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Managing Water for Environmental Provision and Horticultural Production in South Australia's Riverland

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Abstract: This paper outlines and analyses preliminary research in South Australia's Riverland, part of Australia's largest river system, the Murray–Darling Basin, and one of the nation's most important horticultural production areas. It focuses on the Renmark Irrigation Trust (RIT), which supplies water to c570 irrigators. Management of the Basin is controversial, with conflicting demands from stakeholders, including smallholder irrigators, broadacre farming, indigenous groups, and the environment. Climate change and the water market have contributed to uncertainty over environmental sustainability. Using sequential mixed methods, including a questionnaire survey, focus groups and interviews, we investigate the chief risks perceived by irrigators and their future-plans in face of concerns over variable water flows and economic uncertainty. We highlight the RIT's contribution to river restoration and investigate its plans for additional on-farm water stewardship. We reveal high levels of uncertainty among irrigators regarding their future viability, including unintended consequences from the water market, the controversial role of water brokers, and environmental viability of the river system. The growth of 'lifestyle blocks' occupied by hobby farmers has added both to landscape diversity and fragmentation. To maintain a resilient horticultural industry, there may need to be adjustments to water management in the Basin to protect smallholders' livelihoods whilst continuing to meet specified environmental needs.

Keywords: Murray–Darling Basin; Riverland; water market; irrigators; horticulture; environmental watering

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1. Introduction

Around one-third of the food and fibre produced by Australian farmers comes from the Murray–Darling Basin (MDB), which contains Australia's largest river system and has been termed the country's 'food bowl'. It is the twentieth largest river catchment in the world and one of the world's major drainage basins, covering 1,061,469 km^2, with 770,000 km of river channels. It includes Australia's longest river, the Murray (2530 km), 22 major catchments, and accounts for 70% of the country's agricultural water use, almost 50% of its irrigated agricultural production value, and contributes AUD 22 billion to the Australian economy [1]. It is of critical significance to the country's rural and export economies, generating 40% of Australia's agricultural produce. The MDB also contains 16 internationally recognised and protected wetlands, 120 species of waterbirds, more than 50 native fish species and 35 endangered species, in addition to 40 different groups of indigenous peoples who rely on its water to maintain traditional practices. Yet, its management has been the subject of much contentious debate and controversy, with the interests of the four states (New South Wales, Queensland, South Australia, Victoria) and one territory (Australian Capital Territory), in which the MDB is located, often competing both with one another and various stakeholders. The latter include environmental groups and indigenous peoples [2,3].

Much of the argument regarding sustainable management of the MDB has focused on obtaining a balance between the competing uses for water, especially for irrigation and for maintaining thriving ecosystems [4–6]. In the last three decades, it has been recognised that this balance is being affected by climate change, generally bringing drier, hotter conditions, and more extreme weather events [7–11]. For example, Garnaut [12] predicts that the MDB will lose half its irrigated agricultural output by 2050 and over 90% by 2100 through drought, decreased rainfall and runoff.

Integrated catchment management has been practised since 1986 with the creation of the Murray–Darling Basin Commission (MDBC), which attempted to address Basin-wide problems, especially water sharing between states and users, and rising salinity in the lower reaches of the Murray. It introduced a natural resource management strategy, with lofty strategic aims premised on collaboration between government and communities [13,14], but was ultimately unable to produce solutions to meet conflicting needs of stakeholders. It was superseded by the Murray–Darling Basin Authority (MDBA), established in December 2008, which oversees and regulates water use within the Basin through a partnership between federal government, the four states and a territory.

The MDBA established a Plan in 2012 intended "to bring the Basin back to a healthier and sustainable level, while continuing to support farming and other industries for the benefit of the Australian community" [15]. This has attempted to balance the needs of various sectoral interests and the ecology of the river system [16–18], setting the amount of water taken from the Basin each year, via local water plans and water resource plans. It includes the concept of 'water for the environment,' whereby federal and state environmental water holders decide when, where and how much water is released for environmental purposes that have measurable outcomes [19,20].

This paper focuses on one part of the Basin, namely, the Riverland of South Australia, drawing on a case study of the Renmark area, close to the border with Victoria (Figure 1). The Riverland is one of the most important areas of agricultural production in Australia, accounting for nearly one-quarter of the country's wine grape crush, nearly one-fifth of its almond harvest, and 7% of its fresh stone fruit. Agriculture is the main employer. Hence, any threat to water supplies could have huge consequences for the region, threatening the future of farming and the livelihoods of all its communities. There is an urgent need for greater understanding of how farmers reliant on water from the river system are dealing with the regulations imposed by the Basin Plan, the ongoing variability of the markets for their produce, and the threat posed by climate change alongside various other risks to their businesses. How farmers are responding to risk is determining the dynamic land use pattern across the region, and so identifying the risks and the factors affecting decision making at the farm level is vital to addressing the future trajectories of farming, the riverine environment and local communities.

In Renmark, land use is dominated by irrigated horticulture, with owner-occupier smallholdings. The aim is to understand how the irrigators are responding to risks posed by variable economic conditions, climate change and implementation of the Basin Plan. The paper starts by outlining the study area and methodology employed in investigating decision making and farming activities. It then concentrates on a particular entity, the Renmark Irrigation Trust (RIT), its recent initiatives to improve local ecosystems, and the impact of policies, climate change and the changing economy on its members to whom it supplies water. These are irrigators who mostly operate holdings <15 ha. The implications of these results on the future of farming in the study area and for the wider MDB are then discussed.

Figure 1. The Murray–Darling Basin.

2. Materials and Methods

2.1. The Study Area

Renmark (34.18° S, 140.75° E; population c10,000) is located 250 km north-east of the state capital Adelaide and is 460 km from the terminus of the river system. Water from the river Murray is supplied by the RIT to irrigators farming a total area of c4700 ha. Renmark was founded in 1887 as the first irrigation settlement in Australia [21], originally with 15-acre (6-ha) lots. Irrigators acquired a water right and part ownership of the water supply infrastructure, becoming ratepayers liable to pay annually to the RIT for their water supply. Today the Trust manages over 140 km of piping infrastructure and, as of early 2022, had c570 members (irrigators). The paper uses quantitative and qualitative data from a sample of RIT members to understand the responses to risks faced by irrigators and issues regarding sustainable supply of water in the MDB, especially measures taken to maintain the Basin's distinctive ecosystems.

The RIT, constituted by a statute of the South Australian Parliament assented in December 1893, is a key element of the institutional framework. The statute gave irrigators entitlement to water rights and protected the interests of landholders who had taken up and developed irrigated land in Renmark. The Trust owns the pumps and pipes that deliver water to its members. The majority of farm properties, locally termed 'blocks,' are either owned or managed by individual families. RIT membership extends to all who hold land in the areas serviced by its pumps and pipes. The average scale of irrigation operation is small, averaging less than 10 ha per farm, though the granting of water licences was once likened to an opportunity to "turn water into gold" and it has brought economic growth and development [22]. Over time, the Trust has promoted significant efficiencies in water usage, through improvements to infrastructure, moving almost completely away from flood and furrow irrigation to either drip irrigation or under-tree sprinklers, and installing and running new pipes.

The river Murray supports unique habitats, critical to the survival of more than 120 waterbird species and more than 50 native fish species. Hence, one of the ideas underpinning the concept of 'water for the environment' is to keep the river, its wetlands and its floodplains healthy. Actions of the RIT (see below) in ensuring more water is released into the creeks and streams feeding the river have produced noticeable increases in native fish, frog, and waterbird species. These are crucial to the well-being of the riverine ecosystem. The vegetation type on the floodplain (generally from 5 to 12 km wide) is Mallee, i.e., trees and shrubs, mainly certain species of eucalypts (notably river red gums), usually to a height of no more than 10 m.

The climate supports a broad range of Mediterranean-type fruit and vegetables, with hot dry summers and cool winters. Mean annual rainfall is only c270 mm, mainly falling in winter, so that irrigation is essential for crop production. Long summer sunshine hours ensure fruit ripens fully. Low relative humidity helps restrict crop disease. Mean daily temperature in January is 26 °C (mean high = 34 °C, mean low = 18 °C) and in July it is 10 °C (mean high = 16 °C, mean low = 5 °C) [23]. Irrigated agriculture dominates the local economy and that of the wider Riverland region, contributing one-third of the value-added production and half of goods and services exported [24]. In the first half of the 20th century, Renmark was a major producer of dried fruit, but this has suffered from foreign competition, so that today the main crops are wine grapes, citrus, almonds, and stone fruits (notably nectarines, peaches and apricots), alongside Asian vegetables (e.g., Bok Choi), avocados, persimmons, pistachios, figs, cherries and dates.

2.2. Methods

The research conducted draws broadly upon structuration theory, developed by Giddens [25]. The theory helps one understand how irrigated agriculture is shaped by human agency (human action) working within existing institutional processes and structures. Such human agency has the capacity to alter or create new structures and processes to develop new outcomes [26]. In the context of irrigated agriculture, human agency refers

primarily to the irrigators themselves but also other 'agents' such as water brokers and decision makers such as the board of the RIT and farm advisors who influence agendas and the outcomes generated. Institutional processes in this study include overarching legislative and regulatory frameworks linked to the management of water in the MDB, including the operation of the water market. The latter is described by Pahl-Wostl [27] as a strong neo-liberal market-oriented policy, though with the government as a 'meta-governor' to deliver environmental and social objectives, e.g., via plans to ensure sufficient 'water for the environment' [28,29].

This paper reports on preliminary research that follows a previous investigation conducted in February 2009 on RIT members' response to the Millennium Drought [30–32]. The initial follow-up research was conducted in late 2021/early 2022 focusing on human agency by using a sequential mixed methods approach [33]. We began by asking all members of the RIT to complete a questionnaire survey. The questions were pre-tested and refined in a survey forming part of a related project [34]. Some questions referring directly to the role of the RIT were inserted at the request of the RIT management. The questionnaire could be completed online or in hard-copy, with the latter returned to the authors via a stamped addressed envelope. The response to the survey generated a 12% sample of members of the RIT (n = 69). Whilst this is a small proportion of the membership, the prime intention was to generate a sample enabling analysis that would generate findings from which future research could be developed (see below). Though this raises the issue of the sample's representativeness, in terms of the crops grown by the sample respondents, the balance of crop types shown in Table 1 closely resembles agricultural census data for the study area in terms of the proportion of farms with different types of crop.

Table 1. Crop and livestock types on the sample farms.

No. of Farms			No. of Farms			No. of Farms		
Crop	***n***	**%**	**Crop**	***n***	**%**	**Crop**	***n***	**%**
Wine Grapes	39	56.5	Pistachio	6	8.7	Vegetables	3	4.3
Citrus	11	15.9	Misc. fruit	5	7.2	Peach	3	4.3
Apricots	10	14.5	Almonds	5	7.2	Figs	2	2.9
Livestock *	8	11.6	Avocados	4	5.8	Wood	1	1.4
						Hay	1	1.4

* Horses 4, Chickens 3, Sheep 2, Pigs 2, Geese 1. NB. As there are some farms with more than one crop type, $\Sigma n > 69$.

In the questionnaire, respondents were able to indicate if they were willing to participate in a subsequent interview or focus group. So, from those agreeing to participate, five mini-focus groups of two to four members each were selected. These focus groups were conducted in late 2021, with the groups stratified by crop type. There were also five interviews with board members and employees of the RIT. Focus groups and interviews were transcribed and checked for accuracy by participants. This combination of quantitative and qualitative data helped develop deeper understanding and insight into farmer decision making. The findings from focus groups/interviews helped explain and elucidate quantitative data obtained from the questionnaire survey earlier that year [35]. The quantitative data provided descriptive information on broad patterns while analysis of qualitative data generated the key themes discussed herewith and enable reflection upon interviewees' experiences to produce greater depth of enquiry [36].

As summarised in Table 2, the questionnaire survey focused on information regarding the farm and the farmer, including the type of farming, farmers' attitudes to risk and decision making, recent and planned changes to farming activities, and irrigation and water-use practices. All respondents were asked about their views of pro-environmental actions being taken by the RIT and their own on-farm pro-environmental actions. However, this paper is driven primarily by the qualitative data, with the quantitative data providing additional descriptive statistics. The authors conducted a theme-based analysis of the transcripts by coding their content to relevant themes [37]. The focus groups and interviews

enabled the participants to focus on and develop their thinking about the management and sustainability of their farm, the role of the RIT, and Basin management. They could expand on the responses they had provided in the questionnaire, highlighting risks, the role of the MDBA in managing water supplies and the water market, market volatility for farm produce, motivations in managing the farm, the potential for future management changes, and the role of the RIT in promoting sound water management and maintaining a healthy river. The themes recognised emphasise the role of human agency (decisions by irrigators), which is, however, constrained by decisions of other agents (e.g., water brokers, farm advisors) and structures (government policies, regulations, the water market). Quotes from transcripts are utilised to illustrate the three principal themes identified, which were the future of smallholder irrigators, problems associated with water trading, and environmental watering. These are now addressed in turn as the principal results from this preliminary research.

Table 2. The questionnaire survey.

Sections	Theme
1	Information about the farmer and the farm/property.
2	Details of agricultural production and marketing.
3	Government support.
4	Protection of cultural heritage, including relevant certification.
5	Tourism on the farm.
6	Current or potential risks to the farm.
7	Factors affecting decision making.
8	The future of the farm.
9	Irrigation and water use practices, including water trading and views on the water stewardship program.

3. Results

3.1. A Future for Small Irrigators?

Of the 69 respondents to the questionnaire survey, 49 (71%) had a single crop specialisation, of which 29 (42%) specialised in wine grapes. Table 1 shows the various crops and livestock on the sample farms, while Tables 3 and 4 show the distributions for age and farm size. For 84.4% of the respondents, all or the majority of their holding was irrigated to support crops. Just 7.8% had no irrigation water at their disposal either because they were on a property where water had been removed in an exit package (first introduced in 2008) [38] or they had deliberately sold their water entitlement. An example of the latter was a farmer who had ceased farming commercially in retirement and now described themselves as a hobbyist but not using irrigation. In total, exit grants took out 276 ha in the Renmark area in the early 2010s, with 44 ha subsequently reinstated [39]. Re-establishing cultivation on this land can be difficult depending on the arrangements made for future water provision for that block. In some cases, newcomers have to pay to access and reconnect the water supply, and the small size of blocks may also act as a deterrent for newcomers wishing to farm commercially. However, it was noted by one interviewee that growers who sold their property were tending to maintain their water entitlement, so they became a temporary market operator.

Table 3. Distribution of age on the sample farms.

Age (Years)	*n*	%
65+	18	26.5
56–65	35	51.5
46–55	11	16.2
36–45	1	1.4
35–	3	4.4
Total	68	100

NB. One respondent did not state their age.

Table 4. Distribution of farm size on the sample farms.

Size (ha)	*n*	%
<5	26	38.8
6–10	17	25.4
11–15	6	9.0
16–20	7	10.4
21–50	8	11.9
>50	3	4.5
Total	67	100

NB. Two respondents did not indicate their farm size.

Among the sample irrigators, relatively little change had occurred on their blocks between 2016 and 2021, with just eleven (15.9%) reporting changes, one of whom was a new entrant. The main change was introducing or increasing the area under pistachios at the expense of stone fruit, as pistachios are less labour intensive. This did not necessitate purchasing additional water (quotes #1 and #2, Table 5). Diversification was seen as a key strategy to reduce risk, hence the planting of pistachios to reduce previous reliance on grapes, though there is a six-year wait for new trees to start cropping. However, there was substantial concern and uncertainty regarding the future. Only 24 irrigators (34.8%) were planning no changes to their farm in the next five years while 38 (55.1%) expressed uncertainty about possible changes (quote #3, Table 5). Just seven (10.1%) were intending to expand production and 36 (52.2%) were either uncertain whether they would still be farming in five years or stated they would no longer be farming. Only six respondents envisioned expanding their farm business in the next five years, with one of these intending to move into full-time dryland agriculture elsewhere. Two of those planning to expand were amongst the larger farmers in the sample (each with c50 ha), who were wine grape growers intending to benefit from greater economies of scale.

The ability to switch from one crop to another is limited by the sunk costs associated with many of the crops currently grown. For example, replacing existing fruit and nut trees or vineyards with a different crop can be costly and a new crop may take time to become productive and generate income. Hence, for most of the smallholders, diversification often starts on a small scale, for example, by initially replacing older fruit trees whose yields are decreasing. Large operators with more capital may be able to move into a new area of production more easily, as they are more likely to have greater capital reserves. This helps explain the move into almond production, typically occurring on some of the largest and most commercially operated holdings in the district.

Several respondents explained that they simply could not expand their operations, as they were constrained by the size of their block: "There's nowhere to expand to and I'm nearing retirement" (male, 60s, part-time, growing pistachios); "The land is at full capacity and I cannot expand" (male, c60, full-time, growing wine grapes); "Our current land is 100% developed" (male, 60s, part-time, growing citrus). Using Seidl et al.'s [40] classification of irrigators' adaptations to risk into expansive, accommodating or contractive strategies, future contraction was dominant in the sample, a contrast to Seidl et al.'s own study of over 1000 irrigators across the Basin in which expansion was dominant. The more negative views of the future apparent among RIT members may reflect a lack of sufficient financial capital to expand, limitations of small blocks, the high age of many respondents (78% > 55 years of age) and general pessimism about the state of farming and the water market.

Table 5. Selected quotes from focus groups and interviews.

#1	"We have planted a small area of pistachios in the thinking that they don't use as much water as almonds". (Male, 50s, full-time, citrus)
#2	"We're putting in some pistachios. They're a 'hedge.'" (Female, 60s, part-time, wine grapes)
#3	"Those small operators are either supplementing with other income . . . or they're moving out of the business. And there's a social cost to that". (Male, 60s, full-time, apricots)
#4	"Lost markets in China have hurt the wine industry immensely". (Male, 60, part-time, wine grapes)
#5	"I'm very supportive of the regeneration (from farming organically); it is incredible what's happening ... it was kind of a specialise or get out" (Female, 50, certified organic wine grapes and miscellaneous organic fruit)
#6	"I could not afford the high cost of water. When the peak of water pricing occurs, that's when I and people like me will get out of the industry because we can't sustain those costs, even in the short-term, whereas corporates can". (Male, 60s, full-time, apricots)
#7	"The price of water back then (c2010) was $1500 or $1600 a megalitre . . . now it's touching $8000 or so". (Male, 50s. full-time, citrus)
#8	"I can buy a mega litre of water in the Molonglo River next to Canberra. And claim it here, less 10% for evaporation". (Male, 60s, full-time, citrus)
#9	"I think one of the mistakes that we've made nationally is separating water from land. It's made it a tradable commodity; we get investors and all that other stuff". (Male, 60s, full-time, apricots)
#10	"We have a grandson who would love to buy some of our water, we've got excess worth a lot of money. But you know, we'd give it to him. He can't do it . . . can't be done. It's got to go through a broker, who will then put a price on it. So, they'll make . . . they'll take it from us for a little bit of money. The broker will put a price on it, sell it to our grandson, for an exorbitant price". (Female, 60s, part-time, wine grapes)
#11	"Now we own the water, I've got water left over. It's worth money to me. I'm going to sell it. So, it is dragging more out (of the river) unnecessarily". (Male, 60s, full-time, citrus)
#12	"At $7 a kilo average price at four tonnes per hectare, you've got a $28 gross per ha for a full bearing of almonds. And that with our set-up out there, we're only at about 11 meg per ha. But older sprinklers are more like 14 to 15. And while the grapes are only 7, but grapes at an average price this year, lucky to be . . . call it 20 to 25 tonnes a hectare, you're actually talking eight grand a hectare to 28 grand a hectare. So, a little bit more water for a much better return . . . five times the return for almonds". (Male, 40s, full-time, almonds)
#13	"And basically, citrus has declined because of the cost of water. The ones that still keep going. And the ones that, you know, were around when the water was, you know, that when they were given the water. But if you look at the age demographics, they're well into their 60s and 70s now". (Male, 60, part-time, wine grapes and misc. fruit)
#14	"I think this Trust is 25 years ahead of its time. And it's been 25 years ahead of its time for my lifetime . . . the fact that they are prepared to develop the land that's on the books in that environmentally sustainable way, is great for our town". (Male, 60s, full-time, apricots)
#15	"Down in here we've got a quite a low-lying area, so we just filled it all up with water hungry natives and we set up the irrigation to it to get them established first". (Male, 40s, full-time, almonds)
#16	"Child abuse here is if you leave your property to your children". (Female, 60s, part-time, wine grapes)
#17	"The figures we came up with last year was 143 acres (c58 ha) as the absolute minimum to support a generic, you know, four-person family of mum, dad and the two kids". (Male, 60s, hobbyist, wine grapes)

High labour costs were proving difficult for many small growers, though there were also complaints about having to meet new regulations introduced by Fair Work Australia, eliminating much piece-work. There were claims that even inefficient workers must be paid a minimum amount with limited possibilities of dismissing them. It was argued by some that growth in the area under both almonds and wine grapes in the 2010s was partly related to their relatively low labour usage. However, following the Chinese government imposing tariffs of 116–218% on bottled Australian wine imports in March 2021, the loss of the Chinese market for Australian wines was having a negative effect on some grape growers. Exports fell by around 30% between March 2021 and March 2022, with even small suppliers of grapes affected (quote #4, Table 5). Falling prices for wine grapes were encouraging some grape growers to look for alternative crops. Some crops, such as persimmons, mangoes and avocados, were identified as being labour and finance intensive, but potentially very lucrative. There were also various strategies mentioned for controlling the amount of money spent on labour, such as using family members or young locals and paying them via a mixture of hourly rates and piecework.

Climate change was identified as one of the five main risks affecting farming by 26 (37.7%) of the respondents. Several related the risk to relatively recent experience when

historically low river levels were recorded in the Basin in the period 1997 to 2006, with flows up to 50% lower than the long-term mean in South Australia [41]. This coincided with the Millennium Drought, and in 2008 the federal government introduced Small Block Irrigators Exit Grants for owners of <40 ha with at least 10 ML of water available for sale to the government. On exit blocks, all crops and surface irrigation infrastructure were removed, with no irrigation possible on that land for five years [42]. This affected around 7% of the irrigated area under the RIT [43], producing stranded assets or a 'Swiss cheese' effect on land use, with dead trees, vines and bare ground alongside cultivated blocks, possibly precipitating negative environmental impacts on the latter [44]. As citrus prices were generally low at the time, it was citrus growers who were most willing to exit, though across Australia high levels of farm exits without grant encouragement have been recorded in multiple sectors in recent decades [45]. The legacy of other responses to the Millennium Drought is still evident in the form of moves towards organic and unconventional production, i.e., crops previously not widely grown in the area, especially amongst wine grape growers, as 'alternative' crops were regarded by some as offering more water security [46]. The drought also accelerated exit decisions by farmers facing financial difficulties [42]. Interviewees predicted both more exits and further moves into alternative crops if there were future water shortages and/or costs of water rose.

The need to develop strategies to cope with rising costs was a common concern expressed by focus groups and interviewees. One of the small organic wine grape growers noted that the cost of production was higher than that for the larger growers, but that the quality of the product enabled them to compete because of the associated price premium. A similar sentiment was expressed by an organic grower of various fruit crops and wine grapes who had diversified to spread risk. This had enabled her to sell in different markets, again spreading risk, though there were problems with greater incidence of weeds. The move to organic farming was also brought about by the grower having seen organic production elsewhere and being confident that pest management would not be problematic. Only six irrigators in the sample had organic certification, but this was part of a typical broader strategy for the smaller producers, namely, to specialise or to find a point of difference with an 'unusual' crop (quote #5, Table 5).

The high level of uncertainty regarding the future viability of their farms reflected various underlying concerns as voiced to the authors. The main worries were a combination of economic issues, the threat posed by climate change and the management of water in the MDB. In addition to the loss of the Chinese market mentioned by several wine grape growers, oversupply in the market was considered one of five major risks by 25 (36.2%) irrigators, while the power exerted by agribusiness and the large supermarkets was cited by 26 (37.7%). The overall economic situation was cited by 13 (18.8%) irrigators, though 19 (27.5%) referred specifically to living costs. Lack of labour and cost of labour both attracted 14 (20.3%) responses. Dissatisfaction with government policy was expressed by 18 (26.1%) irrigators, but when this was interrogated further, the main concerns expressed related to water trading and the MDB Plan, as discussed in the next section.

3.2. Experiences with Water Trading

While the Millennium Drought had increased uncertainty amongst the irrigators [47], for some respondents this situation is now compounded by their negative views on the water market, concerns over water security and the escalating costs of water. Water costs and the operation of the water market were deemed highly problematic by the focus groups (quotes #6 and #7, Table 5). Research elsewhere in the MDB has also revealed uncertainty amongst irrigators regarding farm-based water decision making [48], though there are also more positive views of the water market [49,50]. In terms of water trading by RIT members, only nine respondents had recently sold water back to the government (four full-time, three part-time, two hobbyists), two specifically under the AUD 240 million Irrigation Industry Improvement Program (3IP) component of the South Australian River Murray Sustainability (SARMS) program, a competitive grants program created by industry

to support the restoration of a healthy MDB environment. From 2014, the 3IP funded 255 projects across four rounds throughout the MDB in South Australia and helped secure 40 GL of water, with 38 sales by RIT members [51]. The various sales illustrate the way the water market has fluctuated: from AUD 180 per ML in 2014 to AUD 11,000 per ML in 2021. While there were no statistically significant relationships between sales and age of farmer, type of farm, and farmer type, the relationship with size of holding was significant at the 0.05 level ($\chi^2 = 4.43$ $p = 0.035$). Irrigators with >20 ha were more likely to have sold water to the government than those with <20 ha.

Only eight respondents (11.6%) recorded purchases of water to irrigate their farm in the 2019 growing season. There were no statistically significant relationships noted, though of the eight, six grew wine grapes, and purchasers tended to be >65 years of age, farming <20 ha. Only full-time and part-time farmers had purchased water. Purchases were made from the RIT, though one respondent used the services of a South Australian rural retailer. Despite purchasing 10ML from the RIT, one irrigator remarked, "It is all too difficult. Water policy is a disaster" (male, >65, part-time, wine grapes).

An unusual aspect of the water market is that since 1994 water licences in parts of the MDB, previously attached to particular plots of land, have been 'unbundled' or traded: "You could own land and sell the water licence that had belonged to it. Or you could own water without owning land. The idea was that if water could be traded, the market would ensure it found its highest-value use" [52] (pp. 13–14). This was extended to South Australia (SA) in the SA Irrigation Act 2009, which separated a water right from the land (i.e., unbundling). The RIT still holds the Bulk Licence or the sum of all members' entitlements and any entitlement owned by the board itself. More entitlement has been traded out of the RIT than in but most of the 11 GL of entitlement traded out has been returned to the Commonwealth (federal government) in exchange for efficiency improvement funding [43] (p. 266). During the Millennium Drought, SA irrigators imported large volumes of water allocations from New South Wales in order to maintain high-value permanent crops, such as wine grapes.

Unbundling was widely criticised by the focus groups, especially the ability to trade water outside Renmark (quotes #8 and #9, Table 5). A wine grape producer who had leased 55 ML from the RIT commented, "The water price is impacting a lot. There should be a set water price for temporary water. Government should help to arrange the water or assist to buy for small farmers" (male, aged 26–35, part-time, wine grapes). However, others felt that the situation was improving as irrigators became more used to the workings of the market, though there was growing concern over the role of water brokers (quote #10, Table 5). Some saw an opportunity to make money by trading in water but did not necessarily regard such transactions as a positive overall for irrigators (quote #11, Table 5) [53].

The reference to water brokers relates to the ability of irrigators to trade in water, which has ushered in a new set of players, the water brokers, who act as middlemen between owners of water and purchasers. The functions of the brokers are to bring buyers and sellers together, reduce search costs, improve information flows and assist in obtaining regulatory approvals. Yet, irrigators contended that growth of buying and selling water has further detracted from the sense of a collective community of irrigators that had previously prevailed ([30], p. 102; [54]). A few irrigators have sold their entitlements and rely on the water market. This seems to be based on unrealistic expectations regarding costs and flows [55], with rising costs of water making life difficult for those reliant on annual purchases. Temporary trading has tended to be linked to times of water scarcity. "In areas where sufficient groundwater quality and quantity is available, irrigators have increasingly sold water entitlements as surplus water to adapt to external changes, meet water demands or meet farm business needs" ([56], p. 338; [57]).

One impact of water trading has been an increase in almond production, with water traded to the highest bidder. Yet, young almond trees are one of the thirstiest crops grown in the area. They have often been planted by large companies who can outbid smallholders for water, and who are responding to growing demand for almond milk

(quote #12, Table 5). One of the larger almond producers cited his reason for growing the crop as simply "the return per megalitre". Although the ability to continue growing this crop may be challenged by climate change if it produces more 40 °C days than at present, there appears to be much confidence amongst the almond growers at present. The Renmark-based grower co-operative Almondco had embarked on a AUD 28.5 million processing plant expansion in the town coincident with numerous recent plantings reaching maturity across all major Australian growing regions. Almondco exports 60% of its products.

One apricot grower admitted he could make more out of trading water than growing apricots. This was also acknowledged in another focus group, one participant arguing that trading in water could enable him to turn his holding into a lifestyle block using very little water, succinctly expressed by the apricot grower as, "And I wouldn't have to work my arse off each summer!" It was argued that for many blocks the value of the water was greater than that of the land and the farmhouse. However, it was acknowledged that if members of the RIT left the land, then a higher cost per remaining member would then occur. Indeed, it was argued that there is already an increasing number of lifestyle blocks contrasting with a small number of larger producers, and those in between are being 'squeezed'.

Despite the fact that in recent years the majority of those in the sample had not engaged in water trading, there were major concerns expressed about the rising price of water and the weak position of the small irrigators should there be a recurrence of drier conditions. Some in the focus groups argued that the rising cost of water was adversely impacting various sectors of production, notably citrus (quote #13, Table 5), though good prices were still being reported for navel oranges.

3.3. Water for the Environment

Responding to growing concerns about the ecological condition of the river and its floodplain, initial environmental actions by the RIT were commenced in 2013 in partnership with the Nature Foundation of South Australia, the local council, the Renmark to Border Local Action Plan, and a local irrigator, using federal environmental water to inundate a wetland (Johnson's Waterhole). Success with this project then encouraged the expansion of the Trust's floodplain rehabilitation program [43] (p. 235).

The Trust also participated in MDB Plan water efficiency programs, with individual members returning 10.9 GL of water to the Commonwealth by 30 June 2018 [43] (p. 236). The Trust signed an agreement with the Commonwealth Environmental Water Holder (CEWH) in 2016 to enable some of this water to be used for floodplain rehabilitation, with the CEWH becoming an irrigation customer of the Trust for an initial five years. This environmental water was largely delivered through Trust infrastructure in the off-peak irrigation season. Commonwealth grants enabled the Trust to deliver environmental water via extensions to its pipelines to the edge of the floodplain, initially for five watering sites, but with plans to cover over 100 ha. At the time of the research, there were twelve active watering sites and an additional four planned to commence by July 2023.

In 2020, for its work in rehabilitating the floodplain, the RIT was awarded platinum certification (the highest such honour) by the international Alliance for Water Stewardship, having received a gold certificate in 2018. It is using its system of pumps and pipes to rewater the 16 sites, in contrast to problems elsewhere in the Basin, where some claim the system is near ecological collapse [52] (p. 97). One of the modest aims of the RIT has been to increase the flow of water going into a local creek by about threefold, which will help remove reeds and stop mosquitos from breeding. Commenting on this and the wider watering program, the Presiding Member of the RIT noted that "It's really like we are using less than a gigalitre to do all of this . . . six or seven hundred MGs, so not a lot of water". Yet, these actions may have significant positive impacts on the riverine environment.

In the focus groups, the views of the irrigators with regard to the RIT's water stewardship were overwhelmingly positive (quote #14, Table 5). A common sentiment expressed by many was that the members of the RIT were "getting the absolute best out of the water", and that its use of water was highly efficient. They also took pride in the water steward-

ship of the Trust and its recognition via international awards. As part of their ongoing commitment to improving the biodiversity and general environmental condition of the area served by the Trust, the RIT is considering expansion of their Water Stewardship program. Respondents were asked whether they might be interested in participating in a simple scheme to validate good water stewardship on their farm. Of those that responded, 60.3% said they were willing to participate. Just five said neither yes nor no, but there was more uncertainty about who could benefit from extending the scheme (Table 6). There was little perceived benefit to individual farms, possibly related to a high degree of uncertainty regarding what the scheme might entail, with over half of the respondents not knowing what benefits might accrue. There was more unanimity regarding benefits for the Trust in extending the scheme, related to the potential for improving its environmental credentials. In total, 58.8% stated that the scheme could benefit the Trust compared with 55.9% for the community and 48.5% for business. However, the proportion expressing uncertainty was >20% for each of these three categories.

Table 6. Perceived beneficiaries of a scheme to validate good water stewardship on individual holdings.

	To Your Farm		To the Trust		To the Community		To Business	
	n	**%**	***n***	**%**	***n***	**%**	***n***	**%**
Yes	19	27.9	40	58.8	38	55.9	33	48.5
No	12	17.6	13	19.1	13	19.1	20	29.4
Uncertain	37	54.5	15	22.1	17	25.0	15	22.1
	68	100	68	100	68	100	68	100

NB. One respondent did not answer this part of the survey.

There was no significant variation in the interest shown by respondents in on-farm environmental actions across full-time, part-time and hobby farmers. Around one-third of the respondents (34.8%) reported they engaged in no such actions (Table 7), but 18.8% engaged in five or more activities. With their smaller blocks, the hobbyists were most likely to have no environmental activities. Overall, the most common actions were minimising use of pesticides and fertilisers (n = 31, 44.9%), preventing soil erosion (n = 18, 26.1%), covering unproductive land (n = 13, 18.8%), and using organic fertiliser (n = 11, 15.9%). Whilst these were considered by many as standard 'good management practices', more active attempts to care for the land included providing habitat for native plants and animals (n = 10), restoring native vegetation (n = 7) and creating wildlife corridors (n = 6). Some of the larger irrigators claimed they were already fully committed to environmental improvements on their land (quote #15, Table 5). Some of this is associated with an 'ethic of care' that was reported in part of the MDB by Head et al. [58] with respect to ethnic minority migrants such as Italians and Greeks who are well-represented in Renmark. However, pro-environmental actions amongst RIT members were reported by members of both minority and majority groups.

Table 7. Number of on-farm environmental actions by farm type.

	Environmental Actions			
	0	**1–4**	**5–8**	**Total**
Hobby farms	7	6	3	16
Part-time farms	8	12	4	24
Full-time farms	9	14	6	29
	24	32	13	69

In what is essentially a productivist landscape, it is not surprising that profit featured as a key desired outcome of respondents' farming businesses (average score 4.17 on a Likert scale from 1 to 5), followed by producing more food/fibre/beverage (4.03). Protecting natural environment/landscape scored 3.45 compared with supporting the local community (3.62) and protecting food security (3.56). However, when asked about the five

main perceived current or potential risks, 26 respondents (37.7%) listed climate change, the third most highly recognised risk after reliability of water supply (n = 53, 76.8%) and lack of sufficient water (n = 31, 44.9%). In part, this reflects the recent memory of the Millennium Drought and the link between this and the drying, warming climate. Economic risks were less prominent, the main ones being oversupply of produce (n = 25, 36.2%), pest and diseases (n = 22, 31.9%) (with an outbreak of fruit fly affecting the region at the time of the focus groups), and the impact of large agricultural businesses/corporations (n = 21, 30.4%).

Climate change featured as one of the five most important options influencing respondents' decisions on their farm, cited by 34 (49.3%), with fears of more severe droughts threatening water supplies. Only two factors recorded higher mentions: access to sufficient water (n = 48, 69.6%) and improving profitability (n = 47, 68.1%). Three business-related factors were the next most important: poor returns (n = 28, 40.6%) and market requirements and improving efficiencies of operation (both n = 26, 37.7%). Concern for the environment/commitment to maintaining biodiversity was cited by just 11 (15.9%) respondents. One of the focus groups noted local adaptation to climate change by wine grape growers, some of whom were experimenting with new varieties, i.e., 'heat-adapted' varieties, such as Vermentino and Fiano (whites) and Sagrantino and Nero d'Avola (reds) [59]. However, other adaptations did not feature in discussion, partly reflecting the key adaptation was already widespread, namely, greater efficiencies of water use through the drip and sprinkler systems championed by the RIT. It should be noted, though, that whilst the irrigators were asked to identify individual risks and factors influencing decision making, climate change, drought and water security are intertwined issues. For example, the potential to increase productivity depends greatly on access to sufficient water.

Concern was voiced that, because of all the plantings of tree crops already in the ground, there will be a massive increase in the demand for water across the MDB during the next 40 years, especially reflecting the planting of almonds since 2015. The ramifications of this are not clear at present, as, at the time of the survey and focus groups, there were plentiful supplies of water in the system. However, a couple of years of poor rains could quickly change this situation. This is one of the reasons why the Almond Board of Australia is arguing for a moratorium on new plantings (already imposed in Victoria). The issue of how much water can be allocated to environmental purposes featured in all the interviews and focus groups, with irrigators recognising the need to balance the various demands being placed on water in the Basin, but with major concerns about their ongoing ability to secure reliable water supplies. Rising prices for water in recent years have some irrigators wondering whether they can afford to purchase water for future crops. Although the majority have entitlements, many plan to lease additional amounts in the summer period. Inconsistent water allocations in New South Wales and Victoria have led irrigators in these states to purchase across the state boundary in South Australia, thereby driving up prices there. One estimate is that the diversion of water for the environment by the federal government has reduced the overall consumptive pool by 20 to 25% [60].

4. Discussion

The combination of responses to a questionnaire survey and subsequent interviews and focus groups highlighted concerns for the future viability of many farms in the Renmark area. In particular, there was a widespread view that the overwhelming majority of the children of irrigators would not wish to inherit the family farm, and nor would the irrigators wish to have their children inherit it (quote #16, Table 5). For many, the experience of the Millennium Drought has left them fearful of future drought, and there were repeated expressions of the need for modifications to the current water market arrangements, which were widely viewed as favouring larger agribusinesses and/or causing water shortages. For example, "It only takes one desperate person—who knows what sort of information [they have] been fed, or how much water is in the system—and all of a sudden, they're removing the water, or purchasing the water, and there seems to be a shortage" (Male, 60s, full-time, wine grape grower from [60]). There have been arguments that only businesses

buying water for farming should be allowed to do so and that only farmers who use water to grow produce should be entitled to carry over water from one season to the next. Irrigators tended to view themselves as having lost power in the operation of water markets: "They're playing within the rules—but the rules have changed to put the balance of power and negotiation away from irrigators and to water owners with no consumptive use" (male 40s, full-time, olive grower from [61]). In contrast, one focus group member argued, "If you do things properly and know your market, 15 acres (6 ha) is actually viable" (Male, 50s, citrus producer).

The issue of how best to manage the MDB to meet the multiple competing demands on water in the Basin continues to be controversial. Under the current MDB Plan, the operation of water markets has seen some water retained in the river system for environmental purposes. The operation of water markets has enabled substantial trading to occur and for new entities, such as superannuation funds, to buy water allocations and entitlements, which was viewed most unfavourably by the smaller irrigators and some observers, e.g., [62]. Moreover, unbundling has meant that, in the market, water does not need to be tied to a specific piece of land. However, as the research described above shows, for many small irrigators, traditionally the mainstay of horticultural production in many parts of the MDB including South Australia's Riverland, the complexity of the water market has added to uncertainties related to the changing market conditions and irregular river flows.

In general, focus group members questioned the effectiveness of the MDB Plan while not explicitly making the argument presented by Grafton and Wheeler [63] that the actual increase in the volumes of water in terms of stream flows is less than claimed. This is partly associated with the argument that subsidies to increase irrigation efficiency have actually reduced stream and groundwater return flows, and that many of the gains from water recovery have accrued as private benefits to irrigators. Yet, "more than a decade after water recovery began, there is no observable basin-wide relationship between volumes of water recovered and flows at the mouth of the river Murray" [63] (p. 487). The focus on greater irrigation efficiency has led to an investment of approximately AUD 4 billion of public money in the modernisation of irrigation infrastructure in the MDB linked to "the policy to return water to the environment without compromising agricultural productivity" [64] (p. 2).

The focus groups and other surveys of irrigators [65] revealed preferences for targeted trade in water to yield water for environmental purposes. There are also preferences for investment in infrastructure, as this is associated with direct private benefits and improved irrigation efficiency. Reduced transaction costs may be benefiting irrigators [66]. However, the complexities of water trading and the market in water have led to irrigators perceiving significant mistakes being made in both sales and purchases by individuals [67]. These mistakes can prove costly when water prices rise as supply varies. Trade by environmental water holders may also have detrimental impacts on irrigators [68], so it is unsurprising that irrigators are increasingly expressing concerns about the impacts of the MDB Plan, with views that they are experiencing an unfair share of the costs of the reforms. Lack of trust in the national water agency and the federal government has also risen over time [69]. The uncertainties over water supplies to the smaller irrigators have caused rising psychological distress, which has been at its highest levels amongst horticulturalists [70].

A more positive view is presented by Grafton et al. [71], who argue that water markets have helped deliver improved environmental outcomes; assisted irrigators' adaptation responses to climate risks, such as drought; increased the gross value added of farming; and been regulated in ways intended to meet social goals (see also [72,73]). They argue that the water market has enabled non-landholder stakeholders (NLS) to invest in water ownership, increasing the volume of water entitlements owned by government (as environmental water holders), non-governmental organisations and other investors (e.g., superannuation companies, trade speculators) [74]. Typically, the NLS own a portfolio of diverse entitlements (an estimated 11% of water allocation volumes purchased and 21% of water allocation volumes sold [75]), while financial investors and larger agribusinesses "are more

likely to use/supply highly sophisticated temporary trading products" [76] (p. 1). Most irrigators use temporary trading only to mitigate water supply shortfalls.

The RIT represents a microcosm of the overall MDB, illustrating both the attempts to improve the environmental qualities of the area under the Trust's management and the changing focus of production. Despite the relatively small amounts of water involved, the Trust is re-establishing improved water flows in the river and its various creeks in the Renmark area. Its members, the 570 irrigators, as judged from the small sample in this research, are supportive of this work and see benefits from further such developments. There is less certainty about pro-environmental actions on individual holdings but also evidence for a range of related small-scale on-farm measures already in existence on around two-thirds of holdings. There is widespread recognition of the impact of climate change on both water flows and production, with half the respondents reporting this as a factor in their decision making. Some moves to less water-demanding crops are apparent, e.g., pistachios and dates, and substantial water use efficiencies have been developed by the RIT itself. However, the ability of the market to support larger irrigators to grow high water-intensive crops such as almonds is also evident, aided by favourable demand for the crop, and especially production of almond milk.

A view expressed across the focus groups was that there needed to be more rational planning to balance the needs of those remaining in farming with those wanting to have lifestyle blocks. The growth of the latter in the Renmark area was apparent, with 16 (23.2%) respondents stating they were hobby farmers, compared with 24 (34.8%) part-time and 29 (42.1%) full-time. The difficulty of making a living off the smaller blocks was also widely recognised, and only 20 (29%) respondents stated they derived >75% of household income directly from the farm. Of the 20, 11 were wine grape growers, and the average farm size for the 20 was 31.3 ha compared with the overall mean sample farm size of 15.7 ha. Indeed, one focus group member noted that the requisite farm size to make a living solely from the farm was considerably greater than the size of the majority of blocks (quote #17, Table 5).

Hobby and part-time farms account for 58% of the sample. In part, their presence reflects the overall small size of holdings, with 54% of the sample farms being under 10 ha, making it difficult to make a full-time living off the land. However, there appears to have been a growth in hobby farms in the past decade, with small plots being sold by exiting irrigators, usually to newcomers who are transferring capital derived elsewhere into purchasing 'lifestyle blocks.' None of the hobbyists derived even as much as 10% of their income from the farm and the majority gained no farm-based income. There was a higher proportion of female-headed households amongst the hobbyists and only one-quarter were retirees. So, they tend to be aged in their 40s and 50s, with capital derived from outside the study area, some focused on pro-environmental activities, others on keeping livestock (e.g., horses), and some growing small amounts of fruit and grapes for self-consumption or farmgate sales. In contrast, part-time farmers had larger holdings (average 8.4 ha) and only 40% derived less than one-quarter of their income from the land. Those with smaller farm-based incomes tended to be close to retirement and deriving household income largely from non-farm sources. There are concerns that the growth of hobby and part-time farming is taking productive land out of farming, but at present the non-commercial holdings occupy only a very small area, though numbers are growing.

5. Conclusions

The broad framing provided by structuration theory enabled this study to investigate decision making by individual irrigators within the context of controls and constraints implemented by government in the form of the MDB Plan and institutions seeking to pursue their own decisions regarding water management. Hence, the RIT emerges as a key player in the study area by virtue of its provision of pumps and pipes to irrigators, its own sales and purchases of water, and its important pro-environmental actions. The research shows that the institutional constraints on the irrigators have changed in the past

two decades because of the growth of the water market and the emergence of new 'players' in that market, notably water traders and NLS, the latter exploiting the unbundling of water and land. Hence, change in the structures and institutions associated with water management in the Basin accounts for some of the subsequent decisions being made by irrigators. However, other changes to their management of water reflect concerns about climate change, with risk of future lowered flows, as well as market developments such as falling prices for wine, loss of the Chinese market for wine, and other threats, such as controls on fruit fly infestation.

It is apparent that broader societal concerns about the environment are placing irrigators in conflict with "an emerging discourse of environmental sustainability and the recognition of Indigenous water rights" [77] (p. 110). In general, the gulf has widened between environmentalists seeking public good outcomes and irrigators seeking private profit [78], though the strong support by RIT members for the RIT's environmental activities suggests that some pro-environmental actions are viewed positively by irrigators. Indeed, many irrigators themselves already implement such actions on their farms and are largely favourable towards possible extensions of RIT's environmental stewardship to individual farms.

There is clear unease from some irrigators regarding the nature of the water market, unbundling and the presence of NLS in the market. This is being translated into a high degree of uncertainty about the future, especially from smaller operators. This may be reducing on-farm investment, though a minority are still investing to derive benefits, e.g., from favourable prices for almonds, potential dividends from scale economies in wine grape production, and responding to climate change through new crops and crop varieties. There are also more hobby farmers taking up land for its amenity value, resulting in further changes in land use and community make-up.

Greater levels of institutional support could be given to processes and mechanisms that facilitate better governance of the MDB. An improved institutional capacity to learn lessons and share experiences of how to maintain environmental flows whilst retaining capacity for food and wine production alongside vibrant rural communities would also be valuable, possibly through multistakeholder forums [79] and improved representative inclusion in decision making [80]. This may require greater attention to regional economic development alongside policies explicitly directed at agriculture and climate change [81]. A dominant concern that "the current policies are not right" emerged from the focus groups and interviews. Indeed, new institutional structures may be needed and a rethink of existing arrangements for the water market if both the environmental and economic health of the Basin are to be retained.

The preliminary, small-scale survey of members of the RIT has demonstrated that they are making diverse decisions about change, responding to policy, market and climate change signals and drivers. It is clear that, individually and collectively, irrigation communities are assessing their circumstances and options and making decisions that shape their futures. These futures are not determined exclusively by policy settings, markets or climatic conditions, but by a more complex set of interactions and relationships. Further research is proposed that needs to involve closer investigation of these relationships for a larger sample of irrigators. More consideration is required of the nature of decisions about which crops to grow, the potential for switching crops given the existing investment, and the extent to which land is passing out of productive commercial use to hobby farming and lifestyle blocks. The further need to examine how irrigators are responding to the changing regulatory context and the operation of the water market is also apparent.

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