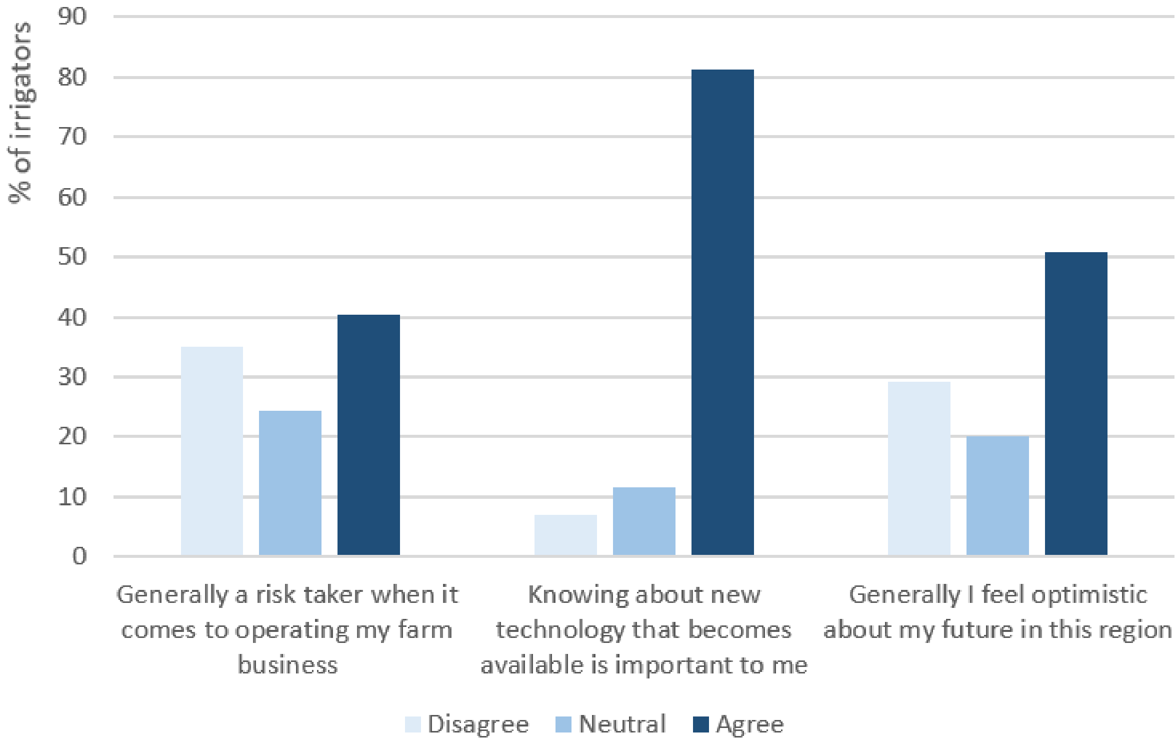
Note: The exact question was “Do you have a whole of farm plan for your property?”

Figure 6.17 Irrigators' views of the productivity change of their own farm over time in the sMDB



Note: The exact question was: "How would you describe changes to the productive output of your farm over the last five years on a scale where 1 = strongly decreasing; 2=decreasing; 3=neither decreasing nor increasing; 4=increasing; and 5 = strongly increasing?"

Figure 6.18 Irrigators' farm management views, sMDB, in 2015-16 (n=1000)

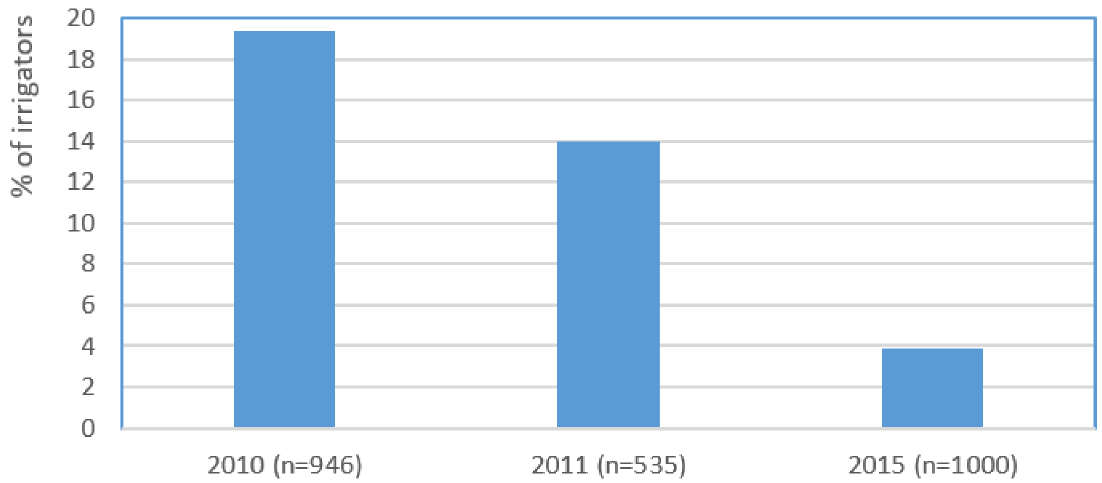


Notes: The exact question was: 'Using the scale 1=strongly disagree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree, could you respond to the following?' The statements related to this figure are 'I am generally a risk taker when it comes to operating my farm businesses', 'Knowing about new technology that becomes available is important to me', and 'Generally I feel optimistic about my future in this region'.

6.2.11 Barriers to trade and market participation

ACCC QUESTION: What do irrigators believe are barriers to trade and market participation (including physical, educational, informational, social, regulatory, financial, behavioural or attitudinal barriers)? What are irrigators' beliefs about their own ability to participate in water markets? How have irrigator beliefs about barriers to trade and market participation, and their views on their own ability to participate in water markets, changed over time?

Figure 6.19 Percentage of irrigators prevented by a cap from trading entitlements in the sMDB over time



Note: This represents the percentage of irrigators who answered yes to: "Has a cap on entitlement trade stopped you from selling any of your water?"

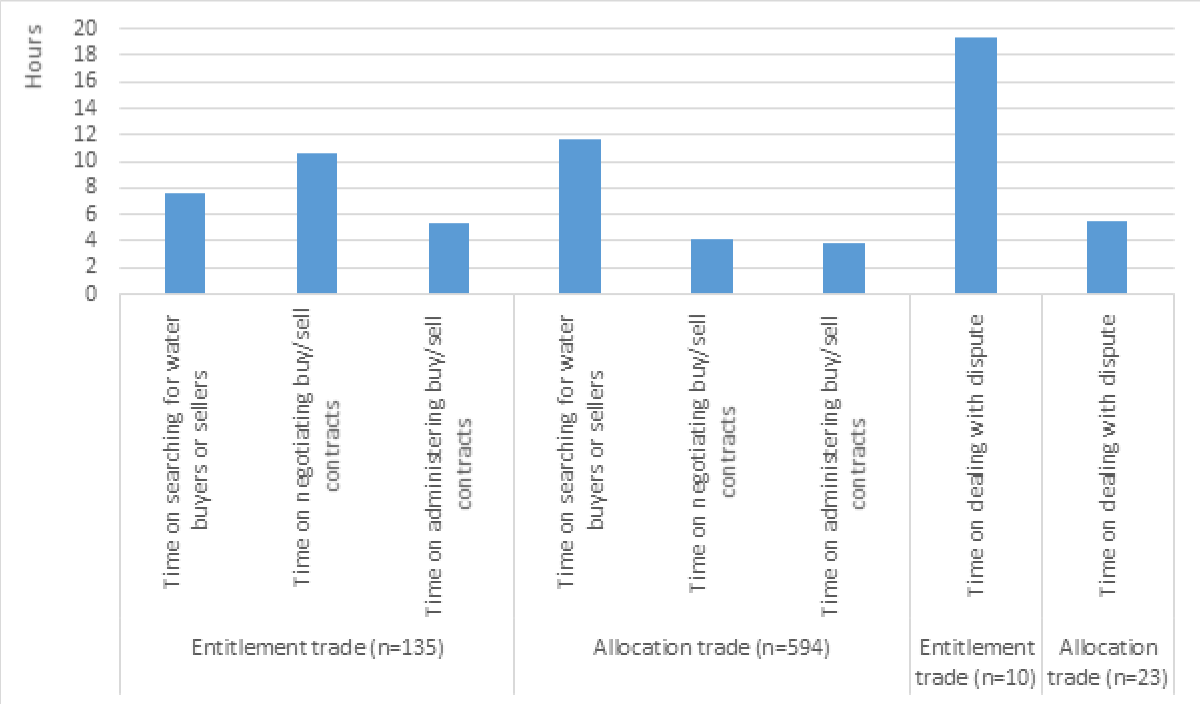
In 2010-11, 19% of the 946 irrigators surveyed indicated that a cap had prevented them from selling some of their own water entitlements. This percentage decreased dramatically to 4% in 2015-16, reflecting the ongoing water policy reform in the MDB (Figure 6.19). Note: a timeframe was not asked in regards to the cap question, so it is not known what year irrigators were referring to.

In addition, one question each in the 2010-11 and 2015-16 surveys provides further insights in barriers to trade (note: this is not shown in a figure or table). First, only 15% of the 946 irrigators surveyed in 2010-11 disagreed or were neutral regarding the statement 'I am well informed about district trading rules', suggesting not understanding trading rules was not likely a barrier for water trade. Second, in 2015-16, 15% of 1000 irrigators indicated that possible delivery restrictions on trade caused them to trade differently in the 2014-15 season.

6.2.12 Water trading experience

ACCC QUESTION: What are irrigators' experiences of actual trading (direct costs such as trade approval or water market intermediary fees, time, difficulty etc.)? How has this changed over time?

Figure 6.20 Average time per irrigator spent on water trade in 2014-15, sMDB



Notes: The exact questions were: 'In 2014/15, how much time did you spend searching for water buyers or sellers (e.g. monitoring exchanges, assessing prices, talking to brokers etc.)?' 'In 2014/15, how much time did you spend negotiating buy/sell contracts (e.g. working out the price/volume, confirming the details, sorting out terms etc.)?' 'In 2014/15, how much time did you spend administering buy/sell contracts (e.g. paperwork in your office, recording details, making payments etc.)?' 'How much time did you spend dealing with that dispute (e.g. consulting with lawyers, participating in settlement meetings, arguing with the seller/buyer etc.)?'

Entitlement traders and allocation traders spent different lengths of time searching for water buyers or sellers, negotiating and administering buy/sell contracts and dealing with dispute in 2014-15. Generally water allocation traders spent longer time than entitlement traders on searching for water buyers or sellers, in particular monitoring exchanges and assessing prices. In contrast, entitlement traders spent more time on negotiating and administering buy/sell contracts and dealing with dispute (see Figure 6.20). Loch et al. (2018) explored and reported this data.

6.2.13 Correlation among trading, water ownership, and trading attitudes

ACCC QUESTION: To what extent do certain irrigator types correlate with certain trading behaviours, water ownership and trading strategies, and attitudes to trading? How have these correlations changed over time?

Table 6.20 Water participant typology and water ownership, sMDB (2015-16 survey)

	Has diverse water holding*		***Has high security water entitlement*****		***Has general security water entitlement*****		***Has low security water entitlement*****	
Irrigator participant typology	***No % (n=618)***	***Yes % (n=382)***	***No % (n=325)***	***Yes % (n=675)***	***No % (n=695)***	***Yes % (n=305)***	***No % (n=712)***	***Yes % (n=288)***
Cluster 1: Water allocation buyer EXPANDERS	29.19	32.55	23.51	33.89	33.68	23.33	30	31.71
Cluster 2: Water entitlement buyer EXPANDERS & DIVERSIFIERS	8.05	4.99	9.4	5.62	5.47	10	8.12	3.83
Cluster 3: Water seller DOWNSIZERS	7.89	6.3	9.4	6.23	6.5	9	7.68	6.27
Cluster 4: Irrigators switching from irrigation to dryland TRANSITIONERS	22.65	9.45	13.79	19.3	19.65	12.67	20.87	9.41
Cluster 5: Irrigator carrying over water SAVERS	32.12	46.72	43.89	34.95	34.71	45	33.33	48.78
Pearson Chi-2 (p-value)	0.00		0.00		0.00		0.00	

Notes: * Owns more than one type of water entitlement.
** Can also own other types of water security entitlements.

Table 6.20 displays the associations between irrigator participant typology and water ownership. Pearson Chi-2 statistics suggest there is a statistically significant association between cluster membership water ownership, at the 0.01 level. Clusters 4 and 5 differ substantially in terms of whether irrigators in the two clusters have diverse water holdings. For irrigators with diverse water holdings, they are less likely to belong to Cluster 4 than irrigators without diverse water holdings; on the other hand, irrigators with diverse water holdings are more likely to belong to Cluster 5 than those without diverse water holdings. Irrigators with high security water ownership are more likely to belong to Cluster 1 than those without high security water ownership. The statistically significant association between cluster membership and general/low water entitlement ownership is likely to be due to the irrigators' state since general security entitlements are available in NSW and low security entitlements are available in VIC, however irrigators are increasingly purchasing entitlements in different regions for risk security purposes.

Table 6.21 presents correlations between trading behaviour and business/individual characteristics and irrigator attitudes from the 2010-11 survey. Strong and practically meaningful positive correlations with buying water allocations are recorded for the attitudes:

- 'Trading water allows me to cope with seasonal uncertainty' (0.32); and

- ‘I closely track water market prices to obtain maximized trade outcomes’ (0.30).

Selling water allocation has a strong correlation with:

- having received an exit package (0.35);
- the horticulture industry (-0.33);
- NSW (0.37) and SA (-0.68).

None of the characteristics have a strong correlation (less than 0.3 in absolute value) with buying water entitlements, while the variable of only having received an exit package was strongly correlated with selling water entitlements (0.42).

Table 6.21 Correlation coefficients between buying/selling water in 2009-10 and business/individual characteristics and attitudes (2010-11 sMDB survey, n=946)

	Buy water allocation (1=Yes, 0=No)	***Sell water allocation (1=Yes, 0=No)***	***Buy water entitlements (1=Yes, 0=No)***	***Sell water entitlements (1=Yes, 0=No)***
Net farm income ($)	0.02	0.17***	-0.14	-0.11
Total area of irrigated land (ha)	0.09**	0.07	0.08	-0.06
Total are of dryland (ha)	-0.09*	0.08*	-0.08	0.09*
Total area of the farm (ha)	-0.04	0.09**	-0.02	0.07
% of irrigation area with laser grading	0.11***	0.18***	0.01	-0.00
% of irrigation area with reuse system	0.11***	0.09**	0.05	0.09
% of irrigation area with centre pivot irrigation	-0.03	-0.04	0.08	0.15***
% of irrigation area with spray or drip irrigation technology	0.09**	-0.17***	-0.08	-0.02
Number of full-time employees	0.17***	-0.05	0.13	0.08*
Total volume of high security water entitlement (ML)	0.05	0.02	0.08*	-0.11
Total volume of low security entitlement water in VIC	0.19**	-0.07	0.08	0.04
Total volume of general security entitlement water in NSW	0.14*	0.08	-0.27	0.08
Total volume of surface water entitlements (high, general and low)	0.09**	0.17***	0.03	0.03
Received an exit package (%)	-0.01	-0.35**	0.28	0.42***
Received an irrigation infrastructure grant (%)	0.10*	-0.11*	0.01	0.10
Debt to equity ratio	0.05	0.05	0.16**	0.01
Those answering that a cap prevented entitlement trade (%)	-0.13*	0.28***	0.13	0.18**
Industry: Horticulture (%)	0.10	-0.33***	-0.28	-0.07
Industry: Broadacre (%)	0.03	0.20	0.03	0.17**
Industry: Dairy (%)	-0.14	0.12**	0.20	-0.13
Individual characteristics				
Age	-0.19***	0.04	-0.23**	0.01
Years of farming	-0.17***	0.08*	-0.21**	0.02
Number of children	-0.07	0.10	-0.03	0.04
Married (%)	0.22***	-0.08	1.00	0.16
Have a successor (%)	0.07	-0.01	0.01	0..10
Whole farm plan (%)	0.26***	0.04	0.28	0.24**
Attitude to risk from farmer (Likert scale from 1 to 5, 1=totally unwilling to take risk; 2=unwilling to take risk;	0.19***	-0.01	0.09	0.15**

3=risk neutral; 4=willing to take risk; and 5=completely willing to take risk).				
Level of education	0.15***	0.07	0.16	-0.00
NSW (%)	-0.07	0.37***	0.03	0.06
VIC (%)	-0.01	0.14**	0.16	-0.07
SA (%)	0.08	-0.68***	-0.28	0.01
Murrumbidgee-Griffith	-0.05	0.34***	-1.00	-0.07
Murrumbidgee-Coleambally	0.05	0.18**	-0.02	-0.18
NSW Murray-Deniliquin	-0.09	0.19***	0.20	0.23***
VIC Murray-above Barmah Choke	0.02	-0.03	0.16	-0.05
Goulburn Central	0.02	0.08	0.10	-0.01
VIC Murray-below Barmah Choke	-0.05	0.14**	0.06	-0.07
SA Murray-Renmark	0.03	-0.52***	-0.90***	0.01
SA Murray-Waikerie	0.15**	-0.60***	-1.00	0.01
SA Murray-Murray Bridge	-0.11	-0.47***	0.07	0.01
[1]Attitude: Family should be an integral part of the farming enterprise	-0.00	-0.04	-0.28	-0.03
Attitude: My family is fully committed to farming as an occupation and way of life	0.04	0.00	0.10	-0.05
Attitude: Farmers should encourage family members to be involved in the family farm	-0.00	-0.07	0.10	0.09
Attitude: I would like to buy or develop enough land for my family to remain or become farmers	0.14***	-0.06	0.22	-0.02
Attitude: Financial gain is the only reason for my involvement in farming	-0.07	0.09*	0.16*	-0.08
Attitude: A maximum annual return from my property is my most important aim	0.00	0.06	0.14	-0.08
Attitude: I view my farm first and foremost as a business enterprise	0.10**	-0.04	0.21*	-0.00
Attitude: My land is just something I use to generate an income	-0.07	-0.03	0.14	-0.02
Attitude: Improving my farm is important because it will increase its future sale value	-0.02	-0.06	0.12	-0.09
Attitude: I could never imagine living anywhere other than this area	-0.11**	-0.02	0.05	-0.08
Attitude: I want to continue farming for as long as I am able	0.05	-0.02	-0.04	-0.10
Attitude: Farming is the only occupation I can imagine doing	-0.05	0.01	0.2	-0.08
Attitude: My quality of life would decline if I moved from this farm	-0.04	-0.01	-0.02	-0.05
Attitude: Land stewardship by farmers is more important than other farming issues	-0.11**	-0.05	0.09	-0.11*
Attitude: The wider community can reasonably expect landholders to adopt recommended practices that lead to improved environmental outcomes	-0.03	0.01*	0.09	-0.11
Attitude: My right to do what I want with my property has to be balanced against wider environmental concerns	-0.07	0.03	0.15	-0.00
Attitude: I would like to leave my land in better condition than I found it	0.12**	0.03	0.11	0.04
Attitude: Knowing about new technology that becomes available is important to me	0.12**	-0.00	0.07	-0.02
Attitude: I am open to new ideas and alternatives about farming	0.17***	0.00	0.10	0.00

Attitude: Humans should have more respect and admiration for water in rivers	-0.02	-0.03	0.17	0.03
Attitude: essential to make allocations to the environment	-0.07	-0.06	0.00	-0.01
Attitude: We would be willing to have our seasonal allocations reduced to ensure sufficient water for the environment	-0.12***	0.05	-0.03	0.04
Attitude: Most irrigators think increasing environmental water flows is a good thing	-0.04	-0.11	-0.11	0.08
Attitude: Governments should avoid changing trading rules or conditions during the season	0.14***	0.10**	0.22**	0.03
Attitude: Covering the fixed water access expense is important when I trade	-0.09**	0.21***	0.12	0.05
Attitude: I am well informed about seasonal allocation changes	0.06	0.06	0.09	0.08
Attitude: I believe water trading has been a good thing for farming	0.16***	0.14***	0.22**	-0.00
Attitude: Trading water allows me to cope with seasonal uncertainty	0.32***	0.16***	0.18	0.07
Attitude: I closely track water market prices to obtain maximised trade outcomes	0.30***	0.17***	0.27**	0.10
Attitude: I am well informed about the trading rules in my district	0.08	0.08	0.26**	0.17***
Attitude: I usually follow the same strategic approach to allocation trading each year	-0.16***	0.00	0.02	-0.04
Attitude: generally a risk-taker when trade	0.23***	-0.04	0.15	0.16

Note: [1] Attitudinal statements are measured by Likert scales: 1=strongly disagree; 2= disagree; 3=neither disagree nor agree; 4=agree; and 5=strongly agree.
Polychoric correlation coefficients are for one binary and one continuous variable and tetrachoric correlation coefficients are for two binary variables. *, ** and *** represents statistical significance at 10%, 5% and 1% levels, respectively.

Table 6.22 presents correlations between trading behaviour and business/individual characteristics and irrigator attitudes from the 2015-16 survey. Strong and practically meaningful positive correlations with buying water allocations are recorded for:

- total volume of general security water entitlements (0.45),
- total water use (0.47), having a whole farm plan (0.43),
- total amount of water carried over (0.35).

Selling water allocation has a strong correlation with the attitude— ‘Water trading has been a good thing for farming’ (0.33), interestingly whose correlation with buying water allocation is -0.04, and with buying and selling water entitlements is 0.21 respectively.

Buying water entitlements have a strong correlation with:

- total volume of general security water entitlements (0.44),
- total water use (0.35),
- total amount of water carried over (0.35),
- having a whole farm plan (0.38),
- and being married (0.32).

Correlations with selling water entitlements are overall relatively weak (less than 0.3 in absolute value) although many correlation coefficients appear statistically significantly different from zero.

Table 6.22 Correlation coefficients between buying/selling water in 2014-15 and business/individual characteristics and attitudes (2015-16 sMDB survey, n=1000)

	Buy water allocation (1=Yes, 0=No)	*Sell water allocation (1=Yes, 0=No)*	*Buy water entitlements (1=Yes, 0=No)*	*Sell water entitlements (1=Yes, 0=No)*
Business characteristics				
Net farm income ($)	0.25***	-0.07*	0.26***	-0.12**
Total area of irrigated land (ha)	0.22***	-0.16**	0.22***	-0.02
Total are of dryland (ha)	-0.00	-0.00	0.11***	-0.14
Total area of the farm (ha)	0.04	-0.02	0.15***	-0.12
Total volume of high security water entitlement (ML)	0.08*	-0.04	0.12**	0.03
Total volume of low security entitlement water in VIC (ML)	0.16**	-0.01	0.17**	0.12
Total volume of general security entitlement water in NSW (ML)	0.45***	-0.05	0.44***	0.12**
Total water use for irrigation in 2014/15 season (ML)	0.47***	-0.09	0.35***	0.05
Amount of water carried over into 2014/15 season	0.35***	0.02	0.35***	0.08***
Hours normally spent in planning water use before start of season	0.11**	-0.08	0.10**	0.00
Number of full-time employees	0.12**	-0.05	0.16***	0.03
Have a whole farm plan (%)	0.43***	-0.17***	0.38***	-0.03
Received an irrigation infrastructure grant (%)	0.11**	0.01	0.17**	0.23***
Have had a water trade dispute (0=No; 1=Yes) (%)	0.53***	-0.10	0.31**	0.04
A cap prevented entitlement trade (%)	0.14	0.19**	0.04	0.07
Industry: Horticulture	-0.28***	0.32***	-0.04	0.35***
Industry: Broadacre	0.20***	-0.01	0.19**	-0.09
Industry: Dairy	0.42***	-0.54***	-0.05	-0.25***
Industry: Livestock	-0.34***	0.04	-0.15	-0.19**
Individual characteristics				
Age	-0.23***	0.02	-0.16	-0.03
Male (%)	-0.05	-0.01	-0.06	-0.05
Years of farming	-0.19***	-0.07	-0.16***	-0.05
Number of children	0.15***	-0.03	0.07	-0.07
Married (%)	0.24***	-0.04	0.32***	0.17*
Have a successor (%)	0.12**	-0.19***	0.03	-0.08
% of household income derived off-farm	-0.15***	0.16***	0.02	-0.01
Planning for climate change on farm 0=No 1=Yes (%)	0.19***	0.01	0.21***	0.13*
Any family members belong to a community group(s) (0=No 1=Yes) (%)	0.09*	-0.08**	0.13***	-0.02
Any family members belong to a professional group(s) (0=No 1=Yes) (%)	0.18***	-0.09	0.39	0.04
Any family members belong to an environmental group(s) (0=No 1=Yes) (%)	0.00	0.02	0.18**	-0.06
Any family members belong to any social groups (0=No 1=Yes) (%)	0.10*	-0.02	0.27***	-0.00
Have income protection insurance (0=No 1=Yes) (%)	0.11**	-0.05	0.28***	0.03
Have crop insurance (0=No 1=Yes) (%)	0.22***	-0.13**	0.28***	0.05
Level of education	0.13***	0.13***	0.19***	0.15***
NSW	0.01	0.16***	-0.02	-0.13*

VIC	0.17***	-0.33***	-0.045	-0.26***
SA	-0.25***	0.21***	0.08	0.40***
[1]Attitude: Farming is the only occupation I can imagine doing	0.02	-0.12***	-0.13**	0.04
Attitude: Financial gain is the only reason for my involvement in farming	-0.03	-0.04	0.01	0.02
Attitude: I am generally a risk taker when it comes to operating my farm business	0.03	-0.05	-0.01	0.01
Attitude: I believe water trading has been a good thing for farming	-0.04	0.33***	0.21***	0.21***
Attitude: I could never imagine living anywhere other than this area	-0.09**	-0.04	-0.18***	-0.02
Attitude: Knowing about new technology that becomes available is important to me	-0.14***	-0.02	0.18***	0.05
Attitude: We would be willing to have our seasonal allocations reduced to ensure sufficient water for the environment	-0.23***	0.23	-0.02	0.08
Attitude: most irrigators think increasing environmental water flows is a good thing	-0.18***	0.22***	0.06	0.20***
Attitude: Generally I feel optimistic about my future in this region	-0.08**	0.08**	0.05	0.06
Attitude: It is essential to make allocations to the environment otherwise irrigation will not be long-term sustainable	-0.14***	0.20***	-0.00	0.18***
Attitude: I want to continue farming for as long as I am able	0.05	-0.12***	-0.05	0.02
Attitude: I like to make my own decisions and not be too influenced by others	-0.12***	-0.05	0.03	-0.09
Attitude: The Commonwealth Environmental Water Holder belongs in the agriculture not the environment department	0.09**	-0.19***	-0.21***	-0.19***
Attitude: the water portfolio belongs in the agriculture not environment department	0.14***	-0.20***	-0.12*	-0.20***
Attitude: Corporate non-farm entities should be allowed to invest in water	-0.01	0.20***	0.21***	0.04
Attitude: Retired irrigators no longer farming should be allowed to retain and trade water	0.03	0.18***	0.11	0.04
Attitude: Water buybacks for the Basin Plan should be suspended	0.25***	-0.21***	0.00	-0.18***
Attitude: More money should be spent on on-farm irrigation infrastructure by the Commonwealth	0.02	-0.13***	0.02	0.03
Attitude: More money should be spent on water buybacks by the Commonwealth	-0.24***	0.18***	-0.04	0.18***
Attitude: The Murray-Darling Basin Authority is serious about helping our community to solve our own environmental flow problems	-0.21***	0.17***	0.00	0.27***
Attitude: I believe the Basin Plan should be suspended	0.17***	-0.26***	-0.10	-0.22***
Attitude: Irrigation infrastructure money has been wasteful and inefficient	-0.03	-0.12***	-0.14**	-0.26***
Attitude: I would rather irrigation infrastructure money was spent instead on rural health and education services	-0.07	0.02	-0.01	-0.11**

Note: [1] Attitudinal statements are measured by Likert scales from 1=strongly disagree to 5=strongly agree. Polychoric correlation coefficients are for one binary and one continuous variable and tetrachoric correlation coefficients are for two binary variables. *, ** and *** represents statistical significance at 10%, 5% and 1% levels, respectively.

6.3 Summary and Key Points

- Six irrigator survey datasets across the southern MDB from 1998-99 to 2015-16 were used to analyse trade participation in allocation, entitlement and carryover. A series of 63 semi-structured qualitative interviews with key trade stakeholders in the MDB in 2018-19 were also used to help provide more information on non-landholder behaviour. Specifically, this included 20 investors and agri-corporates (very large landholders owning and/or trading water but generating their main income from farming); 15 EWH and NGO employees (public or private entities, owning or delivering water entitlements or allocations for environmental purposes); 10 water evaluators (consultants etc. specialised in water valuation); 7 financial investors (non-landholders trading water for financial gain); 6 bankers (employees from financial institutions who were the key individuals responsible for significant lending portfolios in water entitlements); and 5 water brokers (who earn commission-based revenue from water market transactions). Data from a private water broker was also used for insights.
- The data analysis used a variety of methods: independent two sample t-test; person Chi-squared test; principal component factor analysis; and a multinomial logit model to examine the difference between traders and non-traders in different water markets over time. Broadly, the results revealed that greater differences were found between groups of irrigators in the earlier rather than later years – highlighting that as adoption of trade went on in time, the individual and farm-related difference between traders and non-traders decreased.
- Factor analysis was used to create a typology of water market participants. Cluster 1: *Expanders* mainly purchase water allocations, in combination with increasing irrigated area and accommodating strategies such as changes in irrigation production and improvements in irrigation efficiency. Cluster 2: *Expanders and Diversifiers* mainly purchase water entitlements, which are accompanied by farmland purchases. Cluster 3: *Downsizers* clearly identifies a group that are downsizing or exiting by selling both water allocations and entitlements. The remaining two clusters do not have water trading in their dominant strategies. For example: Cluster 4: *Transitioners* seem to be in the process of switching from irrigation to dryland production; while Cluster 5: *Savers* are those mainly using carryover. The results highlight the importance of water scarcity in driving irrigator behaviour, with scarcity issues more likely to increase the likelihood of being an *Expander*, *Expander/ Diversifier* or a *Downsizer*. On the other hand, increases in water availability were more likely to increase being a *Saver*; while the higher the temperature, the greater likelihood of being in Cluster 3: *Downsizer*.
- Some key findings from the small number of qualitative interviews (bearing in mind this may not be fully representative) are that leases are the most commonly used new water market product, and smaller operators appear less likely to use leases than larger operators do. Larger and more corporatised irrigators seem to prefer longer-term leases sourced from big commercial operators, either as part of leasing land, or as a stand-alone water lease from often non-landholder investors. Data from one broker indicated that parking was an important risk management product, but appeared unevenly used across irrigators. Similar to parking, forward usage by irrigators seems unevenly distributed between years and regions, and the broker data suggested very limited take-up of multi-year forwards. In 2018-19, 37% of forwards purchased by irrigators were sold by investors.
- In 1998-99, most irrigators (over 80%) in the GMID agreed that water trade was a good idea. As time progressed, just under half of irrigators in the sMDB agreed/strongly agreed that water trade had been good for farming in 2010-11; and the rate of agreement declined further in the sMDB in 2015 (from 46% to 28%), with between 14 to 16% remaining neutral. There was a large increase in the 'strongly disagree' attitude, and a slight increase in the 'strongly agree' attitude between 2010-11 and 2015-16. In 2010-11, sMDB irrigators agreed that they were well informed about district trading rules, checked market prices very closely, and

believed that trading allowed them to cope with uncertainty. In 2015-16, a very small percentage of irrigators in the sMDB agreed that corporate non-farm entities should be allowed to invest in water (<10%) – while around a third of irrigators in NSW and VIC agreed that retired irrigators no longer farming should be allowed to retain and trade water (SA irrigators were more likely to agree). Overall, irrigators in sMDB became more likely to agree that water markets had not been good for farming. There were differences between cluster attitudes; with *Transitioners* more likely to agree water trading had been good for farming.

- Overall, irrigators in 2015-16 were more likely to agree than disagree with attitudinal statements such as irrigation infrastructure money had been wasteful and inefficient; that the Basin Plan should be suspended (with SA irrigators clearly the outlier); that more money should be spend on irrigation efficiency by the Commonwealth; that water buybacks should be suspended; that water portfolio belongs in the agriculture not the environment department; and that the Commonwealth Environmental Water Holder belongs in the agriculture not the environment department. Irrigators were more likely to disagree than agree with attitudinal statements such as irrigation infrastructure money should have been spent on rural health and education instead; that the MDBA is serious about helping the community to solve our own environmental flow problems (with SA the outlier again); and that more money should be spent on buyback by the Commonwealth.
- There were statistically significant associations between cluster membership and water ownership; *Transitioners* are less likely to have diverse water holdings, while *Savers* have diverse water holdings. Irrigators with high security water ownership are more likely to belong to *Expanders*. Those who buy water allocations are more likely to be correlated with the statement 'Trading water allows me to cope with seasonal uncertainty' and 'I closely track water market prices to obtain maximized trade outcomes'. Selling water allocation had a strong correlation with: having received an exit package (0.35), the horticulture industry (-0.33); and being in NSW (0.37) and SA (-0.68).
- Strong positive correlations with buying water allocations are recorded for: total volume of general security water entitlements; total water use; having a whole farm plan; and total amount of water carried over. Selling water allocation had a reasonably large correlation with: 'Water trading has been a good thing for farming' (0.33), interestingly whose correlation with buying water allocation is -0.04, and with buying and selling water entitlements is 0.21 respectively. Buying water entitlements has strong positive correlations with: total volume of general security water entitlements; total water use; total amount of water carried over; having a whole farm plan; and being married. Correlations with selling water entitlements are overall relatively weak (less than 0.3 in absolute value) although many correlation coefficients appear statistically significantly different from zero.

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Glossary

Adaptation	The response to major changes in the environment (e.g. global warming) and/or political and economic shocks. Adaptation is often imposed on individuals and societies by external undesirable changes.
Adoption (in agriculture)	A change in practice or technology.
Annual crops	Crops that go through their entire lifecycle in one growing season (e.g. cotton, rice, cereal).
Basin Plan	A high level framework that sets standards (see sustainable diversion limits) for the management of the Murray-Darling Basin's water resources balancing social, environmental and economic outcomes.
Broadacre	Broadacre cropping (a term used mainly in Australia) describes large-scale agricultural production of grains, oilseeds and other crops (e.g. wheat, barley, sorghum).
Carry-over	Arrangements which allow water entitlement holders to hold water in storages (water allocations not taken in a water accounting period) so that it is available in subsequent years.
Catchment (river valley)	An area determined by topographic features, within which rainfall contributes to run-off at a particular point.
Commonwealth Environmental Water Holder (CEWH)	An independent statutory office established by the *Water Act 2007* and responsible for making decisions relating to the management of the Commonwealth environmental water aiming to maximise environmental outcomes across the Murray-Darling Basin.
Consumptive water use	The use of water for private benefit (e.g. irrigation, industry, urban, and stock and domestic uses).
Council of Australian Governments (COAG)	Is the peak intergovernmental forum driving and implementing reforms in Australia (members are the Prime Minister, State and Territory Premiers and Chief Ministers and the President of the Australian Local Government Association).
Environmental asset	According to the Basin Plan, include water-dependent ecosystems, ecosystem services and sites with ecological significance.
Environmental water	According to the Basin Plan, comprises water provided to wetlands, floodplains or rivers, to achieve a desired outcome, including benefits to ecosystem functions, biodiversity, water quality and water resource health.
Farming water season	Describes a 12-month period from July 1 to 30 June (similar to the financial year in Australia).
Groundwater	The supply of freshwater found beneath the earth's surface (typically in aquifers).

High security water entitlement	Provide a highly reliable water supply (usually full allocation 90-95 years out of 100) with not much variation between the years (except during extreme drought).
Irrigation Infrastructure Operators (IIO)	An entity that operates water service infrastructure to deliver water for the primary purpose of irrigation.
Long term average annual yield factor (LTAAY)	Expected long-term average annual yield from a water entitlement over a 100 year period.
Low/general security water entitlement	Provide a variable/uncertain water supply. General security provides LTAAY between 42-81%, and low security provides LTAAY between 24-35% in the Murray-Darling Basin.
National Water Initiative (NWI)	The national blueprint for water reform, agreed in 2004 by the Council of Australian Governments (COAG), to increase the efficiency of Australia's water use, leading to greater certainty for investment and productivity, for rural and urban communities and for the environment.
Over-allocation	The total volume of water able to be extracted by the holders of water (access) entitlements at a given time exceeds the environmentally sustainable level of take for a water resource.
Regulated river system	Rivers regulated by major water infrastructure, such as dams, to supply water for varies uses.
Reliability	The frequency with which water allocated under a water (access) entitlement is able to be supplied in full.
Permanent crops	Trees or shrubs, not grown in rotation, but occupying the soil and yielding harvests for several (usually more than five) consecutive years. Permanent crops mainly consist of fruit and berry trees, bushes, vines and olive trees and generally yield a higher added value per hectare than annual crops.
Surface water	Water that flows over land and in watercourses or artificial channels.
Sustainable diversion limit (SDL)	Maximum amount of water that can be taken for consumptive use reflecting an environmentally sustainable level of take (i.e. extractions must not compromise key environmental assets, ecosystem functions or productive base).
Transboundary water	A body of water that is shared by or forms the boundary between two or more political jurisdictions.
Unbundling	The legal separation of rights to land and rights to access water, have water delivered, use water on land or operate water infrastructure, all of which can be traded separately.
Unregulated river system	Rivers without major storages or rivers where the storages do not release water downstream.
Water Act 2007	An Act to make provision for the management of the water resources of the Murray-Darling Basin, and to make provision for other matters of national interest in relation to water and water information, and for related purposes.

Water allocation	A specific volume of water allocated to water (access) entitlements in a given season, according to the relevant water plan and the water availability in the water resource in that season (also known as temporary water).
Water buyback program	Principal government market-based instrument in Australia to produce environmental benefits in deteriorated sites across the Murray-Darling Basin by purchasing water entitlements from willing irrigators. In other words, water, previously allocated for consumptive uses, is reallocated back to the environment.
Water entitlement	A perpetual or ongoing entitlement to exclusive access to a share of water from a specified consumptive pool as defined in the relevant water plan (also known as permanent water).
Water for the Future	A 10-year initiative of the Australian government to better balance the water needs of communities, farmers and the environment and to prepare Australia for a future with less water. Initially, the budget was set at AUD$12.9 billion, which allocated AUD$3.1 billion towards a water buyback program and AUD$5.8 billion towards Sustainable Rural Water Use and Irrigation Infrastructure (SRWUI) projects. Over the years, the budget was increased, primarily for the purpose of the infrastructure program.
Water recovery	Recovering water for the environment through investing in infrastructure to achieve greater efficiency and through the purchase of water entitlements.
Willingness to pay/accept	The acceptable bid amount that an individual is prepared to pay/receive for acquiring/giving up the good in question.

Appendix A

Table A.1 Summary of selected water market economic studies

Study	Methodology	Detail
THEORETICAL MODELLING STUDIES		
Peterson, D., Dwyer, G., Appels, D. and Fry, J. 2004. Modelling water trade in the southern Murray-Darling Basin. Productivity Commission Staff Working Paper. Melbourne: Productivity Commission.	Computable general equilibrium (CGE) model analysis of the Impacts of reductions of 10, 20 and 30% in water availability in the sMDB under conditions of no trade, intra-regional trade only, and both intra- and interregional trade	The model estimates that moving from no trade to intra- and interregional trade together more than halves the impact of the reductions in water on the gross regional product in sMDB, and moving from no trade to intra-regional trade lessens the impact by 35-42%. Including interregional trade reduces it another 22 to 24%. Modelled value of trade from 1997-98 to 2001-02.
Qureshi, M.E., Shi, T., Qureshi, S.E., Proctor, W. 2009. Removing barriers to facilitate efficient water markets in the Murray-Darling Basin of Australia, Agricultural Water Management, 96, 1641-1651.	Irrigation water demand optimisation model	1) Reduction in water market barriers in the sMDB would increase annual net returns significantly 2) Expanding from intraregional trade to interregional trade
NWC 2010. The impacts of water trading in the southern MDB: an economic, social and environmental assessment. National Water Commission, Canberra.	CGE model was used to estimate the aggregate economic impacts of water trading at the regional, state, sMDB and national levels	Found water trading in the sMDB increased Australia's gross domestic product in 2008–09
Mallawaarachchi, T, Adamson, D, Chambers, S & Schrobback, P 2010, Economic analysis of diversion options for the Murray–Darling Basin Plan: Returns to irrigation under reduced water availability, report for the MDBA, Risk and Sustainable Management Group, School of Economics, UQ.	Partial equilibrium model	Assessed allowing water trade inter-regions with reallocation of water from consumptive to environment in the MDB allowed increased gross value of production
Adamson, D, Quiggin, J & Quiggin, D 2011, Water Supply Variability & Sustainable Diversions Limits: Issues to Consider in Developing the Murray-Darling Basin Plan, RSMG, School of Economics, The University of Queensland.	State contingent modelling	Modelled 2,900GL transferred to the environment with trade occurring within the identified northern and southern Basin occurs. It found that 23% less water will be available for irrigation diversions which will cause the area irrigated to contract by from between 16-22%. The reduction in plantings will reduce the gross value of irrigation by about 11-13% and economic returns by 10-14%. Flow to the Coorong was modelled to increase by 30-41%.
Grafton, R and Jiang, Q 2011, 'Economic Effects of Water Recovery on Irrigated Agriculture in the MDB', Australian Journal of Agricultural and Resource Economics, 55, 487-499.	Hydro-economic model	Results indicate that substantial reductions in surface water extractions of up to 4,400 GL per year impose only a moderate reduction on net profits in irrigated agriculture

ABARES (Australian Bureau of Agricultural and Resource Economics and Sciences) 2011. *Modelling the economic effects of the Murray-Darling Basin Plan.* Report prepared for the MDBA. ABARES project: 4311 (November).	Comparative static partial equilibrium model	Simulates water trading both within and between MDB regions, using census data from 2000-01 and 2005-06. Estimated a range of scenarios of water reallocation, before and after interregional trade. For example, Scenario 2 assessed 2,800 GL SDL with Cwlth investment in infrastructure, with and without trade.
Wittwer G. (2011) Confusing Policy and Catastrophe: Buybacks and Drought in the Murray–Darling Basin, The Economic Record, Volume 30, Issue 3, Pages: 289-430	CGE modelling	The irrigation output loss is about half the loss based on a direct calculation using database weights (i.e., 1.9 per cent for drought instead of 3.4 per cent, and 0.7 per cent for buybacks instead of 1.4 per cent). This reflects water moving to other uses: the average product of water is higher in perennials than in rice, so through water trading, rice output will fall by a larger percentage than the fall in overall water availability resulting from either drought or buyback." He also concludes that some capital and labour in irrigation "moves into dry-land production as water availability falls. This in turn explains the smaller modelled impact shown in column (2) 2.7 per cent) relative to the direct impact (column (1), 3.3 per cent) of drought on dry-land output. Similarly, dry-land output increases relative to forecast in the buyback scenario"
NWC, 2012. Impacts of water trading in the southern Murray-Darling Basin between 2006-07 and 2010-11. NWC, Canberra.	CGE model - Modelled without access to water trade in the sMDB. CGE - Modelled expanded intra-and inter regional trade as a consequence of National Water Initiative reforms in the sMDB.	1) Examines aggregate economic effects of water trade on irrigator water adjustment within and across irrigation regions from 2006/07 to 2010/11. 2) NWI institutional reforms were estimated to have reduced the impact of drought within the sMDB from $11.7 billion to $7 billion over the 2006/07 to 2010/11 period—with higher magnitude benefits being incurred during exceptionally dry years when the need to reallocate water was highest
Wittwer, G., Griffith, M., 2011. Modelling drought and recovery in the southern MDB. Aust. J. Agric. Resource. Econ. 55, 342–359.	CGE modelling	The prolonged drought from 2006–07 to 2008–09 in south-eastern Australia presented severe difficulties for dry-land and irrigation farmers in the southern Murray-Darling basin. A dynamic multi-regional computable general equilibrium model (TERM-H2O) is used to estimate the economy-wide small region impacts during and after drought. Drought reduces real GDP in some small regions by up to 20 per cent. Irrigation water trading and farm factor movements alleviate losses. The drought results in an estimated 6000 jobs being lost across the southern basin. Depressed farm investment during drought results in farm capital not returning to baseline levels after drought. Consequently, job numbers in 2017–18 remain 1500 below forecast in the southern basin.
Banerjee, O. 2015. Investing in recovering water for the environment in Australia's Murray-Darling Basin, International Journal of Water Resources Development, 31:4, 701-717	CGE modelling Murrumbidgee	Assumed that half of compensation is respent locally and find "positive impact on GRP is attributed to the increase in government expenditure in the region and the increase in output from a few sectors, including construction, communications and business services." "Considering the results for the Murrumbidgee, real GRP, household consumption, employment, wages, imports and aggregate capital stock increase".
Wittwer, G. & Dixon, J. 2013. Effective use of public funding in the Murray-	CGE modelling	Policy instruments designed to increase environmental flows in the Murray–Darling Basin are compared using

Darling Basin: a comparison of buybacks and infrastructure upgrades, Australian Journal of Agricultural and Resource Economics, 57(3): 399-421.		TERM-H_2O, a detailed, dynamic regional CGE model. Voluntary and fully compensated buybacks are much less costly than infrastructure upgrades as a means of obtaining a target volume of environmental water, even during drought, when highly secure water created by infrastructure upgrades is more valuable. As an instrument of regional economic management, infrastructure upgrades are inferior to public spending on health, education and other services in the Basin. For each job created from upgrades, the money spent on services could create between three and four jobs in the Basin.
APPLIED ECONOMIC STUDIES		
Study	**Methodology**	**Detail**
Qureshi ME, Schwabe K, Connor J, Kirby M. 2010. Environmental water incentive policy and return flows. Water Resourc. Res. 46(4).	Theoretical model and analysis of irrigation data	Found that when incentive programs involve water savings being split between irrigators and the environment and there are high rates of return flows, efforts to generate water for the environment through increases in irrigation efficiency can actually reduce net water available for the environment substantially.
Loch A, Wheeler S, Boxall P, Hatton-Macdonald D, Adamowicz WL, Bjornlund H. 2014a. Irrigator preferences for water recovery budget expenditure in the MDB Australia. Land Use Pol. 36: 396-404.	Statistical analysis of irrigator survey records	Analysed over 950 irrigator survey records in the southern MDB to highlight where irrigators would prefer to have water recovery money spent. Contrary to popular beliefs, there is almost as much support for market- based options (e.g. allocation trade, leasing, water entitlement buyback) as irrigation infrastructure expenditure.
Wheeler S, Cheesman J. 2013. Key findings from a survey of sellers to the Restoring the Balance programme. Econ. Pap. 32:340–52	Statistical analysis of irrigator survey records	Analysed 589 records of irrigators who had sold permanent water to the federal government. Key findings included: Almost 80% of irrigators surveyed said they believed their decision to sell water had been an overall positive decision and had not had to make any changes on farm. Those that did make changes, did the following: This includes an increase in buying water allocations, increasing irrigation efficiency, changing crop mix, utilising carry-over more, increasing off-farm employment, with a small percentage of people buying water entitlements again. Also, many of those who sold all their surface water to the Commonwealth were moving into retirement (hence scaling down anyway), while some were employing other methods (e.g. utilising groundwater sources) to enable them to keep farming. 30% sold water for debt reasons. Irrigators who sold water only historically had used 75% of their entitlements on average.
Wheeler S, Zuo A, Bjornlund H. 2014b. Investigating the delayed consequences of selling water entitlements in the Murray-Darling Basin. Agric. Water Manag. 145:72–82	Log-linear pooled cross-sectional analysis	Modelling was conducted on 1,893 irrigator survey records in the southern MDB from 2008-09 to 2010-11. It suggests that to date, many irrigators who sold water to the Australian Government and continued farming in the southern Murray-Darling Basin have predominately sold their surplus and buffer water (water not used in production). There is only weak evidence from the regression modelling to suggest that there is a lagged negative impact on net farm income from selling water entitlements, which supports the notion that the reduction in farm production has been offset by many irrigators using water sales proceeds to reduce debt (and hence interest payments), restructure and reinvest on farm.

Wheeler S, Zuo A, Hughes N. 2014c. The impact of water ownership and water market trade strategy on Australian irrigators' farm profitability. Agric. Syst. 129:81–92	Fixed effects panel regression models	This study uses irrigation industry survey data collected over a five year period from 2006/07 to 2010/11 (n=3,428) across the Murray-Darling Basin to investigate the relationship that water trade strategy and water ownership have with farm viability (namely farm net income and rate of return). It was found that the actual volume of water received (which is a measure of water allocations for that region and size and security of water entitlements) is a more significant and positive influence on net farm income than water ownership per se, with this result most strongest in the horticulture industry. Water reliability is not as important in the broadacre industry as other industries. Selling water allocations was a significant and positive influence on higher net farm income and rates of return. Buying water entitlements was sometimes associated negatively with farm viability in our time period, with no statistical significance found for the impact of selling water entitlements on farm viability in the current year.
Kirby M, Rosalind Bark, Jeff Connor, M. Ejaz Qureshi, Scott Keyworth, (2014) Sustainable irrigation: How did irrigated agriculture in Australia's Murray–Darling Basin adapt in the Millennium Drought? Agricultural Water Management, 145, Pages 154-162.	Econometric analysis of ABS census data	Averaged across crops the studies find as little as 0.1% reduction in farm production revenue to around 0.6% for each 1% reduction in water allocation with significant variation by crop
Connor, J, John M. Kandulu, Rosalind H. Bark, 2014. Irrigation revenue loss in Murray–Darling Basin drought: An econometric assessment, Agricultural Water Management, 145, 163-170.	Econometric analysis of ABS census data	Comparison revealed that marginal revenue changes in response to water allocations estimated are much less than those implicit in other economic assessments of water scarcity impacts for the same basin that used different methods.
Seidl, C, Wheeler, SA & Zuo, A 2020, Treating water markets like stock markets: Key water market reform lessons in the Murray-Darling Basin, Journal of Hydrology, vol. 581	Statistical analysis of irrigator survey records	This study uses a survey of 1,000 southern MDB irrigators and 63 interviews with water experts. Results: "MDB water markets have evolved and matured: market participation has increased, and new trading products, ownership and trading strategies have developed with non-landholders actively trading water and fulfilling important market functions. Many stakeholders, including non-landholders, prefer to own most of their water needs in higher security water entitlements and use temporary trade to mitigate water supply shortfalls. Non-landholders act as major sellers of leases, forwards and parking to irrigators, potentially having positive market impacts."
Settre, CM, Connor, JD & Wheeler, SA 2019, Emerging water and carbon market opportunities for environmental water and climate regulation ecosystem service provision, Journal of Hydrology, vol. 578	Dynamic hydro-economic simulation	Findings "indicate possible synergies in joint provision of carbon sequestration and environmental flow benefits through a carbon-water trading strategy." For example, funds for environmental water purchases could be generated through sale of carbon credits from improved floodplain conditions.
Zuo, A, Qiu, F & Wheeler, SA 2019, Examining volatility dynamics, spillovers and government water recovery in Murray-Darling Basin water	VARX-BEKK-GARCH time-series regression analysis	It was found that the temporary water market was more volatile than the permanent market. Persistency in volatility only exists in permanent markets. Water scarcity is the main driver of temporary water prices and water market prices mainly influence permanent.

markets, Resource and Energy Economics, vol. 58		Results suggest a negative impact on temporary volume-traded from government water recovery.
Haensch, J, Wheeler, SA & Zuo, A 2019, 'Do neighbors influence irrigators' permanent water selling decisions in Australia?', Journal of Hydrology, vol. 572, pp. 732-744	Probit regression models	Results suggest that irrigators' decision to sell permanent water to the government is influences by their neighbours selling decision. Factors of rural community decline were not associated with higher permanent water sales.
Wheeler, S, Zuo, A & Kandulu, J 2020, What water are we really pumping? The nature and extent of surface and groundwater substitutability and implications for water management policies, Working paper, University of Adelaide, Centre for Global Food and Resources.	Panel regression models	Findings show significant inter-dependencies between ground and surface-water resources: 1) groundwater bores located closer to surface-water sources were associated with more use; 2) higher surface-water allocations, an indicator of surface-water availability, was negatively associated with groundwater use; 3) an increase in the price of surface-water allocations was associated with an increase in groundwater use; and 4) an increase in trading volumes for both water allocations and entitlements in the surface-water market were associated with an increase in groundwater use.
de Bonviller, S, Wheeler, S & Zuo, A 2020, The Dynamics of Groundwater Markets: Price Leadership and Groundwater Demand Elasticity in the Murrumbidgee, Australia, Agricultural Water Management, Vol 239, p. 106204	VAR-X model	Results confirm existence of a substitution effect between surface and groundwater. There is a significant price leadership phenomenon from surface water markets to groundwater markets. The price of groundwater and its quantity traded were dependent on the price and quantity of the surface water traded. Therefore, the need for an integration of water policy that applies to both surface and groundwater resources is imperative. Conjunctive management of water resources is warranted.

Appendix B

Table B.1 Summary statistics for variables used in MNL regression, 2015-16 sMDB (note: n=881 due to missing answers in some independent variables)

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Cluster 1: Water allocation buyer	881				
Cluster 2: Water entitlement buyer	881	0.066	0.248	0	1
Cluster 3: Water seller	881	0.073	0.260	0	1
Cluster 4: Irrigators switching from irrigation to dryland	881	0.180	0.385	0	1
Cluster 5: Irrigator carrying over water	881	0.380	0.486	0	1
% of irrigation area with sprinkler irrigation	881	13.901	30.410	0	100
% of irrigation area with spray or drip irrigation	881	17.724	36.323	0	100
Total area of irrigated land in hectares (ln)	881	4.354	1.665	-0.905	8.987
Total water ownership, LTAAY (ln, ML)	881	5.307	2.052	-2.303	10.342
Number of full-time employees	881	2.616	3.380	1	60
Have a whole farm plan (0=No 1=Yes)	881	0.762	0.426	0	1
Debt to equity ratio	881	0.320	0.457	0	7
Net farm income (ln, AUD)	881	9.596	3.954	0	12.429
Average end season allocation % in the past five years for high security entitlements	881	0.981	0.025	0.93	1
Average end season allocation % in the past five years for general and low security entitlements	881	0.319	0.400	0	0.92
Industry: Horticulture (reference)	881				
Industry: Broadacre (1=broadacre; 0=otherwise)	881	0.284	0.451	0	1
Industry: Dairy (1=dairy; 0=otherwise)	881	0.198	0.398	0	1
Industry: Livestock (1=livestock; 0=otherwise)	881	0.217	0.412	0	1
Age	881	58.540	11.321	25	90
Number of children	881	2.808	1.369	0	10
% of income from off farm work	881	23.974	30.304	0	100
Have a successor dummy (1=successor; 0=otherwise)	881	0.409	0.492	0	1
Agreement level on water stress to affect day to day farming life[1]	881	3.867	1.013	1	5
Agreement level on finance stress to affect day to day farming life[1]	881	3.373	0.816	1	5
Attitude: farming is only occupation[1]	881	3.971	0.955	1	5
Attitude: new technology[1]	881	4.193	0.932	1	5
Attitude: risk taker for farming business[1]	881	3.065	1.297	1	5
Attitude: farming all about financial gain[1]	881	2.482	1.228	1	5
Drought dummy[2]	881	0.253	0.435	0	1
Long term annual temperature (30 years)[3]	881	23.674	1.122	19.118	25.583
Long term annual rainfall (30 years)[3]	881	373.779	74.133	257.537	749.556

[1] Attitudinal statements are measured by Likert scales from 1=strongly disagree to 5=strongly agree.
2 Drought is the 10th percentile rainfall deficiency for the statistical local area (SLA) of the farm, based on 12 month rainfall deficiency grids prior to Oct 2015, through a special request from the Bureau of Meteorology.
[3] Temperature and rainfall data are over 30 year period (1986–2015), through a special request from BOM.